

The Evolution of the Multi-tier Supply Chains in the EU Automotive Industry Driven by Covid-19

A case study at a large automotive OEM

Master's thesis in Supply Chain Management

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CHALMERS UNIVERSITY OF TECHNOLOGY Gothenburg, Sweden 2022 www.chalmers.se Report No. E2021:147

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SUMMARY

Covid-19 has impacted global supply chains in an unprecedented way. It is fair to say that the automotive industry took the hardest hit when the pandemic first striked due to sensitive supply chain (SC) characteristics. During the crisis, the importance of a seamless, connected, agile and transparent multi-tier SCs is recognized by stakeholders and major original equipment manufacturers (OEMs) are called for taking more responsibilities to govern their multi-tier SCs through the development of supply chain risk management (SCRM). Being initiated and driven by the focal company, an OEM, this thesis describes the impacts of Covid-19 on the EU automotive industry in detail. It also provides recommendations on how the focal company can better manage its SCRM efforts and increase SC transparency as one of the core SCRM strategies in order to enhance SC resilience and prevent future disruptions. The focal company's multi-tier SC is studied in this report which included the focal company, two of its tier-1 suppliers and two of its tier-2 suppliers.

The impacts of Covid-19 experienced by the studied companies are categorized as direct and indirect effects of which the companies' corresponding counter measurements are analyzed. Further, the SCRM strategies used by the studied companies during Covid-19 are analyzed using presented theoretical frameworks. The findings suggest that the focal company needs to increase SC transparency by addressing several key barriers mentioned by the interviewed suppliers, specifically information utilization, business process and power structure; and increase the level of information sharing with the identified key suppliers based on the characteristics of the business relationships. The analysis and recommendations of this thesis are made based on empirical data collected through conducting semi-structured interviews with companies' representatives and a thorough literature review on the subject of Covid-19, SCRM approaches and SC transparency. The collected data are then analyzed based on several comprehensive frameworks in the related subjects established by antecedents. This thesis contributes to the sponsor OEM and industrial research in applying existing framework to map the various SCRM methods implemented by different tier suppliers, understanding the barriers needed to be addressed to allow efficient information sharing in an EU automotive supply chain and providing suggestions on how to increase transparency based on the OEM's current SC settings.

Keywords Covid-19, Supply chain Risk Management, Supply Chain Transparency, Information sharing, Automotive Industry, Multi-tiers, Supply Chain Resilience

Paper type Case study

Acknowledgement

Time flies, and in a blink of an eye, college life is coming to an end. We have learned a lot here to take forward in our next journey. We would like to sincerely express our gratitude to the people who have supported us during the journey of writing this thesis during Autumn 2021.

We would like to thank the focal company for this thesis for bestowing upon us this amazing opportunity to conduct the study. We are thankful to the supervisor at the focal company who has been always helpful and supportive throughout this journey. We would also like to thank the employees at the department where this thesis was carried for welcoming us in the team for this short time wholeheartedly. Nonetheless, the representatives from the interviewed companies who spared time for interviewing with us from their busy schedules and shared their views on the topics.

Furthermore, we would like to express gratitude to our supervisor Gabriella Gatenholm and examiner Arni Halldorsson from Chalmers University of Technology. We thank them for their tireless teachings and careful guidance in every link of this thesis from scope building, conception to finalization. Their suggestions and inputs have contributed greatly to the successful completion of the thesis.

Last but not the least, we would also like to thank all the scholars to whom we referred to in this thesis. Without the help and enlightenment of the research of these scholars, it would be a challenge for us to form a foundation for the study.

Gothenburg, January 2022

Kelsi Liu

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CONTENT

Acknowledgement	1
CONTENT	3
1. Introduction	7
1.1 Background	7
1.2 Aim	10
1.3 Limitations	11
1.4 Research Questions	12
1.5 Structure of the Thesis	13
2. Methodology	14
2.1 Research Method	14
2.2 Data Collection	14
2.2.1 Literature Review	15
2.2.2 Empirical Data	15
2.2.2.1 Primary Data	15
2.2.2.2 Secondary Data	17
2.2.3 Covid-19	17
2.3 Data Analysis	17
2.4 Research Quality	18
3. Literature Review	19
3.1 SCM in Automotive Industry	19
3.2 SCRM	20
3.2.1 SCRM Framework	21
3.2.1.1 Proactive SCRM	22
3.2.1.2 Reactive SCRM	23
3.3 Multi-tier SC Transparency	24
3.3.1 Mapping SC Transparency of a Company	25
3.3.2 The Elements of SC Transparency	27
3.3.2.1 Visibility	27
3.3.2.1.1 Blockchain Technology	28
3.3.2.2 Information Sharing	29
3.3.2.2.1 Transparency Barriers	30
3.3.2.2.2 The Level of Information Sharing	34
4. Covid-19 Impacts on EU Automotive Sector	37
4.1 Overview on the Impacts	37
4.1.1 Direct Impacts	38

42
47
47
47
48
50
53
53
53
54
55
57
57
58
59
61
61
61
62
64
65
66
66
67
69
69
70
72
72
73
73
74
75
75
77
78
78

6.3.2 Transparency Barriers	79
6.3.3 Information Sharing with Key Partners	82
7. Conclusion	84
REFERENCES	88
APPENDICES	99

1. Introduction

1.1 Background

Globalization and increasing competitiveness among the companies have made the supply chains (SCs) in the world more complex with long links and involvement of many stakeholders (Fan and Stevenson, 2018). The recent outbreak of the Covid-19 and the resulting supply chain disruptions worldwide has illustrated the vulnerability of today's disaggregated and globalized value creation (Wang-Mlynek and Foerstl, 2020). Companies have encountered massive uncertainty over demand, long delays from suppliers and logistics partners, and operations stoppages caused by unavailability of resources (Rainer et al., 2021). This crisis has created unprecedented stress on global SCs. Some SCs faced a burden due to the sudden rise in the demand (such as medical and pharmaceutical companies) where the supply couldn't meet the demand. Whereas, some SCs (for example, the automotive industry) faced drastic fall in supply and demand which led to production stops, need of government support and even bankruptcy (Ivanov, 2020).

Automotive supply chains are generally considered as complex because a vehicle comprises over 20,000 parts, which requires a vast and complex network of suppliers in multiple tiers for OEMs (Zhu and Zhang, 2018). A recent ongoing crisis is regarding shortage of semiconductors due to various reasons. Global semiconductor shortage has been causing global automotive OEMs to cut production volumes which acts as an alarming call to supply chain stakeholders to identify and manage risks through the collaboration with supply chain partners and the enhancement in multi-tier supply chain transparency (Aref, 2021). To recover from these disruptions, global supply chain resilience as well as the role of technology in supply chain management are identified as key strategic drivers (Alyssa et al., 2020).

Gartner (2020) mentions the increasing need by supply chain executives in making the supply chain resilient. Supply chain resilience is described as "*having the capacity to absorb stress, recover critical functionality, and thrive in altered circumstances*" (Reeves and Whitaker, 2020). To enhance this capacity, managing multi-tier SCs can help companies react faster when disruptions occur (Rainer et al., 2021). The Covid-19 pandemic has increased the uncertainty which impacted the supply and demand sides of the supply chains (Gartner, 2020). The motive behind supply chain risk management is to identify and foresee supply chain risks and develop strategic plans and present solutions to avoid, mitigate and/or minimise supply chain disruptions

(Shahbaz et. al., 2017). Supply chain risks should be managed by a company proactively and reactively (Dias et al, 2020). Similarly, Kilubi (2016) categorised the supply chain risk management strategies into proactive strategy and reactive strategy depending upon the severity of supply risks and demand risks. Proactive strategy includes identifying risks and implementing measures before the risk appears so as to minimise the impacts of risks. While reactive strategy includes monitoring the changes in the supply chain as per the demand, suppliers and technology and reacting quickly to them (Dias et al, 2020). The strategy of increasing visibility & transparency across the supply chain partners is observed as a common strategy in both proactive & reactive strategy for effective supply chain risk management (Kilubi, 2016).

A multi-tier supply chain is a complex system as it covers the focal company and multiple tiers of suppliers in a complex supply chain network (Yu et al., 2021). The term is defined as "multiple single-level collaborations, meaning multiple suppliers to buyer relationships, within one supply chain" (Ravikanti, 2019). In order to achieve multi-tier supply chain management (MTSCM) and prevent supply risks due to multi-tiers, supply chain transparency is identified as a prerequisite (Fraser et al., 2020). Different from supply chain visibility which allows the understanding of a particular activity with access to data at a specific node, supply chain transparency opens up the supply chain allowing stakeholders to see all nodes which enables shared data at the desired level to be communicated across the supply chain. Even though achieving supply chain transparency has immense benefits to companies, the adoption of supply chain transparency has been slow due to the fragmented information which lives on isolated systems and that stakeholders are unable to connect the data to each other's operations (Brandvoice, 2021). To achieve efficient supply chain resilience, companies need to gain visibility into their entire supply chains, beyond the tier 1 suppliers (Schuster et al., 2021) and this has called for a technology tool that gathers data with real-time capabilities from all stakeholders at one place in order to drive this change (Brandvoice, 2021).

Companies are investing heavily in digitalisation and technologies such as Internet of Things (IoT), digital twin and blockchain to improve transparency and increase collaboration between its multi-tiered supply network and this need for digitalization is accelerated due to Covid-19 (Gartner, 2020). The focal company (referred to as OEM AB in the report) started their transparency project in 2020 and has planned a roadmap towards the achievement of full supply chain visibility by the year 2040 (Business Improvement Leader, OEM AB, personal communication, September 24, 2021). A multiyear and integrated supply chain digitalization

strategy roadmap will be an enabler of successful digital business transformation to optimize costs and improve customer satisfaction (Gartner, 2020). The focal company's supply chain transparency project was initiated to address the lack of visibility in supplier capacity and sustainability due to inefficient information sharing. Information sharing and transparency is defined as interchangeable terms by the company (Business Improvement Leader, OEM AB, personal communication, September 24, 2021). The efficient level of information sharing between the supply chain partners provides opportunities for joint problem solving and facilitates the implementation of best practices in the multi-tier supply chain (Wakolbinger and Cruz, 2011) which is one of the drivers towards successful SCRM.

Many studies in MTSCM have been done on different industries, for example, the chemical and pharmaceutical industries. However, the automotive industry, due to the high level of complexity in the supply chains, is still struggling to achieve efficient visibility and transparency in their MTSCM efforts (Fraser et al., 2020). Research has also been done on identifying transparency barriers in the automotive and aircraft industries because they are interlocked business domains with a multi-tier supply system (Wang-Mlynek and Foerstl, 2020). However, the team learnt that there is no study specifically conducted in the past describing the transparency barriers faced by different tiers within the same supply chain in the automotive industry in view of Covid-19 impacts. Given the focal company's vision to reach full supply chain visibility in 2040 and the identified research gap, the team dedicates this thesis to investigate the various transparency barriers existing in the chosen case companies which are categorized as tier 1 and tier 2 suppliers of the focal company, OEM AB and how they are impacted by the crisis. By understanding these barriers, the focal company gains insights into their own supply chains so that they could better leverage the MTSCM strategies (Director, OEM AB, personal communication, September 30, 2021). The authors of this report choose to investigate up to tier 2 due to that it becomes very expensive to invest in MTSCM beyond tier 2 suppliers which may result in low return on investments and a 3-tiers' network (OEM and its tier 1 & 2 suppliers) is considered the smallest suitable unit for MTSCM (Choi and Wu, 2009; Mena et al., 2013).

This thesis is designed as a cross-case study conducted in order to compare best practices in the relevant subjects implemented in the automotive industry. The overall logic of this report is divided into two focus areas corresponding to the research questions which is introduced in section 1.4. The first focus area is dedicated to present an overview of the impacts of Covid-19 on the EU automotive industry and to understand how the multi-tier supply chains of the focal

company are compelled to increase transparency in the supply chain towards tier-2 suppliers by the experience of Covid-19. Later part of the first focus area discusses the supply chain risk management strategies used by the focal company's supply chain during the disruption caused by Covid-19 ending with recommendations for the future disruptions. The second focus area targets specific supply chain risk management strategy of supply chain transparency with regard to the efficient level of information sharing with supply chain partners and the transparency barriers needed to be overcome to enable such strategies. To allow the readers to gain a clear understanding of the subjects presented, the team designed the two focus areas using a top-down approach that goes from the general to the specific details. In the following sections, the aim, limitations, research questions and the structure of the thesis are presented.

1.2 Aim

This study aims to provide high level recommendations on how OEM AB should govern their resilience efforts in SCRM in order to better handle disruptions and implement resilience in their supply chains for the future to come. To do this, the team is taking a deep dive into the challenges faced by the focal company's multi-tier SC during Covid-19 and the importance of efficient information sharing towards the achievement of supply chain resilience. The deliverables for this thesis include but not limited to:

- A summary of Covid-19 impacts on the focal company's supply chain and on the overall EU automotive industry
- 2. Summary of the supply chain risk management strategies implemented by the focal company's multi-tier supply chain during Covid-19
- 3. Recommendation of SCRM strategies for the focal company's multi-tier supply chain in case of future disruptions
- 4. Summary of the interviewed companies' views on transparency
- 5. Outline of the existing transparency barriers in the focal company's multi-tier SC
- 6. Recommendations on the level of transparency that the focal company should have with suppliers based on the specific categories and the corresponding risk profiles

By fulfilling the aim of the thesis, it is believed that the focal company will be able to improve its SCRM system from understanding the SCRM strategies adopted by its suppliers in the face of a crisis or other supply chain risks and to make its SC more resilient by enhancing SC transparency. The department will also get more insights on the ongoing trends in the EU automotive industry to improve their resilience efforts strategically.

1.3 Limitations

The focal company 'OEM AB' is a multinational OEM spread globally over different regions like EU, North America, South America and APAC. It has a supplier network spread all over the world to gain competitive advantage. Due to the fact that OEM AB's global supply chain is very complex and interlinked in between these regions, this thesis is primarily focused on the company's supply networks in the EU region for scope management. This study covers a wide range of subjects which includes Covid-19 impacts, SCRM strategies and SC transparency. The impacts of Covid-19 cover the different types of impacts from market research and thus do not analyze the quantifiable or measurable impact of Covid-19. This thesis is conducted with a limited time duration of 20 weeks of rigorous study, discussion and research. It is due to the broad scope and the tight schedule, that the depths of the analysis of certain topics are limited.

Eight representatives from five companies were interviewed for data collection purposes for this thesis. Each interview was designed to be one hour long and accommodated with full interview transcripts. The team was not able to conduct more interviews because of the interview length and the large amount of work put into making the transcripts. Some questions were not answered in a comprehensive way mainly because of the sensitive nature of the content, thereby data quality was also limited. The SCRM strategies followed by the interviewed companies were studied based upon data collection. There are several articles describing the categorization and analysis of SCRM strategies, however, the framework adopted for this report is based upon the article by Kilubi (2016). This framework is used for analysis of the interviewed companies for both summarizing their SCRM strategies used during Covid-19 and also for giving recommendations for future disruptions. As per the adopted framework, the SCRM strategy of 'transparency & visibility' is seen as a central SCRM strategy and in addition, the focal company has been recently taking initiatives towards 'transparency and visibility' and is currently in the beginning phase. Taking this into consideration, 'visibility and transparency' is addressed in detail for the second half of the report. Specifically, in section 6.3.3, the team was not able to collect enough information to understand how much the interviewed suppliers depended on OEM AB's business but only the other way around, which led to the recommendation on the level of information sharing based on partially biased inputs.

1.4 Research Questions

In view of Covid-19, OEM AB started the supply chain transparency project in 2020 with the initiative to address the lack of visibility regarding supplier capacity and sustainability (Business Improvement Leader, OEM AB, personal communication, September 24, 2021). The project aims to transform the traditional 'linear' supply chain digital ecosystem into an integrated supply chain digital ecosystem for both internal and external supply chain stakeholders to create process and digital solutions for supplier capacity and compliance (Business Improvement Leader, OEM AB, personal communication, September 24, 2021). OEM AB's transparency project holds the vision to reach full supply chain visibility in 2040 which motivates the team to focus this thesis study on transparency in multi-tier supply chain management in the EU automotive industry.

After thorough discussions with the project stakeholders, the team reached the consensus with OEM AB and the team's supervisors from Chalmers University of Technology for the following research questions in order to fulfill the aim of the thesis:

RQ1a How has the Covid-19 pandemic impacted multi-tier supply chains in the EU automotive industry?

RQ1b How is the OEM's supply chain performing in the area of SCRM during Covid-19?

RQ2 How should the OEM increase transparency in their multi-tier supply chain as a SCRM to enhance resilience and prevent future disruptions?

a) How transparent is the OEM at present?

b) Which transparency barriers should/must be overcome in multi-tier supply chains to allow efficient information sharing?

c) What is the recommended level of information sharing/transparency based on the OEM's supply chain?

The RQ2 is answered through dividing into the three sub-questions under it which helps in addressing the wide research area of transparency.

1.5 Structure of the Thesis

The later chapters in the thesis follow the following structure which also provides a brief overview of the content of the chapters.

2. Methodology

This chapter describes the detailed research methods used to answer the research questions and also describe the adherence to research quality.

3. Literature background

This chapter elaborates upon the relevant theoretical background and different theoretical frameworks used to answer the research questions as per section 1.4. The chapter ends with the explanation for how the team intended to use the frameworks to answer the RQs.

4. Empirical findings - OEM AB and its Suppliers

This chapter presents the data collected from the interviews conducted with the seven interviewees from the five interviewed companies in the EU automotive industry. All findings are sorted and categorized in the cross-case analysis chapter and they are collected purposely to provide answers to all five RQs with three focus areas namely, Covid-19 impacts, SCRM methods and views on supply chain transparency.

5. Covid-19 Impacts on EU Automotive Sector

This chapter presents a brief background of Covid-19 and how it impacted the European automotive industry directly and indirectly. This chapter forms a basis for answering the RQ 1a which is addressed in the next chapter.

6. Cross-case Analysis

Based upon the previous chapters of literature background, Covid-19 and empirical findings, this chapter presents an analysis of the studied five companies on the three focus areas. The overview of the studied companies is presented in the tabular form in each subsection which are used to provide direct answers to the RQs in the conclusion chapter.

7. Conclusion

In this last chapter, each of the research questions are answered individually for a clear understanding of the reader.

2. Methodology

In this section, the methodology used for the advancement of the thesis is presented. The section is divided into the following four subsections namely; research method, data collection, data analysis and research quality, which are presented below.

2.1 Research Method

Since this study is initiated by the focal company which is a large automotive OEM, the research is done by focusing on the focal company's supply chain. In order to understand the evolution of the focal company's multi-tier supply chain driven by Covid-19, along with literature review, semi-structured interviews were conducted with the focal company's internal employees and with the focal company's tier-1 and tier-2 suppliers. In order to answer both the research questions, a case study was performed using a qualitative research method. Interview invitations were sent out to the suppliers of the focal company based upon the suppliers' different industry types and company sizes to understand the impact of Covid-19 on different supply chains. This helped the team in visualizing the impacts of Covid-19 that reflected over the supply chain, supply chain risk management strategies adopted by different actors in the MTSCM and also the supply chain transparency in between them. This is done by studying the supply chain disruptions faced by the chosen case companies of which they encountered during the crisis period and describing the impacts more in detail.

2.2 Data Collection

The data collection done for this study consists of two parts, which are literature review and empirical data. A thorough literature review was conducted to find and develop the guiding framework for the thesis. An empirical data collection including primary data collected from the interviews with representatives from the case companies and the findings of complementary information through the internet utilizing market reports from web resources and consultancy reports. In the following Table 1, the overview of the corresponding deliverables fulfilled by the respective RQs along with key evidence used for them is presented.

SN	Deliverables	Fulfilled by RQ	Key Evidence
1	A summary of Covid-19 impacts on the focal company's supply chain and on the overall EU automotive industry	RQ 1A	Interviews data and Market research
2	Summary of the supply chain risk management strategies implemented by the focal company's multi-tier supply chain during Covid-19	PO 1P	
3	Recommendation of SCRM strategies for the focal company's multi-tier supply chain in case of future disruptions	KQ IB	Literature review,
4	Summary of the interviewed companies' views on transparency	RQ 2A	Theoretical frameworks and
5	Outline of the existing transparency barriers in the focal company's multi-tier SC	RQ 2B Interviews data	
6	Recommendations on the level of transparency that the focal company should have with suppliers based on the specific categories and the corresponding risk profiles	RQ 2C	

Table 1: Overview of Key Evidence used in fulfilling the deliverables and Corresponding RQs

2.2.1 Literature Review

A literature review was conducted to develop the theoretical frameworks which could help answer the research questions and thereby fulfill the aim of this study. Through reading previous works done on the specific subject, the research frameworks are determined for detailed classification and formulation of concepts. These frameworks are presented in the next chapter of literature. The purpose of the literature review is to show the overview of existing theories and research results and summarize all research results in a certain field and clarify the theoretical context of the research.

2.2.2 Empirical Data

The empirical data collection consists of data collected from primary data and secondary data for the interviewed companies. In the following section the primary data and secondary data collection are described.

2.2.2.1 Primary Data

Apart from the focal company, two tier-1 companies and two tier-2 companies were chosen to be a part of the study. To safeguard the confidential information shared by these five companies, it is chosen to keep the participating companies anonymous and hence are referred to by their pseudonyms in this report. The focal company is referred to as OEM AB while its two tier-1 suppliers are A1 and A2 and tier-2 suppliers are B1 and B2. For the collection of primary data for the interviewed companies, a total of seven semi-structured interviews of one hour each

were held with these five companies on Microsoft Teams since the current situation of the Covid-19 pandemic required the interview to be held on distance. A semi-structured interview which gives room for flexibility during the interview as the interviewee can elaborate more on certain topics and follow-up questions can be asked (Rowley, 2012). Three interviews were conducted individually with three employees from OEM AB while one interview each was conducted with the rest of four supplier companies. Table 2 provides the overview of the seven interviews conducted along with the short description of the five companies.

Company	Tier	Country	Product	Staff Size	Designation of Interviewees
OEM AB	Focal Company	Sweden	Trucks	~100k	Senior Buyer, Process Engineer, Business Improvement leader
A1	1	Sweden	Sheet metals	~120	Managing Director
A2	1	Austria	Lighting systems and electronics	~10K	Key Account Manager
B1	2	Sweden	Motion and control technologies	~55k	Supply Chain Manager
B2	2	Germany	Semiconductors	~47k	Vice President and Senior Manager in OEM Business Development

Table 2: Overview of the Interviewed Companies

The four interviewed suppliers of OEM AB were mutually chosen for this study with the focal company based upon the uniqueness of the product offerings, risk profiles, company size and the geographical location in the EU region to adhere to the focus area of the European region. The respondents from these suppliers were interviewed based upon their expertise in the research areas of this report. The respondents from the four suppliers were contacted via email as provided by the focal company since the focal company has existing relationships with them. Since the four companies supply different types of parts directly and indirectly to OEM AB which allowed the team to analyze different types of supply chain in the EU automotive industry and base the study on a wider context.

In order to answer the designed research questions, the team first decided upon what aspects of data would contribute to the cross-case analysis based on the theoretical frameworks the team chooses from literature review. The team then constructed the interview questions around the three focus areas, namely, Covid-19 impacts, SCRM and SC transparency and all the questions were discussed with and reviewed by the focal company. The interview guide was sent to the

company representatives in advance for preparation and it can be found in the appendix A and B. The five companies were interviewed as per appendix A however, only the focal company OEM AB was additionally interviewed with questions as per appendix B. Similarly, prior to the interview, the interviewees were asked for permission regarding recording the interviews and were also informed about publishing of the report in open access. The interviews were recorded and subsequently transcribed to avoid missing details and thereby increasing the reliability of the study.

2.2.2.2 Secondary Data

The secondary data about the four supplier companies of OEM AB was also gathered from the questions in appendix B asked to the focal company. The secondary data about the suppliers obtained from the focal company gives an overview of the business relationships in between them.

2.2.3 Covid-19

The data on Covid-19 impacts only on the interviewed companies was gathered from the primary data of the interviewed companies. However, to get an overview about the Covid-19 impacts on the EU automotive industry, data was collected from several consultancy reports like McKinsey, Gartner and Deloitte, reports published in media and academic articles. After getting an overview of Covid-19 impacts on the EU automotive industry, those impacts were also observed and analyzed in the interviewed companies.

2.3 Data Analysis

The empirical findings collected from the interviews, market research and literature review formed the knowledge base that the team applied to answer the designed research questions. Four theoretical frameworks established in previous research in the areas of SCRM and information sharing are adapted in the thesis forming the foundations for the cross-case analysis. The combined data analysis method is used for two merits:

 Having a theoretical framework helps the team to specify which key variables influence SCRM decisions and apply them to the case companies in order to identify the limits in the automotive contexts (Philipsen, 2018). 2. A cross-case analysis allows the team to identify innovations in the automotive market and come up with specific recommendations for continuous improvements based on the comprehensive contexts being analyzed (Scott, 2018).

2.4 Research Quality

As per Riege (2003), "the validity and reliability in qualitative research can be established with regard to the four design tests of conformability, credibility, transferability and dependability." This thesis follows these four design tests so as to increase the research quality of the study and to make it trustworthy. Confirmability and dependability are developed in the thesis by conducting thorough literature review, market research coupled with empirical data collection from the involved five companies. To ensure the validity of the data collected, interviews are done with five selected companies and in total eight corporate representatives were interviewed. The format of the interviews is semi-structured carried out with a predefined set of questions to avoid the bias values of the team influencing the data collected. This method was also chosen in order to achieve repeatability and transferability (Riege, 2003). The recording of interviews and further transcribing it has also helped in avoiding misinterpretation, missing the details in the empirical findings about the interviewed companies. Interview findings were cross checked by presenting to the focal company of this thesis to make sure that statements made by the interviewees are solid and factual. Also, the validity of the study has been achieved by reviewing the report regularly with the supervisor who has experience in academic research. The main areas for analysis were narrowed down after all interviews were conducted. These frameworks were also reviewed by the thesis supervisor and the team adapted the report to the comments and feedback given by the sponsor company and the thesis examiner throughout the work ensuring the credibility of the analysis base of this thesis.

3. Literature Review

In this section, relevant literature backgrounds and findings are addressed on the subjects of Covid-19, supply chain risk management in the automotive industry and supply chain transparency which serve as the theoretical foundation for this thesis and the knowledge and logic base for the analysis of this study. Several frameworks around the focused topics are also presented with elaborated introduction and interpretation on how they can be adopted.

3.1 SCM in Automotive Industry

Supply chains are the interconnected group of two or more parties which can be organizations or individuals that are involved in the flow of products, services, information from a supplier to customer (Mentzer et. al., 2001). Supply chain management can be defined as "the integration of key business processes from end user through original supplier that provides products, services, and information that add value for customers and other stakeholders" (Lambert and Cooper, 2000, p. 66). The smallest unit that can be used to study a multi-tier supply chain is a buyer-supplier relationship embedded in a triad relationship where an additional supplier or customer of the buyer company is present (Choi and Wu, 2009). In the automotive industry specifically, a multi-tier supply chain contains the OEM, and its tier system which could contain from tier-1 to tier-N suppliers depending on the OEM. Typically, a tier-1 supplier supplies parts or systems directly to the OEM and despite the various OEMs they might have business with, a tier-1 supplier usually maintains business with a variety of OEMs. Tier-2 suppliers do not sell directly to the OEMs and they sell parts to tier-1 suppliers instead which in turn sell to the OEMs. Tier-2 suppliers are specialized in specific domains and they might have non-automotive customers too. A tier-3 supplier is defined as suppliers that supply the tier-1 and tier-2 suppliers with raw or close to raw materials such as metals and plastics (AMATECH, 2017). So, the tier-1 companies purchase raw materials and parts from tier-2 & tier-3 and deliver finished subsystems to the OEM's final assembly lines (Mendes, 2021). Figure 1 gives a pictorial representation of a supply chain from a tier-n supplier to OEM in the automotive industry. Generally, the material flow is unidirectional from left to right eventually towards the OEM and the information is bidirectional between consecutive supply chain partners.



Figure 1: A representation of Supply Chain in Automotive Industry

3.2 SCRM

Supply chain designed to minimize risks helps firms to gain competitive advantage and offer sustainable benefits for all its stakeholders (Dias et al., 2020). Tang (2006) explains two purposes of securing supply chains for a firm which are i) reducing costs and/or improving customer satisfaction under normal circumstances and ii) sustaining the operations during major disruptions. Supply Chain Risk Management (SCRM) has been defined in various ways by different researchers (Fan and Stevenson, 2018). For the purpose of this thesis, the team choose to adapt to the definition developed by Fan and Stevenson (2018) where SCRM is defined as *"The identification, assessment, treatment, and monitoring of supply chain risks, with the aid of the internal implementation of tools, techniques and strategies and of external coordination and collaboration with supply chain members so as to reduce vulnerability and ensure continuity coupled with profitability, leading to competitive advantage".* In this definition, the authors emphasized on the implementation of external coordination and collaboration with supply chain members which could be adapted to situations where multiple partners are presented, therefore, the team used this definition to explain Multi-tier Supply Chain Risk Management (MSCRM) interchangeably in this report.

Risk is described as disruption, vulnerability, uncertainty, disaster, peril and hazard (Ghadge et al., 2012). Supply chain risks are the risks occurring through the exposure to events that cause disruptions in the supply chain network (Wang et al., 2013). Supply chain risks can be categorized in various ways; however, the categorization into 'supply risks' and 'demand risks' seem to have received the most attention in supply chain risk management strategies (Monroe et al., 2014). Supply risk is the risk due to adverse events in the inbound supply that affect the focal company's ability to meet customer demand within anticipated time, quality, quantity or cost. Demand risk is the risk related to adverse events in the outbound flow in terms of variance

in the volume and assortment of the customer's order placed at the focal firm (Manuj and Mentzer, 2008).

3.2.1 SCRM Framework

Kilubi (2016) developed a SCRM framework to suggest strategies for effective SCRM which divides the SCRM into proactive approach and reactive approach. The SCRM can be structured to manage routine and catastrophic risks like natural disasters. The SCRM framework suggested by Kilubi (2016) describes SCRM with strategies considering both supply and demand risks and also the two states of before and after the occurrence of the supply chain risks. The supply and demand risks are differentiated between low and high levels as per their relative severity. The ante-disruption state refers to a normal state of situations and the post-disruption state is referred to as a situation during major disruptions. Figure 2 shows the SCRM framework by Kilubi (2016) as described above.

	low Demand	Demand-side risks high		
low	Ante disruption state	Post disruption state		
	(Proactive Strategy Approach)	(Reactive Strategy Approach)		
	Supply Chain Type-IV	Supply Chain Type-I		
	Efficient	Flexibility & Responsiveness		
ly-side risks	Visibility and Transparency, Partnerships/Relationships	Visibility & Transparency, Postponement, Redundancy, Multiple sourcing and Flexible contracts, Collaboration, Flexibility		
[ddn;	Supply Chain Type-III	Supply Chain Type-II		
S	Hedging	Agility		
high	Joint Planning and Coordination, Redundancy, Visibility and Transparency	Visibility & Transparency, Postponement, Redundancy, Multiple sourcing and Flexible contracts, Collaboration, Flexibility		

Figure 2: The SCRM strategies framework (Kilubi, 2016)

During the ante disruption state which is shown in the left two quadrants, a proactive SCRM approach with the SCRM strategies is suggested by the author. While during the post-disruption stage which is shown in the right two quadrants, a reactive SCRM approach is suggested. The SCRM framework categories companies with four supply chain types, namely, supply chain

types I, II, III and IV based on the severity level of supply risk as well as demand risk that companies are likely to be exposed to. Supply chain I and II are defined in a post-disruption state and supply chain III and IV are defined in an ante-disruption state. Supply chain type 1 is seen to be flexible and responsive as it has low supply risks in case of high demand risks so that it can flexibly meet the demand by responsive supply. Whereas, being exposed to high supply and demand risks, supply chain type 2 is categorised as agile. These supply chain types have to constantly adapt to high supply chain risks. In an ante-disruption state, supply chain type 3 has low demand risks but high supply risks so they try to hedge or avoid these supply risks in normal situations. The fourth supply chain type is seen as the efficient one as it has low risk magnitude from supply and demand. From the framework, it is suggested that reactive strategies are more applicable in terms of mitigating supply risks whilst proactive strategies are more applicable in terms of mitigating demand-related risks. The strategies that are recommended for these four types of supply chain types are mentioned in the respective quadrants. For example, in case of supply chain type IV, when the supply risks and demand risks are low, it can be considered as an ante disruption state. To maintain the resilient supply chain risk management in this situation, a proactive approach is recommended with strategies like visibility and transparency and partnerships/relationships. As per Kilubi (2016), these four supply chain types are suggested with SCRM strategies depending upon their risk profiles, see Figure 2. The suggested eight strategies are presented in Table 3 with a brief description of each of them.

3.2.1.1 Proactive SCRM

The proactive supply chain risk management approach identifies risks beforehand and implements actions to prevent and minimize the impact from such risks (Dias et. al., 2020). There are majorly four SCRM strategies proposed by Kilubi (2016) which would help the firms in anticipating and mitigating the impact of supply chain risks and stabilize the company's supply chain. These are visibility and transparency, joint planning and coordination, redundancy and relationships/partnerships.

SCRM Strategy	Description
Visibility and Transparency	Improving information sharing and connectivity through process management, IT systems, service provider management for transparent and real time data to minimize the risks (Kilubi, 2016).
Postponement	Holding the base materials, subassemblies as strategic backup inventory and delaying the assembly of the final product so as to react quickly to demand risks (Manuj and Mentzer, 2008).
Flexibility	Reacting to any external disruptions without paying too big of a price in terms of time, cost, resource, effort and performance (Stevenson and Spring, 2007).
Relationships/ Partnerships	Developing supplier relationship management for close relationship building which can guarantee high delivery performance and result in strong ties (Kilubi, 2016).
Redundancy	Adding safety stocks to safeguard the supply chain from unforeseen disruptions as well as to have a buffer in case of supply and demand risks (Rajesh et al., 2015).
Joint planning and coordination	Joint problem solving with a cross-functional team possessing a broad spectrum of expertise; coordinating to improve communication (Hallikas et al. 2004).
Collaboration	Working closely together with other supply chain members, share risks, take decisions through joint product design, collaborative research and collective innovation so as to react to the supply chain risks (Kilubi, 2016).
Multiple Sourcing and Flexible Contracts	Ensuring the possibility of sourcing from another supplier if the existing supplier is unable to deliver due to various reasons like quality, cost, performance (Kilubi, 2016). Flexibility in contracts ensures non-adherence with contract terms of minimum order quantity, security to change the demand in case of high demand risks, speeding of deliveries in case of emergencies (Angkiriwang et al., 2014).

Table 3: Description of SCRM Strategies used in Kilubi (2016)

3.2.1.2 Reactive SCRM

The reactive supply chain risk management approach enables quick reaction to risks by monitoring changes occurring in the supply chain, customer needs, suppliers' strategies (Dias et al., 2020). So, a reactive approach is effect-oriented that reduces the negative impact and takes action on the harm caused by the risk. Kilubi (2016) suggests six strategies for effective SCRM in the post-disruption state which follows the reactive approach which are flexibility,

collaboration, multiple sourcing and flexible contracts, visibility and transparency, redundancy and postponement.

It is observed that from the SCRM strategies discussed in the framework, the strategies of 'redundancy' and 'visibility and transparency' are perceived as both proactive and reactive strategies for an effective SCRM. However, redundancy involving adding up buffers is effective only when either supply risks or demand risks or both are high. This strategy could however not be possible for all types of components as it might have the risk of obsolescence, wastage, high tied-up capital and so on (Rajesh et al., 2015). On the other hand, the strategy of 'visibility and transparency' is claimed to be an effective SCRM in all scenarios of supply chain risk combinations and in both ante-disruption and post-disruption states (Kilubi, 2016). In the next section, the literature review of the SCRM strategy of supply chain transparency is presented which also forms the foundation of the second research question.

3.3 Multi-tier SC Transparency

Opaque supply chains and upstream operations can leave the OEMs sightless which increases the uncertainty, exposure to supply chain risks and disruptions (Venkatraman et al., 2021). In light of the recent series of crises caused by Covid-19, supply chain transparency across the entire supply chain is getting recognized by companies and researchers as the essential mandatory strategy for effective supply chain risk management both proactively and reactively (Kilubi, 2016). Supply chain transparency enables the companies to understand about their upstream supply chain and help them to communicate the knowledge with internal and external stakeholders (Bateman and Bonnani, 2019). Supply chain transparency comprises two elements which are supply chain visibility and disclosure or information sharing (Harbert, 2020). Supply chain visibility defines the accuracy with which data is collected from all the supply chain links while disclosure defines the sharing of the information with internal and external stakeholders in the supply chain (Harbert, 2020). Supply chain transparency provides a company to gain useful insights and understand the supply chain in a better way in order to make informed decisions. The need for increasing supply chain transparency can be generated from multiple stakeholders with different objectives (Venkatraman et al., 2021). In the following section, the method to map a company's supply chain transparency is presented.

3.3.1 Mapping SC Transparency of a Company

The evaluation of a company's supply chain transparency can be performed by a transparency mapping model suggested by Bateman and Bonnani (2019). A firm's progress moving towards supply chain transparency is measured using this model that considers two dimensions. The first dimension is supply chain scope defined by the depth of the firm's interaction in the supply chain. The supply chain scope ranges from internal operations to the depth of raw materials level. While the second dimension determines the milestones achieved so far by the firm towards achievement of transparency. The transparency milestones achieved by a company range from sharing code of conduct to full disclosure between the stakeholders. Figure 3 displays the supply chain transparency model by Bateman and Bonnani (2019) which shows the transparency milestones on the X-axis and supply chain scope on the Y-axis.



Figure 3: Model for mapping supply chain transparency (Bateman and Bonnani, 2019)

Depending upon the company's supply chain transparency, this model categorizes companies into four categories namely; majority, early majority, early adopters and innovators. Bateman and Bonnani (2019) claim that many of the companies fall into majority or early majority stage. The companies in majority stage have an overview of their internal facilities, code of conduct, standards and certifications required internally. The companies in the early majority stage however, conduct audits of their direct suppliers additionally and communicate the performance-based metrics with their direct suppliers. The 'early majority' companies thus monitor the direct suppliers' compliance. Companies in the 'early adopters' category engage

with indirect suppliers and have traceability for the transactions with them. Very few companies who have full disclosure with raw material suppliers are known as 'innovators'.

After mapping the position as per the above-described supply chain transparency model, a company has to decide whether they want to invest towards increasing the supply chain transparency. An affirmative answer will further involve the evaluation of objectives to fulfill through becoming transparent. It would also involve understanding the meaning of transparency by the company based on the risk profile of its product portfolio (Harbert, 2020). A company's advancement towards increasing its supply chain transparency can be achieved by the five general steps as described by Bateman and Bonnani (2019). These five steps are described below for a clear presentation.

1. Map risks & set goals:

This first step requires a detailed investigation of probable supply chain risks taken into consideration. This step also involves materiality assessment which means analysing the issues that are most important for the company's internal and external stakeholders. After analysing the supply chain risks to be addressed thoroughly, it is convenient to set the goals to be achieved by becoming transparent.

2. Visualise the supply chain:

After the complete understanding of risks and goals, the next step to be taken by the company is to visualise the target supply chain. The target supply chain is the supply chain whose issues the company wants to prioritise. This step will let the company know its supply chain better, analyse the process flow and expose the information flow gaps.

3. Collect actionable information:

The visualisation of the supply chain is followed by the collection of information on performance and practices that will provide insights about potential risks, scope of improvement and filling the information gaps. This step will also involve tracking the source of origin and code of conduct of finished goods.

4. Engage:

After gathering the necessary and relevant information, the company has to decide upon the ways of engaging with the supply chain partners using this information. The issues to be addressed using the information could range from social and environmental threats for responsible sourcing decisions to the monitoring of delivery performance KPIs like lead

time, capacity of the tier-n supplier. The engagement with suppliers can thus include supplier collaboration, monitoring and providing support.

5. Disclose:

This final step requires the company to make decisions on the level of disclosure it wants to establish. The level of disclosure consists of a range to disclose the information from the code of conduct to the raw material as explained in the model.

As the above steps are dynamic, the progress should be followed in a continuous manner for efficient supply chain transparency. Many companies are reluctant in taking initiatives for supply chain transparency and the transition to become a transparent company is slow (Bateman and Bonnani, 2019). There are many reasons for companies' slow pace of transitioning towards becoming transparent. Companies fear of disclosing too much information which might get them into other issues like criticism, losing competitive advantage over their peers, irrelevant and erroneous data from upstream supply chain and also less return on efforts invested for supply chain transparency (Bateman and Bonnani, 2019).

3.3.2 The Elements of SC Transparency

In the following sections, the two elements of the supply chain transparency which are supply chain visibility and information sharing are explained in detail.

3.3.2.1 Visibility

Supply chain visibility is defined as the "*ability of the stakeholders to access real-time data related to the order process, inventory, delivery and potential supply chain disruptions*" (IBM, 2021). Increasing supply chain visibility enables accurate information on demand forecast, supplier inventory, supplier capacity, distribution network inventory level, etc. (Williams et al., 2013). Visibility helps companies in acting proactively to risks and reduces costs and waste within the supply chain. Supply chain investments to improve visibility and traceability was seen as one of the main investment areas in 2018 and 2019 (Venkatraman et al., 2021).

One of the leading technologies that provides solutions for enhancing supply chain visibility is blockchain technology. The following section explains how blockchain technology contributes towards supply chain visibility.

3.3.2.1.1 Blockchain Technology

Blockchain is an emerging technology which is a decentralized digital ledger of transactional records or events shared across the involved stakeholders. The authenticity of each record in the blockchain is verified through a consensus of participating stakeholders. The blockchain can be technically defined as a chain formed of information sharing 'blocks' and each such 'block' is a bundle of information consisting of transactional data with date, location, amount and people. This technology also allows access to the history of all the assets stored in 'blocks' linked together in the chain serving as a database (Laaper et al., 2017). Blockchain technology is implementable in various industries like banking and finance (ex. international payments, capital markets, money laundering protection), businesses (ex. supply chain management, healthcare, real estate, energy), Government (ex. identity management, record keeping, taxes, voting) and other industries seeking support in data storage, cyber security, financial accounting (Insider Intelligence, 2020). As per IBM (2020), blockchain technology implementation helps the supply chains in seamless collaboration and coordination across the value chain of suppliers, producers, banks, regulators, logistics providers and retailers. This technology keeps the information regarding the transaction goods like record of price, date, location, quantity, certifications and other to manage supply chains ((Laaper et al., 2017). All this information helps different supply chain functions like sourcing, procurement, manufacturing, logistics and distribution in different ways to proactively mitigate supply chain disruptions (IBM, 2020).

Having highly complex international supply chains, the automotive industry consists of numerous players at different stages. In supply chain management, the blockchain technology helps the sourcing and procurement function in contract management, supplier information management, responsible sourcing of raw material for sustainable purchasing, and with dispute management. Whereas, blockchain helps immensely into logistics by increasing traceability of material, end-to-end visibility at each part level and also helps the logistics service providers in sustainable load optimization (IBM, 2020). It can also support manufacturing functions by providing compliance over outsourced contract manufacturing thereby enhancing an OEM's leadership in responsible manufacturing (Laaper et al., 2017). The leading German automotive conglomerate BMW Group has been one of the few European automotive companies implementing blockchain technology through a project 'PartChain'. This project has helped the company in ensuring seamless and convenient traceability of parts and provides data transparency to all supply chain partners. In purchasing, this project has helped the company to track down critical raw materials from mine to smelters (BMW Group, 2020). While stating

other use cases of blockchain technology, BMW Group exemplified the advantages of blockchain in everyday operations like easier certification, shorter customs procedure, better protection against counterfeit spare parts to name a few (Wilhelm and Müller, 2019). Another blockchain solution, Vinturas, a data sharing platform developed by IBM, helps the customers in getting a clear estimate of delivery of their customized vehicles. Since customization of vehicles is a common trend in Europe for new car buyers, such traceability can help the manufacturers and dealers to ultimately increase the customer satisfaction level (IBM, 2020).

3.3.2.2 Information Sharing

It has become a common understanding that companies need to collaborate and share information with supply chain partners and customers in order to stay competitive in today's global market (Kembro, 2015). The term 'information sharing' has been defined by many and for the purpose of the study, this thesis is adopted to the one definition that is most relevant to the thesis contexts defined by Olorunniwo and Li (2010, p. 455), in which they referred to information sharing as "*The extent to which data is accessible to partner firms through mutually agreed exchange infrastructure*".

Companies that are good at building trusting relationships with supply chain partners will see advantages in mitigating potential risks and discovering opportunities that will be beneficial to the entire chain (Kembro, 2015) Many benefits are proven to be gained from higher levels of information sharing in supply chains by industrial practices. Some of the benefits include but are not excluded to, improvement in the sales and operation planning (S&OP) process, reduction in inventory levels, minimizing the possibility of getting affected by the bullwhip effect and optimization of supply chain resources (Kembro, 2015). Especially in the automotive industry, information sharing of demand-related levels such as sales forecasts, delivery schedules, stock level and trends added significant values to improve suppliers' performance. It is also seen that the majority of the suppliers in the automotive industry have been implementing electronic data interchange (EDI) in their operations planning and control (OPC) processes (Reekers and Smithson, 1996)

Unfortunately, despite the merits of information sharing, existing studies show that information sharing in the automotive industry is limited and, in most cases, it only exists between the OEMs and their most immediate and strategic partners, the tier-1 suppliers (Wang-Mlynek and Foerstl, 2020). However, as the automotive industry is representative to have a multi-tier supply system (Wang-Mlynek and Foerstl, 2020), each node and link in the system bears the possibility of

risks which could cripple other players in the game (Norrman and Jansson, 2004). The automotive industry is a very competitive industry where actors in the supply chains often fight to protect and maintain their own commercial interests and better leveraging positions (Aydin et al., 2010). Companies often refrain from sharing information due to the lack of trust and collaboration or the attempt to seek competitive advantage (Hallikas et al., 2004). Wang-Mlynek and Foerstl (2020) argue that it is essential for companies in the automotive industry to share information across upstream multi-tier suppliers as it is the most effective way to build partnership and trust in the supply chain that drives the implementation of supply chain visibility reducing supply chain uncertainty, and enhance supply resilience.

3.3.2.2.1 Transparency Barriers

It is suggested that the automotive industry should embrace broad communication in the supply chain by adapting to a triangle model where the focal company, its tier-1 suppliers and its tier-2 suppliers each have mutual information sharing (Wang-Mlynek and Foerstl, 2020). However, information sharing beyond a dyadic relationship in the automotive industry is believed by some as nearly impossible. There are many barriers and challenges companies need to overcome in order to implement efficient information sharing across the entire supply chain (Kembro et al., 2017). In the study of barriers of information sharing in multi-tier supply chains carried out by Kembro et al. (2017), the authors defined barriers as factors that are too difficult to solve for enabling effective information sharing across multi-tiers whereas challenges are factors that are possible to solve. For the purpose of this thesis, the team defines barriers and challenges as two interchangeable terms that both words mean factors that are essential to be considered for solutions for companies trying to implement information sharing across their entire supply chains. Six categories of transparency barriers were identified by Kembro et al. (2017) which are information utilization, technology utilization, power structure, culture, business process, and legal aspects. Figure 4 summarizes the six main transparency barriers that exist in today's working environment among supply chains. These barriers need to be addressed or considered in order to achieve information sharing in a multi-tier supply chain. Each of these six barriers are presented in detail in the following sections.


Figure 4: Barriers in Supply Chain Transparency (Kembro et al., 2017)

a) Power structure

Power structure consists of three barriers: dominant players, power asymmetry, and dependencies between companies (Kembro et al., 2017). Companies holding stronger market positions have the ability to influence the behaviors of their supply chain partners due to the inter-dependencies that exist between them. This unbalanced power structure gives one firm the leverage to 'force' other firms into information sharing arrangements which might be considered by less dominant firms as a loss of control and competitive advantage. This fear of losing power and competitive advantage causes the unwillingness to share information which is considered as the most compulsory element to enable information sharing across multi-tier supply chains. Firms that are considered by the market as dominant players, thereby, hold the cards and power to connect the supply network and enforce the initiatives for information sharing beyond immediate tier-1 suppliers (Kembro et al., 2017).

b) Information utilization

As explained by Kembro et al. (2017), the barrier of information utilization consists of elements like forecasting ability, planning competence and information quality. Information sharing from companies that lack forecasting and planning capabilities could send data of poor quality that is not satisfied or might be misinterpreted by the receiving ends, the suppliers who might try to calculate their own results instead of utilizing the information sent by the focal companies. As

the information moves up the chain, data becomes more difficult to be accurately interpreted and aggregated. Upstream suppliers face difficulties to understand data to utilize it without the knowledge of how the data was generated and what was the initial intent for using the data by the senders. Tier-2 suppliers often do not get the opportunity nor have the time to reflect on a regular basis with the focal companies to understand the way in which the received data is to be interpreted. In the meantime, the chances of information getting delayed become bigger. In today's fast changing environment where demand changes hour by hour, speed plays an essential role in information sharing in the multi-tier supply chain. As Kembro et al. (2017) emphasized in his study, there is little or close to none value in delay information for the decision-making process in a complex dynamic supply chain environment.

c) Legal aspects

Confidential information, legal framework, and intellectual property rights compose the last barrier category, legal aspects (Kembro et al., 2017). Most companies consider the risk of leaking confidential information as the most challenging barrier to address to achieve information sharing across multiple tiers. Not only companies worry that the confidential information they share up the chain will be leaked or taken advantage of by other companies to gain negotiation leverages, they also worry that they will be seen as potential leaks or risks by their customers as they will by passing customer information to other companies as well. Thereby, a legal framework consisting of specifications on what information to be shared, how the information should be interpreted, utilized, stored and treated; and with which companies to be involved, is recommended by Kembro et al. (2017). Such a framework will help to govern and get an overview of the implementation of information sharing and prevent violation of intellectual property rights or information leakages.

d) Culture

The culture category comprises the elements of trust, cultural differences, and partnerships. Kembro et al. (2017) defined culture under this particular research context as *"business relationships and the attitude and willingness toward collaborating and sharing information with supply chain partners"*. Firms perceive strong relationships and trust with a partner will have higher willingness to disclose high value information and make the efforts to collaborate in the process of interpreting data and factoring them into the decision making. While on the other hand, the lack of such culture will produce fear for opportunistic behaviour that compromises the firms' willingness towards information sharing. This case becomes stronger

as the number of involved actors in the information flow increases. It is more difficult and resource heavy to build and maintain trust and partnerships as the higher up the chain, the less direct links exist between two actors (Kembro et al., 2017).

e) Technology utilization

The next barrier category, technology utilization includes five challenges in information sharing in multi-tier supply chains which are implementation costs, linked IT systems and common platforms, IT-maturity, standardized terminology, and standardized format for data exchange (Kembro et al., 2017). As per the authors, technology utilization is defined as the means used by companies to send, receive and interpret supply chain related information. There are many service providers and potential solutions of information technology in the market. Working systems and formats exist that could potentially address information sharing in multi-tier supply chains. However, the automotive industry is a dynamic sector where numerous links and nodes are connected and are standardized to achieve information sharing at an ideal state. Connecting such a dynamic and complex network with suppliers across multiple layers remains a challenging and costly task.

f) Business process

Business process is a result of amalgamation of linked business processes, benefit-sharing and risk-sharing model, common goal, and common performance measures as per Kembro et al. (2017). To connect firms from different tiers, firms need to have a common goal which is worth working towards. There also needs to be standardized automated working processes for the exchange of information instead of communicating through some sort of intermediate, in this study context, the tier-1 suppliers. Moreover, as information sharing is an important strategy to improve the overall competitiveness of a supply chain, sometimes involved firms have a hard time recognizing the return on the investments made in this regard at the corporate level. Also, due to the complex nature of this task, companies also face uncertainty in measuring potential risks in order to quantify the magnitude of trade-offs in the decision-making process. Thereby, companies that are initiating the implementation of information sharing across multi-tier supply chains need to make sure the involved parties have a clear understanding of the potential risks as well as visualizing the benefits for each partner based on their KPIs to reduce the fear of uncertainty and increase the confidence of engagement.

3.3.2.2.2 The Level of Information Sharing

As the higher up in the supply chain, effective information sharing becomes more difficult to achieve. Previous research showed that not all supply chains are suitable for the strategy to increase supply chain transparency. Some examples of such unfavorable supply chain settings are low complexity of products and low demand uncertainty. Due to low complexity of these supply chain structures, information sharing is recommended to be maintained at a lower level to allow effective decision making and lower costs (Kembro, 2015). Table 4 suggested the favorable supply chain contexts taking the two perspectives of product & market and supply chain types for adapting to more transparency so that the claimed benefits of information sharing are applicable.

Kembro (2015) summarized in his doctoral paper based on previous research that the favorable settings for increasing transparency include high product complexity, high market uncertainty, agile and fast changing environments and high structural complexity of supply chains. In these settings, multi-tier information sharing helps reduce lead times and allows efficient decision

Aspect	Favorable Context
Product & Market	Introduction stage in product life cycle
	Short product life cycle
	High product complexity
	Short time to market
	High demand variability and uncertainty
Supply Chain	Agile supply chain strategy
	High structural complexity of supply chain
	Many partner companies
	Collaborative type of relationships

Table 4: Favorable Contexts for Multi-tier Information Sharing (Kembro, 2015)

making in response to uncertainty. With the favorable supply chain settings being identified, it is important to consider the aspect of what information to share with whom Kembro (2015) categorized the level of information sharing a company could communicate in its supply chain as the operational level, the tactical level and the strategic level. Table 5 below provides a summary on the information sharing levels with respect to the data types and claimed benefits. Information sharing on the operational level includes order information and sales data.

Information sharing on the tactical level includes monthly and quarterly forecasts, plans and business trends. Information sharing on the strategic level includes yearly demand plans, sales promotion and marketing strategies.

Information Sharing Level	Information Sharing Types	Claimed Benefits
Operational Level	Order information and sales data	Facilitate orders and reduce information distortion and stock levels.
Tactical Level	Monthly and quarterly forecasts, plans and trends	Help the upstream partner to reserve adequate capacities for production and logistics.
Strategic Level	Yearly demand plans, sales promotion and marketing strategies.	Help firms to plan future purchases and growth within the alliance.

Table 5: Level of Information Sharing and the Claimed Benefits (Kembro, 2015)

In addition to the classification of the level of information sharing, it is important to consider the intensity level of interdependence with supply chain partners in order to understand the extent of information to share with whom (Kembro and Selviaridis, 2015). Intensity of interdependence is defined by the strategic importance of the relationships between two supply chain partners. Factors such as percentage of each other's portfolios in terms of volume and value, rareness of potential buyers and suppliers, switching costs, and uniqueness in offerings represents the level of interdependence between two companies influence the intensity level of interdependence. They are also being considered by previous research as important factors influencing the level of information sharing among supply chains. A high percentage of the above-mentioned factors also indicates high intensity level of interdependence (Kembro, 2015; Kembro and Selviaridis, 2015). On the other hand, demand uncertainty represents the possibility to foresee future demand. Some examples of high uncertainty of demand are quick production changes due to campaigns, promotions, seasonality or new product development (Kembro and Selviaridis, 2015).

Figure 5 based on the level of intensity and demand uncertainty was therefore established to help understand the suggested level of information sharing with key supply chain partners. In a case where strong interdependence exists, the emphasis is placed on intensive exchange of strategic and operational information (Kembro and Selviaridis, 2015). The framework suggests

that it is important to match the information sharing level according to the intensity of interdependence and the uncertainty of demand.



Demand Uncertainty

Figure 5: Framework for Identifying the Level of Information Sharing with Key Partners (adapted from Kembro and Selviaridis, 2015)

The SCRM framework by Kilubi (2016), see figure 2, is used to categorise the interviewed five companies into the four supply chain types as per the supply and demand risks in ante and post disruption state. The categorisation of the five companies into different supply chain types provides the base for recommended reactive and proactive SCRM strategies and answers RQ (1b). Supply chain transparency of OEM AB is mapped using the model developed by Bateman and Bonnani (2019), see figure 3, to determine the transparency level of the OEM's supply chain with the given matrices which helps the analysis to answer RQ 2a. Kembro et al.'s (2017) framework of the transparency barriers, see figure 4, is used to categorize the specific barriers existing in the OEM's multi-tier supply chains. This is to help with the analysis to answer RQ 2b. Lastly, to answer RQ 2c, the framework for identifying the level of information sharing with key partners adapted from Kembro and Selviaridis (2015), see figure 5, is used to provide recommendations on the level of information sharing the OEM should have with key supply chain partners.

4. Covid-19 Impacts on EU Automotive Sector

The Covid-19 disease is caused by the newly identified coronavirus which was first noticed in the Wuhan city of China on 31st December 2019 (Kilpatrick and Barter, 2020). The infections which were more prevalent in China in January 2020 started to spread in Europe after a few weeks (Pató and Herczeg, 2020). This disease was declared as a pandemic on 11th of March 2020 by the World Health Organization with cases getting reported from new countries every day and a record number of infected cases from already reported countries. This highly infectious viral disease shows a high number of fatalities. As of May 2021, 153 million people were affected and over 3.2 million deaths reported with Europe being one of the worst hit regions (WHO, 2021). Many industries including automotive, electronics, consumer goods, pharmaceutical, medical equipment and others have been significantly affected by this pandemic around the world (Betti and Ni, 2020). In the following section, the impacts of Covid-19 on the European Automotive Industry specifically are presented to get a detailed view on the industry.

4.1 Overview on the Impacts

The EU Automotive industry accounts for 5% i.e. 675 billion Euros of the total value-adding activities in the EU economy which generates various business activities (European Commission, 2020a). The automotive manufacturing itself provides 14 million jobs in Europe and the turnover of around 7% of EU's GDP, which underlies the importance of the automotive sector in the EU's economy (Schmidt et al., 2020). Due to the highly contagiousness, the Covid-19 pandemic imposed lockdowns in various parts of Europe and the rest of the world which severely affected European automotive industries and its supply chains.

The impacts of Covid-19 on the European automotive industry are divided into 'direct impacts' and 'indirect impacts' for a clear presentation in this report. The immediate impacts on the European automotive industry are referred to as 'direct impacts' which started to appear in the beginning of the year 2020. While, in the later part, the indirect impacts are presented which eventually occurred later in time after the direct impact has been experienced. The overview of the direct and indirect impacts of Covid-19 on the EU automotive industry are summarized in the figure 6.



Figure 6: An overview of Covid-19 impacts on the EU Automotive Industry

The following section describes in detail each of the direct and indirect impacts as per figure 6 faced by the companies in the EU automotive industry. However, the impacts explained in the following sections are the most general impacts experienced by the European automotive industry and are not exhaustive.

4.1.1 Direct Impacts

Direct impacts presented in this section are the overall impacts commonly seen in the whole European automotive industry to understand the Covid-19 impacts in a broad view. To understand the direct impacts in a structured way, the impacts are categorized under titles as Government interventions, layoffs, supply disruptions, demand disruptions, transportation disruptions, production stops and layoffs. Such categorization allows visualization of a clearer picture of the interconnected issues occurring in the automotive supply chains due to the Covid-19 pandemic.

1. Government Restrictions

After the declaration of Covid-19 as a pandemic, the affected countries' national and local governments interpreted the guidelines given by WHO differently depending upon the severity and the number of the cases in their region. In March 2020, Italy reported the second largest number of confirmed cases after China and became the first country in the world to impose gradual nationwide lockdown (Wikipedia, 2021). The spread is possible to limit by avoiding human contact and maintaining social distance (Pató and Herczeg, 2020). No sooner had every

other European country confirmed Covid-19 cases, than nation-wide lockdowns were declared. Lockdowns involved mandatory quarantines, recommendations to stay home, closure of businesses and markets, ban on social gatherings to limit the increasing number of infections (McFall-Johnsen, 2020). There were restrictions on people for unnecessary travel and in several countries in the world, people were forced to work from home. However, countries like Sweden did not institutionalize lockdown and recommended the people to follow safety precautions and maintain social distancing (McFall-Johnsen, 2020). The European supply chains were affected by countermeasures taken by Governments against the spread of Covid-19 like increased health and safety regulations of the people like mandatory RT-PCR testing, quarantine rules, various international/national sea and land border crossing restrictions (Schmidt et al., 2020).

2. Supply disruptions

As a primary producer of high value products and components, 'the world's factory' China puts global supply chains at risk in case of any major supply chain disruption (Kilpatrick and Barter, 2020). The Covid-19 outbreak coincided with the Chinese New Year when major industries and markets were on a long vacation, which expedited the continued shutdown and extended closure measures taken by the Government in reaction to the pandemic (Kilpatrick and Barter, 2020). The automotive industry was heavily impacted from the limited material supply from the Chinese suppliers due to the first shutdowns of Chinese factories (Schmidt et al., 2020). Later, as Covid-19 hit European countries, a similar situation was seen in European suppliers. The domino effect of plant closures and supply shortages across the multi-tier supply chains lead to supply disruptions in European industries (Kilpatrick and Barter, 2020). The travel restrictions and lockdowns in several countries stopped the manufacturing units of direct and indirect suppliers, leading to high and uncertain supply disruptions of many parts to the automotive industries. The automotive industry in general operates on the basis of just-in-time and thus relies upon timely and uninterrupted supply of material and components (Uetz, 2021). In addition to 'just-in-time', the automotive companies have global networks to leverage from low-cost labor and lean inventory to minimize working capital, all of which acted as the main reasons behind the industry's supply disruptions and vulnerability (Schmidt et al., 2020).

3. Demand disruptions

In the beginning of the pandemic in March 2020, the demand of the automotive sector declined due to increasing travel restrictions and regulations from several Government bodies. It is also suspected that people and businesses were hesitant to make new purchase of automotive and were in a 'wait and watch' situation during the first half of 2020 during these difficult and uncertain times (Gazdik, 2020). All of these reasons reduced the demand of automotive towards the onset of Covid-19 pandemic (Hammerschmidt, 2020). The number of passenger car registrations in the year 2020 has been continuously below compared to the year 2019. The registrations in April 2020 were the lowest at -76.3% than those in April 2019 stating the lowest demand seen in the month of April. According to many OEMs, the customer demand is still lower than the pre-crisis level with frequent and unanticipated ups and downs in the demand patterns (ACEA, 2020a).

4. Transportation disruptions

As explained in the previous sections, there exists a high amount of material supply from Asia to Europe supplying to different automotive companies and parts manufacturing industries. This supply is majorly transported through sea shipments. As several Asian countries went on complete lockdown due to Covid-19, the ports also stopped their operations leading to stoppage of sea shipments through ships (Supply Chain Brain, 2020). With people staying in their homes for most of the time in the year 2020, the consumption and shopping patterns were changed and a surge in demand for home electronics and manufactured consumer goods was observed. A large amount of these consumer goods is shipped in containers in ocean freight (UNCTAD, 2020).

Containers are considered as essential equipment for global trade since they help in efficiently handling large volumes of consumer goods, manufacturing parts and other such material across the global long supply chains (Berger, 2021). As the restrictions were eased, several businesses started stocking up the goods to prepare themselves for erratic customer demand patterns in the market as they came across the news of the second/third wave of the pandemic which again increased the global movement of containers. Thus, such excessive movement of containers disturbed the capacity planning of the carriers and led to shortage of containers worldwide (UNCTAD, 2020). Once these containers are unloaded, the companies have to bear the cost of return of empty cargo mainly to Asia.

The rates of shipping containers have increased which are six times more than the rate in the start of 2019 for shipping a container from China to Europe (Remes and Saxon, 2021). The high imbalance between supply-demand for containers and such added costs for return cargo are considered as one of the reasons for the surge in sea freight prices (Northam, 2021). Traditionally, air freight was a reliable mode of rush transports in case of emergency

requirements (Supply Chain Brain, 2020). However, the restricted air movements limited the number of passenger flights and reduced the amount of available cargo space (Supply Chain Brain, 2020). Overall, the logistics industry was impacted with increased transportation times, soared freight rates, restricted movements and such impacts; all of which resulted in delayed deliveries towards the automotive industries.

5. Production Stops

Though the next wave of the pandemic is still anticipated while writing this report, most of the supply chains were disrupted especially in the beginning of the crisis in March-April 2020 which coincided with the period when the overall EU manufacturing industry experienced a sharp decrease in the production (Maarten, 2021). Besides, with the rapid spread of Covid-19 during the first half of the year 2020, the automotive manufacturing sector had to take several precautionary measures to safeguard its employees (Pató and Herczeg 2020). The automotive OEMs' direct and indirect suppliers were also struggling to survive in the pandemic and have suspended their production due to some major reasons like employees' sickness, longer lead times, transportation issues and raw material shortage (Schmidt et al., 2020). Such reasons pointed the major automotive companies in Europe towards eventually shutting down their production lines.

Few companies stated the shutdowns for two weeks while few said it would last for 'indefinite period'. Porsche, BMW suspended the suspension of production in its European plants as well as in its factory in South Africa while Daimler temporarily stopped its production of passenger and commercial vehicles for a certain period. Similarly, Volkswagen shut down its plants in Germany, Portugal, Slovakia and Spain initially for two weeks along with its subsidiary Seat in Spain. Toyota also suspended the car production in Europe for an indefinite period of time whereas Ford also suspended its production paints in Germany, Romania and Spain for a few weeks. Few other European automotive manufacturers who followed the teens are PSA Group, Nissan Jaguar Land Rover (Hammerschmidt, 2020).

On an average the EU automotive factories were closed for an average of 30 days where the factories in Sweden had the shortest downtime of 15 days and those in Italy had the longest downtime of 41 days (ACEA, 2020c). The total production loss due to Covid-19 amounts to more than 4.2 million vehicles consisting of segments like passenger cars, trucks, vans and buses. The amount of production loss in terms of vehicles produced equaled 22.9% of total EU

vehicle production in 2019. The major reasons for production loss are factory shutdowns and lesser production volumes than pre-crisis level (ACEA, 2020c).

6. Layoffs

Out of 2.6 million jobs in direct automotive manufacturing, the Covid-19 pandemic affected more than 1.1 million jobs due to the shutdown of factories from March to May 2020 (ACEA, 2020b). The decline in demand and reduced production levels in the manufacturing plants forced the automotive OEMs, car dealers and other automotive parts manufacturers to reduce the costs and the resources after the shutdown of almost two months. However, the impact of Covid-19 on industries dependent on automotive manufacturers is even more critical. After the restarting of plants in the second half of May 2020, layoffs of the employees were a commonly seen impact of Covid-19 in such companies (EIU, 2020). Swedish commercial vehicle OEM Scania, a part of Germany's Volkswagen Group, also declared 5000 job cuts which accounts for 10% of their global workforce due to a 41% drop in vehicle deliveries in the first half of 2020 (The Local 2020). Stating the negative economic impact of Covid-19 in many markets, the Volvo Group declared the reduction of 4100 white-collar workforce during the second half of 2020 (Volvo AB Press release, 2020). Anticipating the impacts of Covid-19 impact to last beyond the year 2022, the German auto-parts maker, ZF also revealed to cut 15000 jobs which is 10% of its workforce by the year 2025 due to achievement of lower sales targets (EIU, 2020). However, various European Government's financial support packages to the companies and employees reduced the staff reductions (Volvo AB Press release, 2020).

4.1.2 Indirect Impacts

After the description of the direct impacts of Covid-19 on the European automotive industry, this section describes the indirect impacts of Covid-19. The indirect impacts are the impacts which have slowly evolved after the direct impacts have begun to appear from early 2020 and are affecting different supply chain actors in the automotive industry. Like direct impacts, the indirect impacts are also categorized and explained below.

1. Semiconductor Crisis

As one of the most serious indirect effects of the experience of the Covid-19 pandemic, experts predict that the global semiconductor shortage will have a long-lasting negative impact on the automotive industry due to the complicated nature of the event. Some said that this chip

shortage could possibly last for three to four years which may ultimately change the ways that cars are produced at a global scale (Schmidt, 2021). According to the estimation made by Goldman Sachs, around 170 industries were and still are disrupted by the shortage. Long lead times for semiconductor chips which have stretched out to 6-12 months causes a ripple effect on the automotive industry (Schmidt, 2021). Being a complex supply chain, the automotive manufacturing industry can be affected adversely with absence of just one missing part to shut down the production line and can have damaging ripple effects quickly spreading throughout the entire supply chain (Uetz, 2021). To understand how this crisis unfolded and look into potential recovery strategies, one has to first go back to the origin of the series of events leading to this point.

Starting at the end of 2020, the world's manufacturers suddenly found themselves short of semiconductor chips supply. Automotive sales in the EU market drop for nearly 80 percent (Ondrej et al., 2021). At first, all spendings from the consumer side sunk to the bottom as people faced great uncertainty of the unprecedented Covid-19 outbreak. Millions of workers were sent home to wait for further instructions (Rivero, 2021) hence the rapid decrease in demand for transportation and the drop in auto sales. Quite a few semiconductor suppliers also temporarily closed down in response to the sudden outbreak. It was around the same time when demand for home appliances and electronic devices surged unexpectedly to the roof as people got ready to set up their home offices under the instructions of Government regulations and company policies. The limited number of suppliers of semiconductors soon received huge piles of orders from giants of consumer electronics like Apple, IBM and Microsoft (Rivero, 2021). The automotive industry missed the window to increase orders for semiconductors and secure the supply. When the demand for transportation recovered much faster than initially predicted, major suppliers of chips already reserved most capacities to ensure the demands of those who placed orders first and usually paid with higher prices were met (Ondrej et al., 2021).

Specifically on the EU automotive industry, automotive sales remain fluctuating in the year of 2021. The rate of the inability to meet demands for the sector in the EU just hit a record high of 23% in September 2021 since the year 1995. Automotive brands in the Asian market are doing relatively better as they have the geographical as well as cultural advantages to maintain deeper relationships with semiconductors manufacturers in the region. European automotive manufacturers such as Volkswagen, BMW and Renault are warned by regional automotive associations that reliance on the supply of semiconductors from Asia must be reduced. Leaders of EU car-makers have called for the establishment and development of local semiconductors

manufacturing facilities preferably in France and Germany as it would greatly ease the shortage for OEMs in the EU region (Campbell et al., 2021). Many automotive companies have plans to stock up inventories or establish their own production lines to secure volumes of important parts such as batteries. One example is Volkswagen who announced their plans to build 6 production sites in the EU. Others, such as Tesla, established new processes to allow the company to quickly switch to other suppliers or find substituted parts in sights of potential shortages (Freedonia Report, 2021). Moreover, due to the continuing semiconductor shortage, Ford closed down its factory in Turkey which manufactures transits over the summer and their production of the Fiesta has been stalled from May to mid-July this year. Mercedes-Benz also announced that they had to reduce the production of some models in an effort to reduce delays on delivery schedules (Warrick, 2021). All measures taken emphasize the importance of having flexibility is key for a resilient supply chain (Freedonia Report, 2021).

2. Commodity Price Fluctuations

As the global markets gradually recover around the world in 2021, prices of certain industrial commodities have also soared to the sky. Prices for industrial steels, for example, have reached record high in 2021. There are several reasons for the increased prices for steels. Many mining production sites were shut down during the first wave of Covid-19. Then freight rates were increased due to port congestion in such as the China Yuanjiang Port, quarantine restrictions, export difficulties and the increase in fuel prices (Stuermer and Valckx, 2021). The price rise in steels and metals are expected to raise a series of challenges for automotive OEMs as predicted by industrial experts. At the beginning of 2022, many auto OEMs will go into a new round of negotiation with suppliers of steel and metals which will very likely set the average price range for the industry. Therefore, the pressure is on. Different negotiation methods are known to be taken by suppliers. For instance, some OEMs were given only two weeks to sign the contracts and the other option is to take the risk of having no supply for the materials. Ford stated earlier this year that this dramatic rise in raw materials' prices will cost the automaker an additional \$2.5 billion (Reisman and Hauser, 2021).

3. Demand Uncertainty and Consumer Behaviour

During the pandemic, the automotive industry took the hardest hit on sales. The EU market dropped 80% in the first two months of the Covid-19 outbreak which is the most severely impacted market compared to 71% in China and 47% in the US. But the market bounced back

quicker than expected. OEMs around the world have received record sales and rapid surge in production level from the third quarter of 2020 through the first quarter of 2021 (Russell et al., 2021). Meanwhile, the world is seeing high-end vehicle sales are affected by the global semiconductor shortage (McCall, 2021). Before the pandemic, most automotive sales were made through onsite dealerships where customers could see the actual models and maybe take the car out for a test drive. During Covid-19, dealerships around the world had to close down the shop floors to meet the restricted regulations such as social distancing or no gathering over four people. It was when people discovered the value of digitalization and online auto shops like never before (Russell et al., 2021). As per Furcher et al. (2021), the intent to buy new and used cars in 2021 is almost back to pre-Covid-19 levels. In the EU, consumers display strong inclined intent to buy electric vehicles as it is encouraged by the Government subsidies for the sustainability initiatives. The automotive sector has now entered the 'new normal' phase and full recovery is within perspective. However, demands remain fluctuating and auto companies still face great uncertainty in the sales and production planning processes (Furcher et al., 2021).

The pandemic has also brought a change in automotive customer behavior where customers are now having different mobility preferences and online shopping which are expected to stay even after the crisis (Schmidt et al., 2020). It is also argued that the pandemic has given an opportunity to the consumers to reassess their needs and accelerated the environmental sustainability and digitalisation in automotive businesses. Despite the demand for new vehicles having declined during the pandemic in 2020, it is observed that the demand of electric vehicles has not been severely impacted by the pandemic (Maarten, 2021). The strategic importance of value chains of microelectronics, autonomous driving, batteries, and artificial intelligence has also been increased in the journey towards digital transformation and electromobility (Maarten, 2021). Even before the Covid-19 pandemic the automotive industry was undergoing a transformational journey towards changing customer demands and sustainability initiatives. With the pandemic, the automotive industry is even more heading towards finding new solutions towards disruptions in areas of connected, autonomous, shared and electric mobility, consumer behavior and production facilities (Furcher et al., 2021).

Reports have said that the biggest automotive markets, Spain, Italy and France, declined 20% in September this year on average compared to 2019 in terms of new car registrations. Some argue that this decline is caused by the chip shortages which prevent the recovery of production rate in the EU automotive market. Lead time for delivery remains to be very long which understandably, keeps a certain number of sales out the door (Autovista 24, 2021). To take a

separate look, market analysts have made comparisons of the sales data in 2019 and 2021 in the three markets to try to get a sense of the real market trends in the EU automotive industry. In France, compared to 2019 before Covid-19, by October 2021, the automotive market dropped by around 23%. Other than the pandemic and chip shortages, the incentives for building electrically-chargeable cars reduced in France as well which have worsened the decline in auto sales and impacted the auto market demand. The same data for Italy is around 26% (Autovista 24, 2021). However, the Italian government just announced their plans to refinance the Ecobonus incentives for 2022, which is the incentive for customers to buy new, more environmentally friendly cars, and it might addition, affect the market demand (Italy24News, 2021). In Spain, compared to 2019, the market contracted by around 27%. The Spanish government reduced the purchase taxes in June 2021 for new car registration in the efforts to increase demand which was negatively impacted by the global semiconductor shortage. Positive results have shown but it will still take longer to rebalance the demand of the automotive market in the EU.

4. Emerging Players

The Covid-19 pandemic brought in severe supply risks to the whole automotive industry. Most of the OEMs are suffering from supply risks and rely on a handful of giant suppliers like Bosch, Continental, ZF for important components. Semiconductor manufacturing companies like Infineon Technologies, NXP, Samsung are also in huge demand by such OEMs due to the semiconductor crisis. This supply demand imbalance for many key components has given the supply-side a bigger say and many emerging players are taking over the game. These emerging players are driving the inflation in the automotive industry stating raw material costs and longer production cycles (Kung and Jun, 2021).

The summary of the Covid-19 impacts on the EU automotive industry as per figure 6 is used to understand the impacts specifically on the OEM AB's multi-tier supply chain in the next chapter. It also points out the common impacts on the five interviewed companies along with some supply chain impacts faced by some companies exclusively contributing to the answering of RQ 1a.

5. Empirical Findings - OEM and its Suppliers

In this section, information collected from primary data by conducting seven interviews with the five selected companies are presented. Key findings from the interviews with the OEM, A1, A2, B1 and B2 are presented in four sections, beginning with introduction of the interviewed companies, followed by Covid-19 impacts, the SCRM methods generally deployed by these companies during the crisis and in general and their unique perspectives on the importance of supply chain transparency as a SCRM.

5.1 OEM AB

OEM AB, is one of the biggest original equipment manufacturers in the world manufacturing commercial vehicles. OEM AB's purchasing department purchases automotive products, parts and the aftermarket for all the brands under OEM AB. With over 200 BSEK in purchasing power, OEM AB manages around thousands of suppliers in tier-1 alone. OEM AB experienced massive disruptions when Covid-19 first strike as no contingency plans have been established to deal with such a unique event. However, OEM AB soon realized that they have quite a proactive and reactive risk management system which allowed them to quickly recover from the initial shocks and start dealing with the situation effectively.

5.1.1 Covid-19 Impacts

In the beginning of 2020, OEM AB sensed the movements happening in Asia regarding Covid-19. Later the company started to know about its many suppliers who are located in Asia started getting affected from the Covid-19 disruptions. In March 2020, when the affected people by Covid-19 started to peak in Italy, it was an alarming situation for OEM AB's production. As countries like Italy and Spain were one of the worst hit areas in the EU with government lockdowns, quarantine rules and enormous Covid-19 tests being carried out, the company started experiencing immediate impact from the large supplier base situated in these regions. The OEM faced and is still facing longer lead times than usual due to the pandemic due to various reasons. One of the reasons is insufficient logistics infrastructure faced by the freight forwarders due to shortage of containers. The other reason is due to the shortage in various raw materials faced by the suppliers and their sub-suppliers. The rush transport by air has increased tremendously which has put a financial burden on the company. The shortage of parts that are to be used in production plants leads to replanning for the production. Certain parts which are unavailable at the moment are replaced by other substitutable parts. So, this required the company to do a lot of replanning to strategically decide upon the sequence of the production and achieve the delivery targets towards its customers. The demands were very low in the first half of 2020 due to overall decrease in movements in the world. Later, the demand gradually increased in 2020 and thus required re-planning of the delivery schedules with the suppliers. The demand uncertainty thus requires resources to be utilized for joint planning and coordination with the suppliers.

There have been even more severe issues regarding material flow from suppliers located in the United Kingdom. Before Covid-19, trades between the UK suppliers had been affected due to Brexit. With Covid-19, there have been even more obstructions for successful flow of goods with increased travel restrictions from the UK Government. There has been a shortage of drivers along with trucks for transport flow between the UK and the other EU countries. The majority of drivers working in transport companies performing international goods transport with the UK belong to the European Union. These drivers had to face strict quarantine rules and travel restrictions to transport the goods. So, the set of rules and regulations varied a lot with different countries as per the severity of Covid-19 and other local issues in those areas.

The company is also impacted by various issues like increased workload mainly due to sickness, several follow-up meetings and structuring of various emergency routines and contingency plans. The white-collar employees were recommended to work from home and thus the company had to adapt to a different working culture. It also had to dedicate workforce to several initiatives created by Covid-19 towards their mitigation like Covid-19 task force, semiconductor task force, follow-up of critical and risk suppliers and meetings of the management with supplier's management. The daily workload of meetings with different internal and external stakeholders involved in each risk raw material have increased heavily. The follow-up meetings with suppliers, supplier management have become a routine activity for the responsible teams at the company.

5.1.2 SCRM Methods

The Covid-19 impacts faced by the OEM as explained in the above section has made many changes in the existing supply chain risk management methods of the company. The cross functional collaboration has been on the agenda for departments to be involved in procurement, production and logistics. The supply chain coordination meeting is one of such cross functional

meetings which involves people from procurement, production logistics, packaging, sales and operational planning, and process management. This was mainly introduced to facilitate information sharing, breaking inter organizational silos and provide solutions to daily problems faced by different teams in Covid-19. The company does the classification of risks as per the root cause of the disruption. This has been a historical approach followed by the company to identify the type of risks and they try to divide the impact evenly on the production plans in case of a risk like material shortage. Besides, the risk suppliers impacting the production the most are reviewed frequently. Various tools and techniques are used to measure the impact of deliveries deviated from the planned schedules due to shortage of raw material, increase in lead times and capacity issues. One of the ways of measuring impact on the production facilities is measured in terms of deviation in the number of manufactured trucks which are incomplete due to certain issues than the planned production. The other way categories the part numbers into three levels called primary, secondary and tertiary level. These levels define the severity to which the unavailability of the part will impact the production. Primary level being the less critical part, secondary level belongs to medium critical part and tertiary level defines the parts without which the production will be completely stopped.

When the company started to anticipate Covid-19 impacts on specific suppliers, the company communicated with the suppliers through different ways. The company uses a common EDI (electronic data interchange) platform for the daily exchange of delivery schedules, lead time, transport time, minimum order quantity and also past, present and future delivery schedule with all of its suppliers. So, the company provides real-time information sharing regarding the status of material flow using the EDI technology. The supplier portal is a common platform used by the company with majorly their tier-1 suppliers. During Covid-19, all the necessary information regarding local lockdown, travel restrictions, quarantine rules, etc. was interchanged through this portal. The company conducted a survey through the supplier portal platform so as to get a picture of the impact by each supplier. The company expected its suppliers to have communication in a timely and orderly fashion regarding all sorts of anticipated risks. The procurement management carried out regular meetings with disputed suppliers who were not keeping up with the delivery promises. Similarly, the management helped them to prioritize the production and decide upon the shipments to be sent as per the changes happening in the production planning. The relationships with the existing suppliers were maintained by understanding the problems faced by these suppliers and providing them solutions by a dedicated team of supplier relationship managers. The company follows a structured way for supplier relationship management (SRM). The company follows a five-step escalation ladder. The procurement department escalates the suppliers who are not delivering as per the contracts to the SRM. In the pandemic, several suppliers who impacted the company's performance were involved in extensive discussions and follow-ups by SRM. The supply relationship managers are involved in daily follow-up meetings with internal stakeholders to update the status of the critical suppliers. The supplier relationship management has dedicated supplier relationship managers who conduct regular meetings with the selected high-volume suppliers having a significant impact on the production.

A dedicated Covid-19 task force was formed to address different issues raised by Covid-19 and implement the mitigation action plans. This task force involves cross functional team members to discuss and regularly follow up on issues affecting the production facilities all over the world. The semiconductor crisis in the year 2021 which was an indirect effect of Covid-19 also affected the production facilities. This task force also worked in a similar way as Covid-19 task force except that it focused on only 440 part numbers which involve the semiconductors.

The company has also started a project in the year 2020 towards achievement of full supply chain visibility by the year 2040 as one of their initiatives towards proactive supply chain risk management strategy. This project works towards full visibility of suppliers' tier-N information, subcomponents origin, capacity, sustainability and equal information sharing to all the stakeholders involved. This project involves advanced digital systems to create alerts on issues like capacity, rules, sustainability, predictive maintenance and digital twin to run simulations.

5.1.3 Views on Transparency

Similar to many international OEMs, OEM AB rarely manages suppliers beyond tier-1 suppliers due to the complexity of its supply chains and the enormous global supply network. In general, OEM AB utilizes the strong relationships they have with the tier-1 suppliers to monitor and manage the tier-2 suppliers. For some tier-2 suppliers that supply OEM AB with essential and strategically important parts such as semiconductors or electronics, direct communications are encouraged to make sure that the tier-1 suppliers have access to these components when a crisis occurs. This suggests that both direct and indirect MTSCM approaches exist in the company.

Supply chain transparency is viewed overall as an important SCRM approach at OEM AB in the improvement process to enhance supply chain resilience and prevent future disruptions. Supply chain transparency could mean different things for different people in different positions. During the process of data collection, two different types of transparency were discussed during the interviews. One being the supply chain visibility and the other one is the information sharing between supply chain partners and the OEM. Supply chain visibility is the knowledge of what are the subcomponents of a risk product, who are the sub-suppliers and where are they located according to the OEM AB team. The company representatives believe that the best way to address the lack of visibility is by mapping out the entire supply network all the way up to tier-N suppliers with the help of IT solutions and technology development. They defined information sharing as all communication made between suppliers and the OEM through formal and informal forms.

From a risk management point of view, it is very difficult to understand and mitigate supply chain risks without visibility according to the company. Having full visibility on the supply chain allows the ability to anticipate supply chain risks in certain regions before actual disruptions. Proactive measures could be done by, for example, securing safety production or booking extra volumes from suppliers before everyone else starts fighting for resources. The company representatives emphasized that having the knowledge of suppliers up to tier-N also enables the sharing of responsibilities which is especially beneficial in risk situations. With respect to information sharing, according to the OEM, other than that it will help in reacting to crises faster, being transparent actually poses more merits on the suppliers' side than on OEM AB due to the way the SCRM system is set up at the company. If a supplier informs OEM AB about shortages or a potential risk proactively, the crisis will be handled at a lower level meaning that the supplier will be escalated a lot later than a supplier with poor communication in the company's risk management system which means less pressure being applied by OEM AB on a transparent supplier. With a lot of leverage in the industry, OEM AB intends to help suppliers of high transparency in crisis situations by, for example, providing deviation approvals to quickly mitigate the shortages, changing specifications or pushing for better transportation options.

1. Barriers

In order to increase supply chain transparency, OEM AB believes that there are certain barriers that must be overcome. The barrier that raises the most concerns is the suppliers' unwillingness

to share information about their supply chains. This includes full disclosure on the supply chain visibility and active communication with OEM AB of the potential supply chain risks. The lack of trust is believed to be due to the belief that OEM AB will take advantage of the knowledge if full supply chain visibility is revealed and that the suppliers want to protect their commercial interests. It is known that suppliers that perform value-added works to the products before they sell them to OEM AB, are more willing to disclose information on their supply chains because it is less likely for OEM AB to utilize that information to diminish their business. Additional costs is another reason that suppliers are reluctant to share information. This goes hand in hand with the lack of IT setups and standardized processes. With the lack of common tools and established processes for suppliers to share information about their sub-components and subsuppliers, it takes many resources for them to acquire information from their sub-suppliers and feed them to OEM AB without knowing exactly what information is required and what is not. There are certain templates in place right now for suppliers to fill in sub-supplier information. However, without standardization, information is easily lost in every step in the process and the quality of data is challenged. Information packages that can be shared indiscriminately through the entire supply chain are essential for the company to realize the level of transparency that enhances supply chain resilience and prevents future disruptions. Lastly, considering the global size of business OEM AB has established over the years, the company believes that it is important to consider not only centralized information exchange processes but also locally suited processes. When OEM AB purchases a factory in a foreign country, not only has it established local presence to the customers, OEM AB also inherits the entire supply chain in that region hence information from the suppliers about their sub-suppliers according to the legal frameworks in that culture is also important to be understood. When Covid-19 first striked, OEM AB's employees faced great unknown both internally and externally. The only means for people to get information was through the so-called 'telephone chains' according to the senior buyer. After the initial stage of the experience, it was convinced that common service solutions and virtual working processes are urgently to be developed with supply chain partners that will allow people to share on time information freely and safely from the comfort of their home in the face of crisis.

2. Information Sharing Level

Even though it is a common acknowledgement at OEM AB that Covid-19 has to a large extent sped up the development of technology to realize the need for high level of transparency in supply chains, the optimal level of information sharing remains uncertain especially between different tier suppliers. It was said during the interview that the higher level of information requires better services which are also very costly. To make the investment in digitalization worthwhile, OEM AB representatives were asked to identify the optimal level of information sharing with respect to tier-1 and tier-N suppliers to enable efficient information sharing. In addition to the demand of full supply chain visibility, early communication from suppliers regarding potential supply chain risks such as material shortages and capacity risks were commonly identified by OEM AB representatives as the most important information to obtain. As OEM AB trusts its tier-1 suppliers to manage their own supply chains, it believes that the same information should be obtained by the tier-1 suppliers from their sub-suppliers as well. In the best-case scenario, tier-N suppliers should proactively share their risk information to OEM AB so that mitigation plans could be established at an early stage of a crisis.

5.2 Tier-1 Companies

The team conducted interviews with two tier-1 companies who supply directly to the focal company OEM. The two tier-1 supplier companies namely A1 & A2 are from a wide pool of tier-1 suppliers that the OEM gets the material supply. Both these tier-1 companies supply the OEM with different product categories and therefore represent a different set of supply chain constraints. The empirical findings from these two-tier companies are presented below.

5.2.1 A1

A1 is a small size sheet metal supplier delivering sheet metal parts and assemblies to big automotive OEMs according to their specifications in the heavy vehicle manufacturers and other engineering industries. As A1 supplies sheet metal parts directly to OEM AB, the company is identified as a tier-1 supplier of OEM AB. The selection of A1 as one of the tier-1 interview candidates was based upon the fact that the company is operating in the traditional market of which technology development has not posed a significant effect on the operations of the company. This could be used as a representative example for suppliers belonging to such markets for comparable analysis.

5.2.1.1 Covid-19 Impacts

In the beginning of 2020, A1 was aware of the outbreak of Covid-19 in China and other countries in Asia. However, they did not expect it to be a potential risk to their operations in early 2020. Consequently, Covid-19 spread in the whole world and eventually hit Europe where

A1 has most of their suppliers. They experienced a decrease in demand and had no orders in March and April 2020. As the OEMs stopped the production lines, they also had to stop their production units because of no demand from them. This imposed a severe financial crisis on the company and they were threatened by the situation of bankruptcy due to no demand from their customers. They applied for furlough or short-term layoffs of their employees and applied for financial support from the Swedish Agency for Economic and Regional Growth. Along with, they borrowed loans from banks to maintain cash flow in a crisis situation. Being unaware of the period for which this situation will last, they supposed that this effect will last for 3-4 months more after the stoppage of production units. After the OEMs restarted the production, A1 was back in 100% of its production capacity by the end of June 2020.

After the resumption of production in mid-2020, A1 experienced constant fluctuation in demand from its customers. They stated the fact that "the daily sales in October 2021 are approximately 45% higher than it was in September" (Managing Director, personal communication, November 17, 2021). The uncertainty in demand raised issues in capacity planning and resource utilization for the company. In addition to demand uncertainty, the company was affected by other issues in the year 2021 like high surge in metal prices, shortage of semiconductors and increase in electricity prices. The company's spend on steel metal accounted to 32% of the costs before the pandemic which is now accounted to upto 75% as on July 2021. These dynamic metal price surges have affected the profit margins for the company. The company tried to renegotiate the contracts for a better profit margin with the OEMs due to such market situations. However, the company expressed that such OEMs are very difficult to negotiate on prices and cannot understand the issues faced by the company. The company neither has semiconductors as a part of their product portfolio nor they are a sub-component in their product portfolio. But the production at OEMs has decreased due to the shortage in semiconductors and thus the vehicles supply is not able to meet the demand. This has generated ripple effects on A1 which has reduced the demand from the OEMs. Thus, this was a very difficult time for this small-size company who was heavily impacted by the pandemic and struggled hard to survive financially in the market.

5.2.1.2 SCRM Methods

The above section described the financially difficult situation for A1 due to the Covid-19 impacts. In the beginning of 2020, as a primary reactive measure to the news of Covid-19, the company communicated with its customers to learn more about the pandemic's foreseeable

impacts by their customers which can subsequently affect them. They communicated with their big automotive OEMs in March 2020 to which customers replied about not anticipating any disturbances in their production or deviation from the sales and operational planning. However, later the company had to respond to high uncertainty in demand and frequent replanning of the delivery schedules with its customers. They stocked up the buffer of certain parts to respond to sudden demand increase on certain parts. However, the company expressed that it is not always possible to stock all the parts that they sell to their customers.

The company identifies its critical suppliers and has regular follow-up meetings with them and plans recovery with them. The company was facing another type of risk regarding delayed transport time of materials from their suppliers. The conventional transport modes are causing delay due to slack in transport infrastructure faced by the company's suppliers. So, the company opted for premium freights by paying more and trying to keep up with the delivery promises. The company relies on single sourcing mainly as the company believes that the price of metals and metal components that they buy are centrally regulated. So, the company does not see the benefits from multiple sourcing from an economic perspective. Besides, they believed that multiple sourcing requires a lot of transactional costs which the company is not willing to pay. Rather, the company maintains close relationships with suppliers and supports its suppliers in case of any issues they may come across. The company understands its suppliers' problems towards deliveries and often collaborates for resolving the mutual issues. The company follows routine procedures to avoid risks in a normal situation. They keep a check on their suppliers' capacity, lead time negotiations and timely service. They express their need to be agile to react to the rapid fluctuations happening in the market in terms of demand, electromobility and material innovations.

5.2.1.3 Views on Transparency

Viewing OEM AB as one of their biggest customers, A1 is keen to disclose its full supply chain visibility as a small company does not have much leverage power to say no and that they could actually benefit with OEM AB stepping in to help in crisis situations. Similar to OEM AB's multi-tier management strategy, A1 only directly manages tier-1 suppliers and they ask tier-1 suppliers to manage tier-2 suppliers. There was no specification made on the definition of transparency during the interviews. But based on the company's responses, A1 inclined to the idea of information sharing when discussing supply chain transparency. Regarding transparency from suppliers to OEMs, A1 believes that as long as the suppliers to OEMs are

delivering according to the delivery schedules then the goals of the customers will be fulfilled. No further communication is needed from the suppliers to the OEMs if suppliers are doing their jobs for delivery. In fact, A1 expressed that "*I know OEM AB, they don't want to have contact with us. If we perform perfectly well, we send all the schedules, then they have no issues with us. That is their goal. And I have the same goal with my suppliers, they should do their job, I write the purchase order, we agree upon the price and they perform the job for us. Because all communication costs money*" (Managing Director, personal communication, November 17, 2021). Hence, the company has made little investment on information technology before, during as well as after the experience of Covid-19. The sheet metal market has been slow for product development and the business is more or less the same as many years ago. The only technology investment made by the company was the implementation of a digital planning system about four years ago. However, the company indicated their interests in making investment in an information platform if they are presented with a strong business case.

Unlike transparency from suppliers to OEMs, which is found insignificant by A1, most of the time as long as people are doing their jobs, the company emphasizes a lot on the importance of gaining transparency from OEMs to suppliers. It was mentioned by the company that sometimes, OEM AB intends to hide information from the suppliers which costs operational wastes and money that A1 is less happy to pay for. Examples were given during the interview to justify the negative effects on economic as well as environmental sustainability when OEMs like OEM AB withhold information from the suppliers regarding the actual demand or production buffers. It was discussed in the earlier section, when Covid-19 hit, A1 experienced huge supply chain disturbances during Covid-19 which caused many delays in delivery schedules. Thereby, A1 was asked by OEM AB to send materials through air freights to make up for the delays, which are much more expensive and bad for the environment. OEM AB pressured the use of express transportations even though, according to A1, OEM AB has enough production buffers to allow for normal transportations.

Other than the fact that A1 is slow at technological development due to the particular market, several transparency barriers were discussed. Information adds values when it could be correctly understood and utilized. It serves opposite uses when they are being misused or misinterpreted. One example for this is the capacity questionnaire OEM AB sends to the company, which according to them, was not tailored in a way to fit A1's environment. This causes wastes because in order to fulfill OEM AB's requirement, A1 was forced to write down information which neither A1 nor OEM AB will find to be useful in any way. The quality of

information obtained in such ways is thereby questionable to say the least. In OEM AB's effort in searching the service provider to increase supply chain transparency, A1 raises concern about the complexity of this mission. When asked about the barriers in sharing information with the customers, the company representative answered that companies have little trust towards each other because everyone is trying to survive the crisis and secure their own production plans in today's intense and fast-paced production environment. The company expressed that it would be difficult to convince all supply chain partners to agree upon the implementation of exchange of real time data towards the achievement of full supply chain transparency.

5.2.2 A2

A2 is a system supplier of innovative premium lighting systems and electronics for global automotive companies. The company is identified as a strategic tier-1 supplier of OEM AB. A2 operates a global business with facilities in Europe, America and Asia (A2, 2020). The company is chosen to be included in this study due to the different characteristics as opposed to A1 and that the company is considered as a strategic partner of the OEM. The lighting industry has been transforming at a rapid pace for the past few years in relation to encouraging government policies, rebates, retrofit programs and the advancements of LED lighting and semiconductor technology (Vision Research Report, 2021). As a regional leader operating in such an innovative, fast changing and uncertain market, insights provided by A2 with regards to SCRM approaches and supply chain transparency produces valuable research value.

5.2.2.1 Covid-19 Impacts

A2 got affected in the year 2020 due to the shutdown of most automotive companies. It reduced the demand to zero which led to the shutdown of the company too. Later when these shut OEMs started resuming, the company expected very less forecasts. However, the company experienced more than expected demand patterns from its customers which created material shortage at the company. The company also experienced the commonly seen supply chain issues like increase in lead times, transportation issues, increase in logistics costs and increased demand in internal manpower to handle the issues from its customers. Owing to its product portfolio, A2 is facing extensive problems from the semiconductor crisis and is one of the most affected areas due to Covid-19. They are expecting 24 months of lead time for certain semiconductor components which is a never experienced scenario of the company. Many OEMs are running on reduced capacity due to the semiconductor shortage. The company is again getting affected due to lower demands by the reduced production of the OEMs. The

company is paying five times more for a container cost and still is expecting delays in deliveries. The company also stated that it is now a supply-driven market which is opposite from the traditional customer-driven market where the supply of the materials is impacting the capacity of the production facilities.

The company was familiar with disruptions happening in its supply chain, but doing Covid-19 every supply chain partner was equally affected which worsened the situation. The Covid-19 pandemic gave an opportunity to the company to understand its supply chain better by observing the ability of their suppliers to deal with such disruptive events. The company also believes that it will help them to reflect and rethink upon its supply chain risk management approaches.

5.2.2.2 SCRM Methods

During the pandemic, the company formed a task force which followed up on the ongoing issues with tier-2 and tier-3 suppliers as well as with customers. The company had to put dedicated human resources on certain risk components and suppliers who would have regular meetings to bring focus and facilitate problem solving. Similarly, regular customer meetings are also a part of routine to do reporting on delivery performance, delivery issues and so on. The company feels that it is difficult to focus on all the components at once, so only critical components are taken into consideration. The company tries to foresee potential risks and does risk mapping by continuous communication with the suppliers. This helps the company to do better resource planning and internal cross-functional coordination. The company also follows a fair share approach to serve its customers who are OEMs.

The company identifies the risks behind globalisation and long multi-tier supply chains. This is the reason that the company tries to have the suppliers close to their global manufacturing locations. The company has a single-sourcing approach for the strategic parts which are manufactured very specific to the customer's requirements which often requires close collaboration with the suppliers. It is also very resource-intensive to do the validation and testing in case of frequent switch of such strategic suppliers. The company however dual sources standard components which can be bought at competitive prices from a variety of suppliers available in the market. The company promotes the idea of reshoring certain critical components to Europe to break the monopoly of semiconductor suppliers.

5.2.2.3 Views on Transparency

The representative from company A2 believes that supply chain transparency is one of the defining business challenges of this time as well as of the automotive industry. The interviewee defined transparency as sharing data. Having full supply chain transparency will solve a lot of problems that exist today and the representative believes that everyone within the automotive industry knows the importance of transparency. However, the representative raised that concern that the way the automotive industry has been established and set up does not support the idea of full supply chain transparency. There are not sufficient benefits being visualized to the companies thereby they are reluctant to reveal information. Another issue with the business setting today in the automotive industry is that it is usually the OEMs asking for data from suppliers without compensating the suppliers. Information sharing is more of a one-way street and companies are reluctant to increase transparency without getting any kind of compensation/benefits in order to do that. The interviewee discussed that transparency effort has to start from the OEMs by taking the initiatives to actively share more data and by providing suppliers with benefit cases so that this idea of transparency can be actively promoted and suppliers could understand the benefits they are gaining out of it.

During the interview with the A2 representative, several transparency barriers were emphasized. Before Covid-19, confidential information was one of the biggest barriers of transparency between tier suppliers and the OEM. There might be certain commercial or other agreements between tiers that they don't want to share with any other party. This situation has changed during the experience of Covid-19. Today, in order to get the criticality and priority from a supplier for on-time delivery, sometimes it is necessary to involve the OEM in the negotiation process which ultimately means reveal and share important information with the OEM. However, it is important to know that when an OEM is requesting specific information from suppliers, specific reasons need to be provided. According to the representative, two things need to be considered. First is that the tier-1 supplier does not have full visibility of the supply chain, due to the fact that at some point in the supply chain it gets too complex to follow the flow. Specifically, "due to globalization and the concept of low transport costs, corporations do apply the model of outsourcing and off-shoring to such an extent, that it gets difficult to understand where, as an example, certain electrical components do actually get produced and come from" (Key Account Manager, personal communication, November 25, 2021). The second thing to be considered here is that companies tend to solve their own problems if the issues haven't reached a critical stage hence the trends in the sector to 'cover up' production or

transport problems. Nowadays meetings are held much more frequently as OEMs request it due to Covid so that potential risks are identified faster. However, with the customers requesting action plans or reports behind every issue, the lack of resources surfaced which led to unwillingness of the suppliers to reveal their problems. Another barrier mentioned was the lack of a benefits/risks sharing model. Suppliers are reluctant to provide information as in the current automotive industry, OEMs are asking for transparency from suppliers without informing or considering what the suppliers might get out of it by sharing supply chain information. The representative emphasized that supply chain transparency will not work out if it is a one-way road. Things must be changed and the OEMs need to take initiatives to change it. With regard to technology development, the company representative believe that the lack of standardization and insufficient system landscape does not promote to enhance supply chain transparency as "there is an enormous effort needed on supplier side for the creation, as well to process the data on customer side", however, the representative believes that system solutions is not critical challenge because "the aspects and criteria of transparency are progressively considered in business operations...within the next year requirements and processes will be defined on how to exchange data in a reasonable way" (Key Account Manager, personal communication, November 25, 2021).

Regarding the level of information sharing, from OEM to the suppliers, first of all, insights on where the market is heading in the next 1-3 years in terms of development, should be shared with certain explanations on the forecasts according to the company representative. So, a more active and frequent discussion needs to be established between the tier-1 suppliers and the OEM. If tier-1 could interpret information efficiently and accurately with the help from the OEM, then they could pass the information easily to tier-2 suppliers and the same goes up the chain. This way, there will be no need for more transparency efforts managed by the OEM with their tier-N suppliers. In addition to insights in market development and forecasts, artificial increase in demand should be prevented. The company representative emphasized on the negative impacts of the Bullwhip effect when OEMs provide artificial demands which will never meet the actual market expectation in the attempt to secure volume. Given that if real demand is provided, suppliers should be willing to share information in production numbers in terms of production rates, cycle times etc. With this information, OEMs could get an understanding of the production planning and estimate the volume they are going to get. However, it should be considered that suppliers sometimes refrain from sharing such information due to the concern that it is risk tolerant when production plans are not fulfilled.

5.3 Tier-2 Companies

The team conducted interviews with two tier-2 companies who supply to the pool of tier-1 companies who further supply to the focal company OEM. The two tier-2 supplier companies namely B1 & B2 are from a wide pool of tier-2 suppliers that supply to different tier-1 companies. Both these tier-2 companies supply different product categories and therefore represent a different set of supply chain constraints. The empirical findings from these two tier-2 companies are presented below.

5.3.1 B1

B1 is the world's leading diversified manufacturer of motion and control technologies, with annual sales of more than 10 billion U.S. dollars, providing systematic and precise design solutions for a wide range of commercial, automotive, industrial and aerospace markets. With the widespread global business market, the company aims to deliver the requirements of the customer according to their expectations. The company's products are essential for almost all applications that are mobile or need to be controlled, including the manufacturing and processing of raw materials, durable goods, infrastructure development, and various modes of transportation.

Due to B1's wide range of product lines, the company is identified as both tier-1 and tier-2 suppliers of OEM AB, however, B1 is referred to as a tier-2 supplier of OEM AB in this thesis report. B1 is chosen for this study due to their global supply networks which serve as good study material to understand how the company was impacted and responded to the experience of Covid-19 and their insights on increasing supply chain transparency as a way to enhance supply chain resilience and prevent future disruptions.

5.3.1.1 Covid-19 Impacts

Recognising the early signs of Covid-19, B1 was quite prepared for the pandemic and anticipated the impacts of Covid-19 pandemic on their internal productions as well as being able to see a potential risk in obtaining material from their suppliers. Before the pandemic actually hit their plant location, the company started taking precautionary measures for the safety of the employees in the facility. The company has a large supplier base in Italy which was one of the worst affected areas in Europe. These suppliers supply one of the most critical parts to the facility. The local regulations allowed these critical suppliers to function which was

a relief for the company as they continue to deliver the parts to the company's facility. The varying travel restrictions of different countries in Europe impacted the transport infrastructure and thus the material flows. Generally, sea transportation is avoided by the company to reduce lead times. The parts which are sourced from Japan, Mexico & US are air shipped by the company. But the cargo airplanes were stopped during the first half of 2020. So, the material flow of such materials was delayed frequently. The lead times increased for most of the components and thus affected the production schedules of the company.

The company usually sticks to the firm order planning with its suppliers. However, disruptions and delays in receiving material deliveries, shortage of raw material forced the company to increase the firm order planning period. The increase in the firm order period consequently affected the service level to the company's customers. The demand patterns have been erratic as per the company which were not converging with the forecasts and thus affecting the sales and operational planning. The company also expressed that they are experiencing never seen before demands throughout the pandemic.

5.3.1.2 SCRM Methods

Being a global company, B1 followed their internal safety procedure in the company and put restrictions in place to limit the spread of Covid-19 in their production facility which were stricter than the ones stated by the Swedish Public Health Agency. They tried to identify the potential location-specific supply chain risks as per their global supply chain footprint. This was majorly done from the information obtained from secondary sources like news, google search and websites. As a first reaction to the pandemic, when the company learnt about the specific impact on its suppliers, the company started direct communication with its suppliers in Italy and Spain, which were one of the most affected countries in the EU by Covid-19, as the company has many suppliers in this area. The company collaborated with these risk suppliers to secure the material flow in the pandemic. The company maintained a risk assessment document and started to deal with the supply chain issues from a pandemic perspective. In the beginning, the company reviewed its entire supply chain and tried to identify the underlying risks in the supply of material to their production facility. They began inspecting the supply risks such as suppliers' capacity, transportation means and the raw material supply to their suppliers. They also had to increase safety stock levels to prevent the material shortage in production due to delays from the suppliers. Also, they used safety buffers for the erratic demand patterns from its customers.

Like the other interviewed companies, this company also faced a high risk from transportation of material from its suppliers spread all over the world. The company is reluctant when it comes to sea shipments due to the long lead times. The company prefers air shipments over sea shipments for carrying material from distant countries like Japan and North America. That's why the company prefers local sourcing whenever it is possible to stay away from the hassles of long lead times involved in sea transportation. The company prefers to stay within Europe or even within Sweden to minimise the transportation risks and the warehousing costs. The company often sees no cost advantage when they compare the risks involved in locally sourced versus globally sourced parts. Rather the company claims to save money for certain parts if they are sourced locally. The product portfolio of the company consists of heavy parts which are often not affordable to ship by air. Thereby, the heavy unit of parts is one of the reasons for the company's inclination for local sourcing where the lead times are less and air shipments can be affordable if needed. The company also does dual sourcing for many components to better mitigate the risks of capacity with certain suppliers. The company also tries to become more aware of its suppliers up in the tiers in order to understand the risks that could propagate throughout the supply chain. The company expressed lack of communication from OEM AB when they stopped picking up the orders during the ramping up of Covid-19 and stopped the production.

The company follows a sales organization structure where it jointly plans the production ahead in time as per the customer demands. The company generally does a quarterly review of all of its suppliers and considers topics like quality, delivery performance, finance and reviews overall business they do with them. This helps them to identify any underlying issues well in advance. As mentioned above, the company refers to its risk assessment procedure to encounter and resolve the supply chain risks. This procedure did not contain contingency plans for a pandemic situation like Covid-19. So, the company made additions to this procedure to deal with future disruptions when similar situations might occur. This addition in the procedure also considered the procedure to be followed by each department in the company in order to coordinate, communicate and even escalate the issues. The company invests on digital platforms for interacting with its suppliers as well as customers. The company also utilises advanced technology like blockchain for fast and reliable information sharing among its supply chain tiers. The blockchain helped the company during the pandemic to become more aware of its tiers and thus provided them with information to discuss upon the possible future risks with the suppliers. The company describes the need to be agile to react to new issues encountered on a daily basis and also to increase proactiveness towards supply chain risk management.

5.3.1.3 Views on Transparency

B1 is one rather special case from all the companies the team interviewed. The company is structured in a way where there is a complete separation between the production unit and the sales unit. They called it the sales company structure. This structure causes the lack of information sharing even within the company internally. The company communicates to important customers like OEM AB entirely through the sales company via key account managers. B1 faced a significant production pattern disruption during the Covid-19. Customer demands surged to the roof. A lot of orders were generated due to new changes and Government regulations which were very difficult to predict. B1's supply chain department has a really hard time understanding where the rapid increase of order is coming from. Supply chain discrepancy at the customers has a major role in playing. The sales company of B1 received warnings from customers about fluctuated forecasts and demands, but the information stops there because the sales company does not share such information with the production unit and no direct communication can be made between the production unit and the customers. During the interview, the company representative described the disconnection between functions within the company by saying, "What we would like to see is heads up in troubled times. I think that our sales company is not transferring the information that OEM AB provides them. Or they are coming from the wrong places within the organization that they don't think they should share with us. I just see there is a lack of information sharing within our company internally" (Supply Chain Manager, personal communication, October 8, 2021). When it comes to sharing supply chain information to customers, the company expresses the willingness to share to an extent if being approached. Normally, B1 has a standard format in answering questions regarding supply chain visibility during audits which indicates the level of information sharing depends on the standardized procedures of interrogating the company.

There are lots of initiatives when it comes to digitalization both externally and internally in B1, but the overall speed for implementation of these technology tools is rather slow according to the company representative. B1 and its customers implemented a lot of common information technologies over the years and they received quite a high level of satisfaction from the customers regarding information sharing. This is not the case with B1's suppliers. In the purchasing side of the business, technology development/implementation is slow for essential

tools such as EDI. B1 expects a similar level of communication from the customers as well as the suppliers. Early information on potential supply chain risks or disruptions indicating possible lack of components or changes in forecasts is what B1 expects to receive from both suppliers and customers in crisis situations. The company also expects similar information sharing speed with the regular delivery schedules that would make up for the optimal transparency level between its suppliers and customers.

B1 is quite advanced when it comes to investments in digitalisation and they have a centralised information technology department in their HQ. The company extensively uses blockchain technology to achieve a transparent supply chain and facilitate optimum information sharing. Blockchain technology has helped B1 significantly in terms of improving supply chain transparency and understanding risks in their multi-tier supply chains. High transparency exists throughout the chain which helps the company in determining the issues faced by the suppliers in finding materials from other layers in the blockchain. Technical buyers of the company also obtain awareness of challenges faced by multi-tier suppliers from information provided by the blockchain. This awareness includes that B1 will be noticed if suppliers beyond tier-1 have issues in their supply chains which might have an impact on B1.

5.3.2 B2

B2 is one of the largest global semiconductor companies based in Germany. B2 is identified as a tier-2 supplier of the OEM and one of the few strategic tier-2 suppliers that the OEM has direct communication with. The company B2 generally acts like a tier-2 to the automotive OEMs. However, it also does certain processes on semiconductor and power semiconductor parts which goes through various tiers like distributors, manufacturers, designers before the products ultimately reach the OEM via the tier-1. In the semiconductor business, one entire value chain often consists of the OEM, tier-1 suppliers, tier-2 suppliers and all the way up to tier N suppliers due to the habit of outsourcing or using distributors. Thus, such intermediate tiers involved makes B2 a tier-4 or even tier-5 supplier for certain products in the automotive supply chain. Due to the uniqueness in product offering and the important role the company plays in the supply chain given the recent semiconductor crisis, it is believed that insights provided by B2 would contribute unique values into understanding how the OEM should better govern their supply chain to enhance resilience and improve transparency.

5.3.2.1 Covid-19 Impacts

In the beginning of 2020, like the other interviewed companies, the company B2 was also affected by the shutting down of their intermediate customers which are the tier-1 suppliers to the OEM which were affected by the production stops at the automotive OEMs. Besides, the manufacturing in Asia was shut down again in Spring 2021 due to the increasing number of Covid-19 infections in the factory. This location was shut down for 7 weeks and impacted the production capacity severely. B2 experienced lowered demand from the downstream supply chain due to restrictions and reduced business activities during the first half of 2020. Later, when the OEMs restarted their production, the orders ramped up for B2 from its tier-1 suppliers. In the meanwhile, the demand for the consumer electronics also picked up due to high demand of the household electronics by the society. Consequently, B2 received a huge demand from these consumer electronics companies to whom the supply was increased. Thus, the existing capacity of B2 got shared with other consumer segments creating a shortage for the automotive OEMs. Due to this shortage, the OEMs are generally putting greater than usual demands to B2. Being far away from the OEM in the automotive supply chain, B2 thus experiences a bullwhip effect regarding the demand that eventually reaches them.

5.3.2.2 SCRM Methods

The lead time of the products offered by B2 is very long, which is usually 9 months. The company starts the process of manufacturing the demand 9-12 months ahead in time due to almost 1000 process steps involved in the manufacturing process. Thus, the company cannot react quickly to changes in demand because of inflexibility in the manufacturing process. The company B2 invests a lot in increasing the capacity and in planning new manufacturing locations across the globe to meet the future demands. Similarly, the company highlights the importance of keeping buffers of at least 26 weeks due to the inflexibility in increasing the production of excess demand. This buffer helps them to plan the future demand well in advance. B2 also made a point by stating the importance of getting real demand from the downstream supply chain which consists of OEM, tier-1 and so on so as to reduce the bullwhip effect. The company works towards increasing the capacity however the real demand data would help them in making better future investments.

The company believes that such a long value chain was created by the OEMs that are putting huge price pressures on the tier-1 suppliers who in turn have to look for the cheapest outsourced companies. Therefore, many middle actors are added without raising awareness in the supply
chain and the OEMs are not taking responsibility to manage it. During the interview, B2 discussed the main risks introduced by the long value chain which is that the middle actors often create artificial orders which are much more than the actual orders confirmed by the OEMs and tier-1 suppliers. By the time these orders reach B2, it has already caused the 'bullwhip effect' phenomenon leading to unrealistic high demands causing supply exhaustion. B2 has always been investing in R&D before the pandemic and they have spent in the last fiscal year, a large chunk of their investment portfolio into manufacturing capability due to the strong market growth the company is foreseeing into the near future. However, these investments made in manufacturing capacity will take years to, for example, establish new facilities, before the capacity issues are resolved. On the other hand, unlike OEMs that have a strong preference of flexibility for production planning, semiconductor companies usually are running with full capacity of 95% to 100% thereby there is no flexibility to allow extra volume demanded by the OEMs. In addition, B2 states that the semiconductor business is not suitable for 'just-in-time' as semiconductors need to be ordered at least 9 months up front, buffers are needed at different positions of the value chain.

B2 has inhouse manufacturing and is independent for all the processes and subprocesses to be done for the supply of its product portfolio. This gives them an edge over its competitors by near to zero defect rate in its products. B2 believes in having manufacturing lines in different continents for having supply security and having the suppliers in vicinity for the leverage of resources belonging to the location. During Covid-19, the company experienced a need for increasing efforts in digitalisation. B2 has been very pursuant about digitalisation in their business. B2's respondents mentioned about the proactive approach adopted by the company to mitigate the risks by anticipating the underlying potential risks with its suppliers. However, they talked about the infeasibility of proactive approach at all times and the need for a reactive approach in certain disruptions as they appear.

5.3.2.3 Views on Transparency

Supply chain transparency is recognized as one of the crucial SCRM methods by the respondents of company B2. According to B2, transparency provided by the OEMs through the tier-1 suppliers to tier-2 suppliers in terms of proper production planning is the only chance to tackle the current supply risks due to the imbalance of supply and demand in the automotive industry caused by the experience of Covid-19. B2 respondent inclined to the definition of information sharing when the company talks about transparency. Along the long value chain in

the semiconductor business, there is no transparency and the chain is not managed by anyone. The company emphasized that even though the OEMs should be the ones managing the chain, the OEMs are not aware of this long value chain. B2 believes that the gap in the supply chain due to the bullwhip effect is the main root cause of the current supply crisis of semiconductors and the company suggests that transparency is needed to address such problems to increase ordering accuracy and add stock buffers in the supply chain.

The company does not see technology as a main driver to push for better transparency. They emphasized more on the importance of the OEMs taking ownership of the long value chains if the OEMs choose to install them for lower costs. Other than the lack of control of the long value chain, poor data quality is mentioned as a barrier by B2 respondents. The poor data quality is mainly caused by the lack of understanding of how semiconductors are manufactured and the demand for flexibility from the OEMs side. For a semiconductor company to anticipate production capacity, accurate run rates are needed. For example, if informed by tier-1 suppliers that they need 12 million of microcontrollers in this year, then the company understands that the run rate needs to be 1 million per month for this part. However, oftentimes B2 would receive inaccurately forecasted volume without given the explanation of what the minimum run rate needs to be which therefore causing performance problems. The company respondents strongly advise that in order to increase transparency in the supply chain, the OEMs need to understand how semiconductor companies work to send in accurate production planning, respect the long lead time and build up buffers in the supply chain.

Regarding supply chain visibility and information sharing, B2 respondents believed the visibility is already in place between the company, the tier-1 suppliers and OEMs. They stress that the company is very open to sharing information with the OEMs and they are being very transparent with the production processes. Due to the reason that OEMs are not customers to B2, the company respondents mentioned that information such as the amount of buffer of parts and the capacity level at the company is not shared with OEMs. It was also mentioned that if an OEM asks B2 to secure certain capacity, B2 cannot guarantee anything since they completely own the capacity so this will require further discussion. When asked about information B2 would like to receive from the OEMs, the company respondents discussed the importance of accurate production planning which need to be fed throughout the entire value chain to avoid Bullwhip Effect, and that it would be useful to receive insights regarding future trends and technology developments from the OEMs.

6. Cross-case Analysis

In the following section, a cross-case analysis is presented for the focal company OEM AB and its interviewed tier-1 and tier-2 supplier companies A1, A2, B1 and B2 based upon the literature review, findings in the chapter of Covid-19 and empirical findings from the five companies. The company in focus for the project is OEM AB. The analysis will be concerning the interplay between OEM AB, its tier-1 and tier-2 suppliers, hence no focus will be put on the individual suppliers of OEM AB. Figure 7 gives the schematic representation of OEM AB's supply chain considering the four interviewed suppliers.



Figure 7: Overview of the OEM AB's supply chain considering the four interviewed suppliers

In general, the OEM AB utilizes the strong relationship with their tier-1 suppliers to monitor and manage the tier-2 suppliers whereas the tier-1 suppliers then need to report to the OEM AB directly. However, for some tier-2 suppliers such as B2, that supplies the OEM AB with essential and strategically important parts such as semiconductors, the OEM AB forms strategic relationships with these suppliers and communicates with these suppliers directly. Direct material flows exist between immediate tiers but none exists across indirect tiers.

6.1 Covid-19 Impacts

In this section, firstly, the impacts of Covid-19 on the interviewed companies are summarised by categorizing them into the direct and indirect impacts as presented in the chapter of Covid-19. Table 6 gives an overview of the direct and indirect impacts of Covid-19 on the five companies. The impacts are based upon the information given by the respondents from these companies. It is seen that some of the direct and indirect impacts are applicable to all the companies in the multi-tier supply chain while some companies experienced impacts specific to their industry constraints. In the later parts, the impacts on OEM AB's multi-tier supply chain considering the impacts on the four supplier companies are discussed for direct and indirect impacts individually.

Tier	Company	Direct Impacts	Indirect Impacts	
Focal Company	OEM AB	 Production stopped due to supply disruptions, low demands, safety of staff Financial burden by rush air transport Layoffs 	 Lesser production due to SC shortage Demand of EV unaffected 	
Tier-1 Suppliers	A1	 No demand in early 2020 Production stopped due to financial issues Furlough and layoffs 	 High demand uncertainty Ripple effects due to SC crisis Metal prices skyrocketed, need for renegotiation with OEMs 	
	A2	 Production stopped due to no demand in early 2020 High demand while resuming back SC supply shortage High transportation costs, increase in LT 	 High demand uncertainty from OEMs due to SC crisis Supply side dominance 	
Tier-2 Suppliers	B1	 Varying restrictions from different national and local Governments Air transport not accessible, increase in LT Delay in the production 	• High demand uncertainty	
	B2	 No demand in early 2020 Production stops in Asia Supply demand imbalance 	 Attention due to the SC crisis High demand uncertainty due to bullwhip effect 	

Table 6: An overview of Covid-19 impacts on different tiers in the supply chain of OEM AB

6.1.1 Direct Impacts

The halt in production of OEM AB in the year 2020 put a huge impact on the immediate tier-1 A1 & A2 and subsequently on tier-2 B1 & B2 by reducing all of their demands to zero. Other OEMs also stopped their production during this period. The companies A1, A2 and B1 have the automotive OEMs as the major consumers and these companies supply most of their production volumes to the automotive supply chain. So, this loss in demand from the

automotive companies forced the companies A1, A2 and B1 to stop their production lines too. However, in this difficult period of no demand from the automotive industry, the company B2 received orders from the consumer electronics market segment and their business instead boomed. In order to reduce the operational costs, the companies OEM AB and A1 had to temporarily layoff their staff.

Like many other companies, the interviewed five companies were also affected by government restrictions; however, few companies were more concerned about expressing this impact during the interview than others. During the year 2020, the transportation infrastructure was disturbed due to varying degrees of restriction imposed by different national and local governments in Europe. During the interviews, the companies OEM AB, A1, B1 expressed about having a supplier base for supply of many parts in Italy. As countries like Italy and Spain were one of the worst hit areas in the EU with government lockdowns, quarantine rules and enormous Covid-19 tests being carried out, the company started experiencing immediate impact from the large supplier base situated in these regions. Italy faced a severe first Covid-19 wave from mid-March to mid-July of 2020. The infections started to peak again at the end of 2020 in Italy (Ferrante, 2021).

The government restrictions caused an increase in lead times, increase in logistics costs for all the interviewed companies. The deliveries to tier-2 suppliers from the raw material or tier-3 suppliers got delayed and this delay further creeped down to the OEM AB via tier-1 suppliers as per the 'snowball effect'. Further, the delays in parts coming from all such tier-1 suppliers has forced OEM AB to make frequent changes in the production planning. OEM AB often spends a huge amount of money on rush transports. The air transport which was the most common rush transport mode was also inaccessible during the year 2020 which impacted OEM AB and B1.

Later, when OEM AB resumed its operation, the demand experienced by A1 & A2 and later by B1 & B2 was much higher than expected. The forecasts for OEM AB were not much coherent with the bounced back market demand for automotive and the spare parts. So, OEM AB passed on the increase in demand to tier-1 suppliers like A1 and A2 who further passed on the excess demand to tier-2 suppliers like B1 and B2. This disturbed the whole supply and demand balance causing long-lasting supply shortages for many parts which are seen even till the end of 2021.

6.1.2 Indirect Impacts

The semiconductor crisis has affected the OEM AB in the year 2021 which got gradually built from the year 2020. The indirect impact by the semiconductor crisis has been the most widely seen impact on the interviewed companies. The impact of the SC crisis has been on tier-1 & tier-2 suppliers regardless of the fact that semiconductor is a subcomponent used by them. B2 has been pursued a lot by the OEM AB for the required amount of supply of semiconductor components after Covid-19. B2's inflexibility in adapting to the increasing demand of semiconductors has been the main reason behind the supply shortage of semiconductors. This high supply-demand imbalance of semiconductor parts has also been seen as a factor in changing the power dynamics in the automotive supply chain. Being dependent on the semiconductor parts for its product portfolio, A2 experiences power dominance shifting towards the semiconductor suppliers.

Another indirect impact on OEM AB and A1 was due to the surge in prices for commodities like different metals. This has caused A1 the need of price renegotiation with OEM AB stating the reason for having negative profit margins in the metal business. Demand uncertainty is seen as the most common indirect impact of Covid-19 on all the five companies. Consumer behaviour has been erratic during Covid-19 which reflects the uncertainty in demand in the automotive supply chain right from the OEM AB to A1 & B2 and also till B1 & B2. The downstream supply chain from tier-2 suppliers B1 & B2 till the OEM AB are putting orders more than usual towards their upstream to avoid the supply shortage situation. This has led to high demand uncertainty overall in the supply chain from tier-2 to OEM AB.

This chapter provides an overview on how the OEM's supply chain is impacted by Covid-19 and combining with chapter 5 which paints a big picture on how the EU automotive industry is impacted, RQ 1a is therefore answered.

6.2 SCRM Methods

The SCRM framework presented in the literature review will be taken as a base to perform the cross-case analysis of SCRM methods for the interviewed companies. This section is divided into two subsections of 'supply chain types', where the interviewed companies will be categorised into supply chain types, and 'SCRM Approach', where the different SCRM approaches used by the interviewed companies will be analyzed as per the SCRM framework.

Both these subsections describe the cross-case analysis considering two states which are the post-disruption state and ante-disruption state.

6.2.1 Supply Chain Types

To analyze how OEM AB's supply chains are performing in terms of SCRM after Covid-19 and to recommend on how the OEM could better manage its SCRM efforts, the four involved suppliers are mapped into different supply chain types as per the primary data in figure 8 based on the level of supply risks and demand risks which they experience after Covid-19 in ante disruption state and during Covid-19 in the post-disruption state. The ante disruption state being described here is adapted to the context of this thesis thus it refers to a new normal stage when the impact of a crisis is no longer present. In post-disruption state, apart from B1, the other three companies are supply chain type-4 that is characterized as agile due to high-risk exposures. While, B1 is seen as flexible and responsive due to its low supply-side risks during the disruptions. Similarly, in ante-disruption state, A1, A2 and B2 try to hedge their supply-side risks while B1 is seen as an efficient supply chain with low-risk exposure.



Figure 8: Mapping the interviewed suppliers of OEM AB in the SCRM framework

6.2.1.1 Post Disruption State

The four interviewed suppliers are categorized into SC type I and II depending on their particular supply portfolio in the post stage of Covid-19. According to Kilubi (2016), the team categorized the metal business, the lighting business and the semiconductor business

represented by A1, A2 and B2 as SC type II which has the characteristics of high demand risks and high supply risks. The hydraulics, pumps and motors business represented by B1 is categorized as SC type I which associates with high demand risks and low supply risks. During the pandemic, due to the fluctuating market demand for cars, the OEM AB had a difficult time anticipating disturbances in the production planning as well as deviations from the sales and operational planning. Even though suppliers such as A1, A2 and B2 tried to stock up buffers to respond to sudden demand increases, they still struggled to meet the customer demand. In addition to the unstable customer demands, the needs for metal, semiconductor and electronics are accelerating, driven by the trends from the automotive industry for technological innovation and investments in producing electric cars and promoting automated driving. Besides the 'war' of electrification, these products are essential for the manufacturing-based recovery from Covid-19 and the transportation of these goods remains a challenge as many of them are produced overseas. The combined factors have thereby led to a high level of demand uncertainty and high supply risks in the OEM AB's supply chain in the post crisis stage. Thus, these companies need to be agile to adapt to such uncertainty in supply chains. Different from the other suppliers, B1 is determined to have low supply risks because they view OEM AB as a strategic and prioritized customer that the company would always try to secure supply for OEM AB when crisis occurs which was also the case during Covid-19. So, B1 is very responsive and flexible to meet OEM AB's demand.

6.2.1.2 Ante Disruption State

The ante disruption stage is adapted in this report as the new normal period when the impacts of Covid-19 are stabilised in the automotive supply chain. At this stage, SCRM is regarded as a proactive strategy to enhance resilience so that companies can be better prepared for potential future risks and crises. With this particular context in mind, the team categorized the four interviewed suppliers of OEM AB into SC type III and IV where SC type III represents a supply chain with high supply risks and low demand risks; and SC type IV links to low supply risks and low demand risks. Same as the post disruption stage, A1, A2 and B2 are placed in the same category as SC type III due to the similarities in the properties of the product offerings and risk profiles. For the semiconductor business, it has been learnt that investments in increasing manufacturing capacities will take several years to be up and running while the demand continuously rises.

Regardless if the OEM chooses to enter a more strategic relationship with B2, the security of supply cannot be guaranteed as OEM AB is not a direct customer of the company. The lighting

business is currently heavily emphasizing in new technologies to promote the idea of reshoring certain critical components to the EU region to break the monopoly of semiconductor suppliers. However, as the lighting industry is strongly implicated by the supply of semiconductors, it will also take a long time to see return of investment on this strategy. It is therefore foreseeable that the supply risks remain high for the lighting supply chain. As for A1, it is predicted that the demand for metals will keep increasing due to the market expectations for a greener economy which entails ambitious infrastructure programs for the future to come (Stuermer and Valckx, 2021). These current market trends coupled with the limited availability of global reserves of metals are likely to cause high intensity on the supply side of the business. Thus, these three companies always try to avoid and safeguard themselves from high supply-side risks and are hedging supply chains. B1, on the other hand, is considered as SC type IV which is an efficient supply chain with comparatively smoother operation. With no surprises, the forecasting ability of the OEM will improve once the market slowly stabilizes. B1 could thereby better understand the needs of the customer and secure the supply for OEM AB as before.

6.2.2 SCRM Approach

This section analyses the supply chain risk management strategies for the interviewed companies and is divided into two sections: post-disruption state and ante-disruption state. In the post-disruption state, the SCRM approaches are summarised followed by the OEM AB and its suppliers during Covid-19 as per the empirical findings which are compared with the recommended SCRM strategies as per the SCRM framework by Kilubi (2016). In the ante-disruption state, the proactive SCRM strategies are recommended for the interviewed companies based upon the SCRM framework by Kilubi (2016) for future supply chain resilience.

6.2.2.1 Post Disruption State

The SCRM strategies used by the OEM AB and its suppliers during Covid-19 are summarized in table 7. These SCRM strategies are identified as reactive approaches as they were used in reaction to the impacts caused by Covid-19. The reactive strategies used during Covid-19 can be seen as an example of SCRM approaches in a post-disruption state. As per the respondents of suppliers A1 and A2, they implemented all of the six suggested SCRM reactive strategies except multiple sourcing to mitigate the supply risks. Both these tier-1 suppliers do not use multiple sourcing due to different reasons. A1 being a small-size company cannot afford to invest in multiple sourcing in case of supply uncertainty. Its respondent also stated the fact that the metal tier-2 suppliers face similar supply issues so multiple sourcing does not always help in mitigating the supply side risks. On the other hand, A2's respondent stated the impracticality involved in multiple sourcing the strategic and customer specific parts. However, A2 uses multiple sourcing for standard items to reduce costs. from sourcing from cheaper suppliers. Though OEM AB implements dual sourcing for many parts, it has single sourcing for parts which require specifications and are of strategic importance. Collaboration has been seen as an important reactive strategy which all the companies believe in to mitigate disruptions.

Reactive	OEM	Tier-1 Companies		Tier-2 Companies	
in Covid-19	OEM AB	A1	A2	B1	B2
Visibility & Transparency	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Collaboration	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Redundancy	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Flexibility	\checkmark	\checkmark	\checkmark	\checkmark	Х
Multiple sourcing and flexible contracts	\checkmark	х	х	\checkmark	\checkmark
Postponement	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark

Table 7: Overview of reactive SCRM strategies used by the OEM's supply chain

The company B1 seems to be using all of the six reactive SCRM approaches as per the SCRM framework. It is noteworthy to mention that B1 also benefits from blockchain technology to improve the visibility and transparency during disruptions. Other companies except B1 however do not use much advanced technologies to have visibility and information sharing. The semiconductor manufacturer B2 is not flexible to demand uncertainty due to the complexity involved in semiconductor manufacturing. B2 also expressed the importance of redundancy or stocking up buffers at various stages in the long value chain of semiconductors so as to reduce the impact of semiconductor shortage to the OEMs.

6.2.2.1 Ante Disruption State

As described in the section 6.2.1, the tier-1 suppliers of OEM AB i.e. A1 and A2 are categorized into supply chain type III in the ante-disruption state. The tier-2 supplier B1 is categorized as supply chain type IV while B2 is anticipated as type IV. As OEM AB has a plethora of suppliers belonging to different degrees of supply risks and demand risks, OEM AB is identified as a mix

of supply chain type III & IV. So, depending upon the supply chain types of the suppliers, the SCRM framework recommends the SCRM approaches to follow in the ante disruption state. Table 8 enlists the recommended proactive SCRM strategies to the interviewed companies depending upon their respective supply chain types.

Tier	Сотрапу	SC Type in ante disruption	Recommended Proactive SCRM Strategies
Focal Company	OEM III & IV AB		 Visibility and Transparency Partnerships/Relationships Joint Planning and Coordination Redundancy
Tier-1 Suppliers	A1	ш	 Visibility and Transparency
	A2		o Joint Planning and Coordinationo Redundancy
Tier-2 Suppliers	B1	IV	 Visibility and Transparency Partnerships/Relationships
	B2	ш	 Visibility and Transparency Joint Planning and Coordination Redundancy

Table 8: Recommended proactive SCRM strategies for the OEM AB's supply chain

It was seen that OEM AB usually involves its major suppliers in joint planning and coordination for the upcoming 12 months, however respondents of A1 and A2 have demand risks experienced from OEM AB in terms of frequent changes in demands and order patterns. B2 has also been facing demand risks due to the bullwhip effect and expressed the concern regarding inaccurate demand from the downstream supply chain tiers. It is important that OEM AB, tier-1 and tier-2 suppliers understand the importance of 'visibility and transparency' as a common and most important recommended proactive SCRM strategy to anticipate disruptions well ahead in time.

6.3 Views on Transparency

This section presents the cross-case analysis of the five interviewed companies on the respondents' views on supply chain transparency from the empirical findings combined with the knowledge bases provided by the research frameworks that were established by antecedents. The analysis will have a focus on answering the established research questions. The team will first place the OEM AB on the transparency matrix to understand the current transparency level of the company. By understanding the company's current state in terms of transparency, next

steps to be taken will be recommended in order to efficiently allocate resources and establish development efforts. Next, the team will present all the transparency barriers discussed by the OEM AB's supply chain partners and prioritize these barriers based on the specific supply relations and the level of difficulty to address them. Lastly, recommendations will be given on the level of information sharing between OEM AB and its supply chain partners adapting to the framework of identifying important contexts and key partners by Kembro and Selviaridis, (2015).

6.3.1 How transparent is OEM AB?

The present transparency level that OEM AB has with its suppliers is mapped in this section using the model for mapping supply chain transparency for a company. Presently, OEM AB communicates with its direct suppliers i.e., tier-1 only. The company shares code of conduct and while offering the work contract to the tier-1 suppliers. OEM AB also ensures that the tier-1 suppliers are aware of the standards and certifications to be followed. OEM AB shares the performance-based metrics with its direct suppliers only. Thus, it is observed that, OEM AB falls in the group of 'early majority' when its supply chain transparency is mapped considering the achieved transparency milestones and supply chain scope. Figure 9 maps the present supply chain transparency level of OEM AB.

6.3.1.1 OEM AB's journey towards transparency

After mapping the present transparency level, as per Bateman and Bonnani, (2019), the company has to decide upon putting efforts towards increasing its supply chain transparency. With the OEM's ongoing transparency project, it is seen that OEM AB is willing to move towards becoming 'innovators' in terms of supply chain transparency. As per Bateman and Bonnani, (2019), OEM AB is recommended to follow the five steps as discussed under section 3.3.1 so as to fulfill the objectives of investing in increasing supply chain transparency. For the first step of 'mapping risks and setting goals', OEM AB should initially focus on the most important risks to be addressed and goals to be achieved by focusing on certain supply chains. Further, implementation of a visualization technology, for example blockchain, will help in the second step of visualizing the targeted supply chain. The information gathered through the visualization of the target supply chain should be used to identify the potential risks, improvement scope, loopholes in the supply chain and opportunities to eliminate silos.



Figure 9: Mapping the present transparency level of OEM AB

In the fourth step, the information should be constructively used to engage with the suppliers to work upon the identified risks. Finally, in the last step, OEM AB should take decisions upon the disclosure of information regarding transparency milestones to be achieved within its supply chain scope. The initiatives towards increasing supply chain transparency are to be supported by the risk analysis associated with information disclosure and mutual benefits to be reaped by the supply chain partners.

6.3.2 Transparency Barriers

There are certain contexts of a supply chain where it is not beneficial to increase the level of information sharing. However, by looking at OEM AB's case from the perspectives of its product & market, and its supply chain type, it is evident that the OEM fits the favorable contexts according to Kembro, (2015) to increase information sharing with supply chain partners for efficient decision making in response to uncertain environments. This conclusion is made based on the fact that OEM AB is operating in an environment where product complexity and demand variability and uncertainty is high due to the specialization market the company is targeting. In addition, OEM AB has many suppliers around the globe including the various outsourcing partners which makes the structure of its supply chain highly complex. The company also emphasizes the importance of having collaborative business relationships. Thereby it is safe to conclude that increasing supply chain transparency in OEM AB's supply

chain is a strategic fit. Hence the importance to identify barriers in the company's supply chain that impede transparency and determine what information to share with whom.

The transparency barriers in the information sharing experienced by the interviewed companies between the supply chain partners are analysed in this section. There are in total 24 transparency barriers being identified during the data collection process by the OEM AB's supply chain partners including the tier-1, tier-2 suppliers as well as the views of the OEM itself. The team categorized these 24 barriers into the 6 comprehensive categories namely (1) information utilization, (2) business process, (3) legal, (4) technology utilization, (5) culture and (6) power structure, summarized by Kembro et al., (2017). There are originally 22 factors discussed by Kembro et al., (2017) from which seven of them are not mentioned by the interviewed companies. Five factors discussed by the interviewed companies are not included in the Kembro et al. (2017) and they specifically apply to the automotive industry and the Covid-19 situation. These factors are a). delay in information, b). information misinterpretation, c). tier-1 lack of information on the full supply chain, d). industrial trends to cover up issues and e). OEM lack of control on the value chain. Table 9 provides a summary of the discussed transparency barriers needed to be addressed to increase transparency in the OEM AB's multitier supply chain.

Transparency Barriers	OEM	Tier-1	Companies	Tier-2 Companies	
Darricis	OEM AB	A1	A2	B1	B2
Information Utilization	○ Information lost	 Information misinterpretation Low information quality Lack of forecasting ability due to quick production changes 	 Information misinterpretation Low information quality 	 Information misinterpretation Delay in information 	 Low information quality Information misinterpretation
Business Process	 Validation system Tier-1 lack of knowledge on the full supply chain 	 Lack of benefit and risk sharing model 	 Lack of benefit and risk sharing model Tier-1 lack of knowledge on the full supply chain 	 Lack of internal transparency due to company structure 	
Legal	 Lack of legal frameworks Confidential information 		 Confidential information 		
Technology Utilization	 Lack of standardized processes Lack of IT setup Additional costs 	 Lack of IT setup Additional costs 	 Lack of standardized processes Lack of resources Insufficient system landscape 		
Culture	 Unwillingness to share Information exchange with only tier-1 	 Lack of trust 	 Unwillingness to share Industrial trends to cover up issues 		
Power Structure		• Power asymmetry	 Lack of initiatives from the OEMs 		 Lack of control of long value chain

Table 9: Summary of transparency barriers in OEM AB's supply chain

From table 9, in particular, information utilization consisting of barriers such as information quality, information interpretation, forecasting ability, information lost upstream and information delay, stands out as being the one category mentioned by all company participants. These individual barriers are believed as critical challenges to be addressed to enable visibility and information sharing in the automotive OEM's multi-tier supply chain. Business process, technology utilization and culture are also important barriers found common among the interviewed companies which are to be considered. Taking different tier levels into consideration, tier-1 suppliers are found to emphasize a lot on the importance of having a benefit/risk sharing model and that there must be a standardized business process in place in order to efficiently connect the OEM and the tier-1 suppliers in terms of transparency. One of the main reasons suppliers are reluctant to share information and visibility is that there is a lack of understanding of the benefits they are gaining out of sharing data and the risks that they might be undertaking. By providing the involved partners with use cases and business cases, the idea of transparency can be actively promoted in the value chain which could potentially have a positive ripple effect on the remaining actors.

Technology setup is perceived by the tier-1 suppliers as an important factor but not difficult to be resolved. There is a need for a common platform and a standardized process for data to be exchanged; however, an IT solution is not the most pressing issue due to the simple nature of the problem according to several company respondents. It is believed that this issue will be resolved naturally as the automotive industry is fully aware of the importance and the market trend of implementing transparency in multi-tier supply chains. The idea of being fully transparent is not supported by the current setup of the automotive industry. There is not sufficient evidence of benefits for the supply chain to jump on the train of transparency even if the market and the public demand so. Therefore, the more pressing need emphasized by both tier-1 suppliers as well as the strategic tier-2 semiconductor supplier, is to have powerful leaders initiating the implementation of a common solution and taking the lead and responsibility on promoting the benefits of having transparency in the supply chains.

On the other hand, both tier-2 suppliers that were interviewed are self-equipped with strong technology capabilities due to the size of the business, the wide range of product offerings and the particular product lines that they supply. Regardless of the business relationship, both tier-2 suppliers highlighted the challenge of efficiently interpreting information, utilizing data and extracting useful business insights due to the lack of direct communications with the OEM. Often these suppliers receive demand information from the tier-1 suppliers which is sent by the

OEM. The lack of a direct link between the tier-2 suppliers and the OEM suggests a weak intensity of interdependence which adds the difficulty to correctly translate demand information as it takes resources to make the efforts (Kembro et al., 2017). The OEM is therefore recommended to carefully identify the key partners to invest resources on improving the aspects of information utilization.

6.3.3 Information Sharing with Key Partners

In the current supply chain of OEM AB, information sharing and visibility exists mainly between immediate partners, namely OEM AB and its tier-1 suppliers. Based on the characteristics of business relationships, the current information sharing level between the OEM and its tier suppliers appear to vary. To provide a recommended level of information sharing that OEM AB should have with the suppliers, the intensity of interdependence and the uncertainty of demand are being looked at in order to identify key partners of OEM AB (Kembro and Selviaridis, 2015).

Based on the considered factors and definitions provided by Kembro and Selviaridis. (2015), it appears that tier-1 supplier A2 and tier-2 supplier B2 show strong intensity of interdependence with the OEM. Both companies represent product portfolios of important market volume as well as value. Even though B2 is not a tier-1 supplier to OEM AB, but according to the OEM, if the supplier doesn't deliver, the business would stop. Although there are potential alternatives for the supply of microcontrollers, the amount of work needed to be done is huge so B2 is regarded as a very critical supplier by the OEM. It is the same situation with A2. OEM AB single sources for the lighting system which makes A2 an extremely strategic partner to the company. As regards to A1, OEM AB is dependent on its supply of sheet metals in the EU region. However, it is possible according to the OEM respondent, to go for local sourcing in the US or Asia for the parts that A1 supplies and the process to get the parts are easier compared to semiconductors and headlights. What is more, the company is currently doing dual sourcing for metals so even though A1 supplies many parts to the OEM, the intensity of interdependence is relatively lower due to the slightly larger supplier base and smaller switching costs. B1 on the other hand, delivers many parts to the OEM that are used for customer adaptations which is quite important to the OEM specialization strategy. Nevertheless, these parts are interchangeable thus relatively less uniqueness in product offerings.

Considering the uncertainty of demand, the level is quite low for all tiers as the OEM usually keeps a quite stable forecast for weekly or monthly scheduling. This stability here is referred to

as being in 'normal' situations since Covid-19 is a totally different story when it comes to impeded demand certainty. There are two things to be concerned here that might affect the uncertainty of demand for these suppliers. One is that tier-2 suppliers operate further away from the use point which usually leads to more uncertainty as they need to deliver much earlier to ensure the flow of materials. Tier-1 suppliers, however, deliver within the three weeks of the frozen period where changes are barely made. The second factor is that tier-2 suppliers are also dependent on the tier-1 suppliers to feed them the full delivery schedules sent by the OEM. The team therefore, ranks the intensity of interdependence between these suppliers and the OEM as: A2 = B2 > B1 > A1; and the uncertainty of demand as: B2 = B1 > A2 = A1. The summary of the categorization and the recommended information level is shown in Figure 10.



Figure 10: Recommended information Sharing Level with Key Partners based on the framework adapted to Kembro and Selviaridis, (2015).

7. Conclusion

RQ1a How has the Covid-19 pandemic impacted multi-tier supply chains in the EU automotive industry?

In the beginning of the year 2020, as per the respondents of the interviewed companies, it was not expected that the pandemic of Covid-19 would affect the EU automotive industry. However, the impacts were seen in a significant amount when Covid-19 hit Italy and Spain in March 2020. Though it has been almost two years since Covid-19 was discovered in China, the impacts of Covid-19 are still experienced by almost all the interviewed companies. The report studied the Covid-19 impacts and could see a clear categorisation of these impacts into direct impacts and indirect impacts. Initially in the year 2020, the interviewed companies experienced all the direct impacts discussed earlier in the report like government restrictions, transportation disruptions, supply and demand shortages and production stops. However, these companies have eventually evolved from these experienced direct impacts by adapting to the changes that these impacts have brought to their respective supply chains.

Gradually in the year 2021, Covid-19 started to show some indirect impacts on the automotive industry which were of different nature than the observed direct impacts. Through the studied indirect impacts, it is observed that Covid-19 has been a game changer in the automotive industry and has shifted the power dynamics in the automotive supply chains. The semiconductor crisis has been one of such indirect impacts which is seen as one of the most widely seen impacts on the interviewed companies. The changing consumer behavior and order patterns which have created high demand uncertainty is also an indirect impact and is seen as a new research area in the ongoing trends in the automotive industry. Another trend was the rise of emerging players like semiconductor manufacturers and logistics providers who seemed to be controlling the multi-tier automotive supply chains.

RQ1b How is the OEM's supply chain performing in the area of SCRM during Covid-19?

The SCRM methods used by the interviewed companies during Covid-19 were analyzed using the presented SCRM framework. In order to minimise the impacts of Covid-19, which is treated as a case of post-disruption state, the framework suggested several effective reactive strategies as per the severity of supply chain risks. By categorising the interviewed companies into different supply chain types based upon the companies' contexts, it was found that these companies extensively implement the suggested reactive SCRM strategies. The reactive SCRM method of 'visibility and transparency' has been implemented using blockchain technology by the company B1 which was seen as a unique case among the interviewed companies. However, reactive SCRM strategies like multiple sourcing and flexibility were not used by companies A1, A2 and B2 due to reasons like product portfolio and transaction costs involved in multiple sourcing. It is important for OEM AB to be aware of such constraints involved specific to its certain suppliers which will help OEM AB to efficiently manage supply chain risks concerned to such suppliers.

Similarly, for the new normal state when the Covid-19 impacts are stabilised, which is identified as an ante disruption state, the interviewed companies are recommended with certain proactive SCRM strategies after understanding the severity of supply chain risks. These strategies could be used by OEM AB to govern its supply chain partners to prepare themselves in a better way for future disruptions. The importance of 'visibility and transparency' as an important proactive as well as reactive SCRM should be considered by OEM AB by analysing the benefits to mitigate and avoid supply chain risks. This SCRM method could also be implemented to fulfill different objectives like environmental, social and economic sustainability.

RQ2 How should the OEM increase transparency in their multi-tier supply chain as a SCRM to enhance resilience and prevent future disruptions?

a) How transparent is the OEM?

By mapping the current supply chain transparency of OEM AB, it can be perceived at an early majority stage considering the transparency milestones achieved and supply chain scope. The future journey towards becoming fully transparent would involve steps to be taken in a systematic way by focusing on target supply chains in order to fulfill the objectives planned through these initiatives. Improving the supply chain transparency requires efforts to be put in both the elements of visibility and information sharing by OEM AB. While increasing the visibility through the supply chain tiers, OEM AB should look into advanced technologies like blockchain and understand the use cases to improve the anticipation of future disruptions thereby overall supply chain's performance.

b) Which transparency barriers should/must be overcome in multi-tier supply chains to allow efficient information sharing?

From the six discussed categories of barriers in information sharing, information utilization is

recognized by all interviewed firms in the OEM's supply chain that should be overcome to allow efficient information sharing. The analysis result indicates that most suppliers find it difficult to use data sent by the OEM without giving some forms of explanation on what the data is intended to be used for. Having a benefit/risk sharing model in place is believed to be essential for increasing transparency and the willingness to share between the tier-1 suppliers and the OEM. The strategic partners being identified are A2 and B2 which both claim that the problem with OEM AB's supply chain is that it is too complex, long and lacks control. They also emphasized that it would be efficient for a dominant player to bring partners along the value chain together to enhance the implementation of information sharing. Such leaders will take the initiatives to promote the business model and establish standardized IT platforms and formats for date exchange. Although power asymmetry may entail some negative impacts, it has its merits in effectively addressing other scabrous barriers such as business process, technology utilization and cultural issues.

It is important to consider addressing these barriers with the sense of priority and supply categorization in mind. This is due to the fact that these suppliers each represent a special characteristic of the business relationship with OEM AB and for the suppliers with less strategic importance of the focus company, their concerns regarding transparency barriers might be dealt with of lower level of urgency.

c) What is the recommended level of information sharing/transparency based on the OEM's supply chain?

The following conclusion is made based on the lesson learnt from literature review and the empirical findings. To reduce the exhaustion of supply so that more supply could be secured for the company, OEM AB needs to increase the accuracy of the tactical information they share with B2 and make sure the data is fed throughout the value chain so that 100% accurate data is passed to B2. This will help the upstream partner to better reserve adequate capacities for OEM AB. The OEM is also encouraged to have better joint-planning and coordination to enhance understanding of the difference of each other's manufacturing environment so that common grounds can be found for areas of negotiation. Given the premise that the OEM would consider entering a more strategic relationship with B2, OEM AB is recommended to share strategic information with B2 such as yearly demand plans, future trends and technology developments. A2 represents high market value and strong interdependence with OEM AB and with low demand uncertainty. It is therefore recommended that the OEM focuses on increasing the

sharing of strategic information such as yearly demands, insights on 1-3 year period of market trends with explanation and focus on the accuracy of the operational level of information sharing. By this way, both companies will benefit from reduced inventory, better production planning and co-growth within the alliance. There is no need to increase information sharing with A1 and B1 as compared to the current level. It is sufficiently predictable for suppliers at this level to rely on the regular delivery schedules sent by the OEM and it is not worth investing in increasing the level of information sharing due to the low intensity of interdependence represented by the two companies.

The analysis and conclusion for this thesis was made specifically adapted to the contexts of the studied companies. For future implications, the OEM could identify key supply chain partners and what information to be shared with whom using the discussed framework based on the intensity of interdependence and the level of demand uncertain.

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APPENDICES

APPENDIX A: Questions for all the interviewed companies

Questions for RQ1:

- 1. Can you please give an overview of your company and where it stands in the supply chain?
- 2. Did the Covid-19 pandemic impact the company? If yes, can you describe?
- 3. Can you explain the impact of Covid-19 on the procurement function specifically?
- 4. What are the supply chain risks identified by the company (ex. supply & demand risks)? Have they changed before Covid-19 & during Covid-19?
- 5. How are you responding to these risks? Do you have a supply chain risk management (SCRM) strategy in place? Do you define it as a proactive/reactive/mix? Do you deploy any tools in SCRM process?
- 6. How can you define your relationship with your suppliers? How has it evolved in the storm of Covid-19?
- 7. Has Covid-19 been instrumental in changing your company's supply chain and overall strategy? If so, please tell us more about it.
- 8. Do you identify multi-tier supply chains as a risk? If so, how?

Questions for RQ2:

- 1. Do you think transparency is important in the improvement process to enhance supply chain resilience and prevent future disruptions? If so, can you explain?
- 2. Which transparency barriers must be overcome in multi-tier supply chains to allow efficient information sharing?
- 3. Are you investing in digitalisation of the purchasing organisation? Has Covid-19 accelerated and/or affected this decision?
 - If yes, are there any specific technology tools for information sharing between suppliers that your company is using/planning to use or that you are aware of being used by the industry?
 - Do you see any issues with digitalization, for example, finding the right competence inside and outside of the company to be able to put the right solutions in place?

- 4. Can you describe what you believe as the ideal level of information sharing with respect to tier 1, tier 2 and tier 3 suppliers? Especially considering the automotive industry? And why?
- 5. If approached by your customers, will you be willing to share information about the full visibility* of your supply chain?
 - If yes, to what level?
 - If not, why? What factors will affect your un/willingness to share the information?
 (* By visibility, we mean ex. who are your sub-suppliers, where are the sub-suppliers located, supply chain risks at sub-suppliers, capacity risks at sub-suppliers, what the sub-components consist of, etc.)
- 6. At which stage of doing business with the customer do you prefer to disclose such information?

APPENDIX B: Extra Questions for OEM AB exclusively

- 1. Can you please describe how interdependent* OEM AB is with the following suppliers? Please motivate.
- A1
- A2
- o B1
- B2

(*by interdependence, we meant that for example, the percentage of each other's portfolios in terms of volume and value, number of alternative buyers and suppliers, switching costs and uniqueness of offering.)

- 2. Can you please describe how uncertain OEM AB's demands are (during Covid-19 or after Covid-19?) for the products of the following suppliers? Please motivate.
- o A1
- A2
- B1
- B2

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