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ENSURING MATERIAL AVAILABILITY BY USING RISK MANAGEMENT PROCESS IN POWER AND AUTOMATION INDUSTRY

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ABSTRACT

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Managing supply risks is essential in order to ensure smooth material flow and business continuum. Any disruption in a supply chain can have significant impact on buying companies' material availability. To reduce the risk effects and probability, the implementation of appropriate risk management strategies is needed. The aim of this study is to find out how material availability can be ensured by using risk management process. In this study, the topic is investigated in one company from power and automation industry. The study concentrates on its one business unit, after-sales service. One of the main tasks of this study is to build a risk assessment and monitoring tool for the case business unit. The purpose of the tool is to identify the most significant supplier-related risks and risk suppliers in the case unit. Also, it enables to monitor the development of risks and suppliers' performance.

The empirical part of this study was conducted as a qualitative case study and the data was collected from nine semi-structured interviews. Also, one workshop was organized. The data was analyzed through content analysis method. The results indicated that by implementing carefully all four risk management process steps the supply risks can be managed effectively. As the supply risks are identified in the early phase and evaluated carefully, the focus of supply risk mitigation actions can be moved to the most significant risks. The development of risks and supplier's performance need to be monitored continuously to react immediately to any changes. Through these risk management process steps, the material availability can be ensured.

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Toimitusriskien hallitseminen on välttämätöntä, jotta yritykset voivat varmistaa tasaisen materiaalivirran sekä yritystoiminnan jatkuvuuden. Mikä tahansa häiriö toimitusketjussa voi vaikuttaa merkittävästi ostavan yrityksen materiaalin saatavuuteen. Pienentääkseen riskin vaikutusta ja todennäköisyyttä sopivien riskienhallinnan strategioiden käyttö on tarpeellista. Tämän pro gradu -tutkielman tarkoituksena on selvittää, kuinka materiaalin saatavuus voidaan varmistaa käyttäen riskienhallinnan prosessia. Tässä tutkimuksessa tätä aihetta on tutkittu yhdessä sähkö- ja automaatioteollisuuden yrityksessä. Tutkimus keskittyy kyseisen yrityksen yhteen liiketoimintayksikköön, myynnin jälkeiset palvelut -yksikköön. Yksi tämän tutkimuksen tärkeimmistä tehtävistä on rakentaa riskien arviointi ja monitorointi työkalu case-liiketoimintayksikölle. Työkalun tarkoituksena on tunnistaa case-liiketoimintayksikön merkittävimmät toimittajakohtaiset riskit ja riskiset toimittajat. Lisäksi työkalu mahdollistaa riskien kehittymisen sekä toimittajien suorituskyvyn monitoroinnin.

Tutkimuksen empiirinen osio on toteutettu laadullisena case-tutkimuksena ja data on kerätty yhdeksän puolistrukturoidun haastattelun kautta. Lisäksi yksi työpaja järjestettiin. Data analysoitiin käyttäen sisällönanalyysin menetelmää. Tulokset osoittivat, että implementoimalla huolellisesti kaikki neljä riskienhallinnan prosessin vaiheet, riskienhallinta on tehokasta. Kun toimitusriskit tunnistetaan varhaisessa vaiheessa ja arvioidaan huolellisesti, riskienhallinnantoimet voidaan kohdistaa merkittävimmille riskeille. Riskien sekä toimittajien suorituskyvyn jatkuva monitorointi on välttämätöntä, jotta muutoksiin voidaan reagoida heti. Näiden riskienhallinnan eri vaiheiden kautta, materiaalin saatavuus voidaan varmistaa.

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Julia-Eveline Ussik

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1. INTRODUCTION

1.1 Background

Companies have adopted new business strategies, such as globalization and outsourcing (Tang & Musa 2011, 25). As the result of these new strategies, the supply chains have become longer and more complex (Cucchiella & Gastaldi 2006, 701) as there are more suppliers participating in one supply chain (Tang & Musa 2011, 27), the "end-to-end" visibility is weak (Christopher & Lee 2004, 3) and supply chains operate in numerous geographical areas (Christopher, Mena, Khan & Yurt 2011, 68). Although these new trends have provided many advantages, such as increased competitive advantage, improved customer satisfaction and enhanced productivity (Cucchiella & Gastaldi 2006, 700), the risk of supply chain performance's failure has increased (Tummala & Schoenherr, 2011, 474). In the past, risk management was easier when companies sourced locally, produced materials in-house and sold directly to customers. Nowadays, the global and complex supply chains are more vulnerable for disruptions and managers are facing new challenges to identify and manage the risks that cause these disruptions. (Harland, Brenchley & Walker 2003, 51) Disruptions are unplanned events that disturbs the normal flow of materials (Svensson 2000, 731) and can potentially cause huge damages to supply chains (Craighead, Blackhurst, Rungtusanatham and Handfield, 2007, 132). Therefore, the importance of effective supply chain risk management (SCRM) has increased and become one of the main areas of companies' business strategy and success (Narasimhan & Talluri 2009, 115).

According to Wagner and Bode (2008, 307) the concept of SCRM has gained a lot of attention from academics as the world has faced series of crises, such as natural disasters and epidemics and as the modern supply chains are more vulnerable for disruptions than before. Narasimhan and Talluri (2009, 114) have stated that risk management is an important field in supply chain management and according to Rao and Goldsby (2009, 98) it is considered as a part of a holistic supply chain management ideology. Olson and Wu (2010, 703) highlight that supply chains are one of the most critical field of modern companies and SCRM is highly important. Craighead et al. (2007, 131) have recognized that supply chain risks impacts significantly on company's operational and financial success. According to Sodhi, Son and Tang (2012, 2) supply chain disruptions can even effect on company's stock

prices for a long time and lead to “loss of reputation and even loss of life.” Although, supply chain risk management has been a growing topic area in literature and it has been recognized as a highly important topic, Vieira (2020, 22) reminds that managing supply chain distributions is extremely challenging for companies.

Companies can face many different types of supply risks. These risks can be related to, for example, demand risks, delay risks and transportation risks. (Tummala & Schoenherr 2011, 475) Many real-life examples of supply chain disruptions that have had major impact on companies' performance can be shown. Normann and Jansson (2004, 441-442) described in their article one typical example of supply chain disruption that happened to Ericsson in 2000. Ericsson’s sub-supplier had fire accident in their plant that caused immediate disruptions in material supply. In that time, Ericsson used only single source strategy and it did not have alternative active sources available. The fire accident caused about 400 million dollars loss for Ericsson. Another disruption examples, that have caused huge damages to supply chains are the terrorist event on September 2001 in US and SARS epidemic in 2003 (Christopher & Lee, 2004, 389). Supply disruptions can become very expensive for a company (Craighead et al. 2007, 132). According to Berger, Gerstenfeld, and Zeng (2004, 9) a closed plant can cost a million dollar per hour for a huge auto manufacturer. One company estimated in the research made by Rice and Caniato (2003, 29) that disruptions in their supply chain costs 50-100 million dollars per day. Most recently, organizations are facing consequences of COVID-19 pandemic that already have had huge impact on supply chains globally (Vieira 2020, 22). These examples highlight the importance of effective SCRM and indicate that the type and nature of supply chain risks and their consequences are difficult or even impossible to predict (Heckmann, Comes & Nickel 2015, 120).

Literature has recognized a plenty of different supply chain risk management strategies (Faisal 2009, 46; Elkins, Handfield, Blackhurst, & Craighead 2005, 49). Even though it is possible to mitigate supply risks with the help of different supply mitigation strategies, it is impossible to eliminate risks completely (Zsidisin, Panelli & Upton 2000, 190). Although the concerns about the supply chain risks have increased, only few companies have implemented effective risk management actions (Fahimnia, Tang, Davarzani & Sarkis 2015, 2). Furthermore, according to the study made by Zsidisin et al. (2000, 187) many companies admitted that there could be done more risk mitigation actions in their companies. Therefore, SCRM is an attractive research area.

1.2 Research questions

The previous chapter indicated that SCRM has been investigated extensively for the last two decades. The previous literature has investigated several approaches such as supply risk categories, risk management process and risk mitigation strategies (Olson & Wu 2010, 695). According to Zsidisin and Ellram (2003, 24) all companies face supply risks and therefore it is critical for company's success to identify the risk sources and implement appropriate risk management strategies. Supply disruptions cause severe risks for companies, because disruptions affect on material availability. Zsidisin and Ellram (2003, 24) highlight that the unavailability of materials has major impacts on the continuity of business and Alonso, Gregory, Field and Kirchain (2007, 6649) state that ensuring material availability is critical for all companies. Therefore, it is important to combine these topics and investigate these further. There are several studies concerning SCRM that have investigated the supply risk management process in supply chains. However, there are still only limited amount of empirical studies in the area of SCRM and more case-study based researches are needed (Sodhi et al. 2012, 11). Also, there is limited amount of studies that investigate the relationship between SCRM process and material availability. This study aims to find out how the material availability can be ensured by implementing a risk management process in power and automation industry. Thus, the main research question of this study is

"*how to ensure material availability by using risk management process?"*

This main research question aims to investigate how material availability can be ensured by using SCRM process. The aim is to investigate the relationship between ensuring material availability and SCRM process. The purpose of other three sub-questions is to support the main research question. First sub-question is "*which supply risks may influence on company's material availability?"* The aim is to find risks, that may have an impact on company's material availability and that disturb the smooth material flow. This is essential as in order to manage risks effectively, risk sources need to be identified (Chopra & Sodhi 2004, 54).

Second sub-question is "*how to identify the most significant supplier-related risks and risk suppliers?*" The aim of this question is to find the most significant supplier-related risks among the all identified risks. The purpose is to concentrate on risks, that are significant to the case company's business unit's (after-sales service) and that have a major impact on the

case unit's material availability. This study aims to develop a tool, that will help to identify supplier-related risks and risk suppliers. The tool would be based on the risk matrix that then will be develop further in order to respond to the case unit's needs. The focus will be on the case company's key suppliers.

As the focus of this study is on ensuring material availability by managing risks, the different risk management strategies need to be investigated. Therefore, third sub-question is "*what kind of actions and strategies are used to manage supplier-related risks?*" According to Hallikas and Lintukangas (2016, 488) there are many different ways to manage the identified risks. The purpose is to find the most efficient actions among all identified risk management action. These three sub-questions aim to identify the most significant supplier-related risks that impacts on case unit's material availability and find out how these risks are managed. These questions help to find an answer for the main question and thus are significant for this study.

1.3 Conceptual framework

The purpose of this chapter is to present the conceptual framework of this study. The conceptual framework presents the theoretical perspectives and their linkage with the topic. Figure 1 presents the theoretical framework of this study.

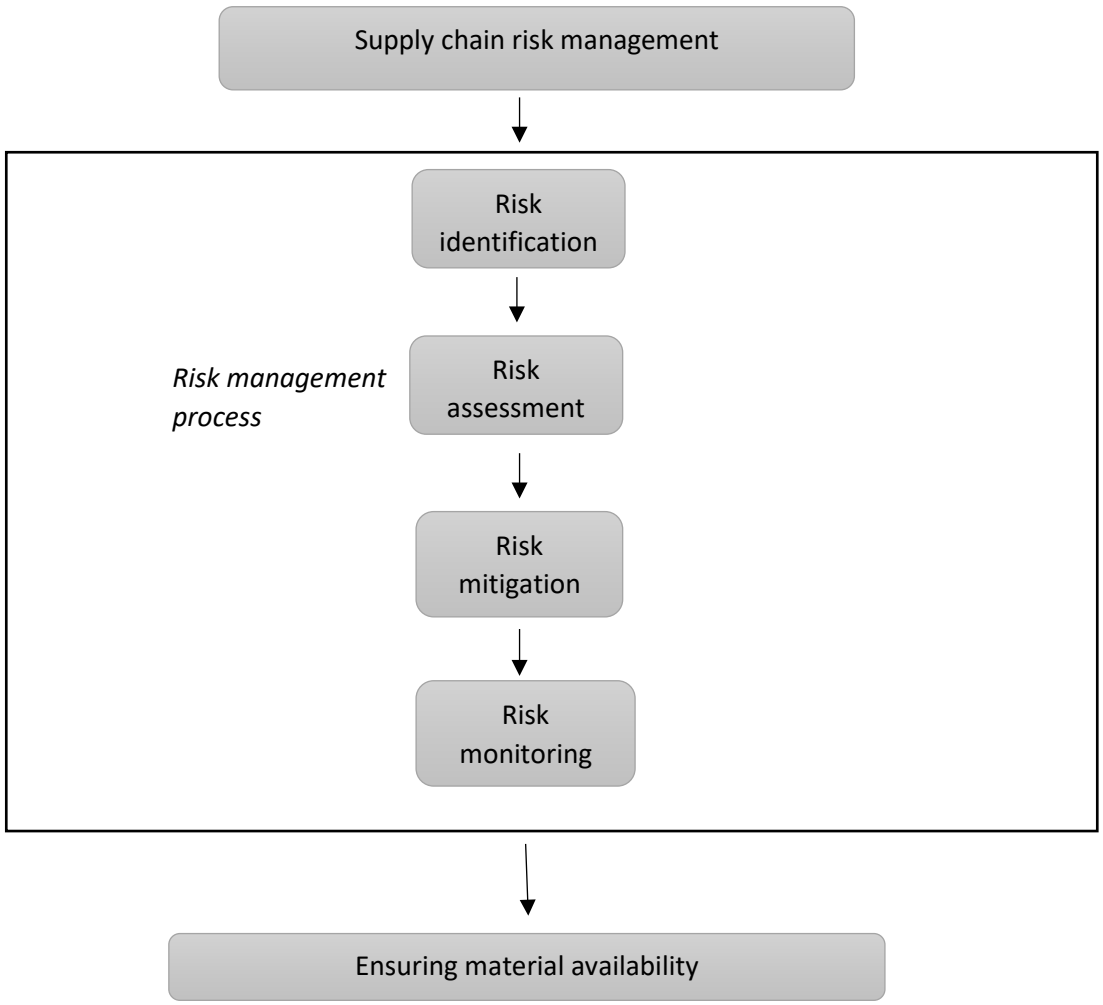


Figure 1. Conceptual framework

The first concept in the top of the figure 1 provides a base for this study. The purpose is to understand the nature of SCRM. After understanding the nature of SCRM, the study explores the supply chain risk management process that starts with risk identification. Risk identification identifies all risks and categorizes them according to their probability and impact. After this phase, the identified risks are evaluated. The next step is to find appropriate ways to mitigate the most significant risks that effect on supply chain's material availability. The process needs to be repeated and the risks are monitored and viewed continuously. The risk management process, that is presented in this study is viewed from the supply chain perspective and the focus is on risks that arise from supplier-side. Later, the theory of this study is applied to the empirical part and the theory is discussed based on the empirical findings. Eventually, with the help of the concepts and risk management process presented in the framework, the main research question of this study can be explored from the point of view of the case business unit.

1.4 Key concepts

The purpose of this chapter is to define the key concepts of this study. These key concepts are: supply risk, supply disruption, risk management, supply chain risk management, key suppliers and SRM.

Supply risk

There exist many different definitions for supply risk. Zsidisin (2003, 217) has provided a grounded definition for supply risk and describes supply risk as "the potential occurrence of an incident associated with inbound supply from individual supplier failures or the supply market, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety."

Supply disruption

Supply disruption refers to unexpected events that disturb the normal flow of goods and materials within a supply chain (Svensson 2000, 731). Supply disruptions can arise from many different sources such as natural disasters, political instabilities and strikes (Kleindorfer & Saad 2005, 54). Disruptions are harmful as they can impact negatively on production and distribution, damage sales and decrease company's revenues (Revilla & Saenz 2017, 558). Craighead et al. (2007, 131) argue that supply disruptions are hard to avoid and all supply chains are exposed to disruptions.

Risk Management

The purpose of risk management is to protect a company from harmful events that have negative influence on company's performance (Gaudenzi & Borghesi 2006, 116). Risk management has been described as "the process whereby decisions are made to accept a known or assessed risk and/or the implementation of actions to reduce the consequences or probability of occurrence." There have been identified four basic actions for risk management: avoid, reduce, share or accept. (Norrman & Jansson 2004, 438-439)

Supply chain risk management

Supply chain risk management does not mean only responding to disasters. The purpose of supply chain risk management is to ensure that a complex process moves efficiently keeping the costs low and quality high. (Hauser 2003, 64) Supply chain risk management can be

defined as identifying the risk sources and implementing effective actions in order to avoid or reduce supply chain vulnerability (Jüttner, Peck & Christopher 2003, 9). Fan and Stevenson (2018, 210) have defined SCRM as following: "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."

SRM

Supplier relationship management (SRM) is an approach to manage interactions with suppliers. SRM refers to building relationships with suppliers and the aim is to create "win-win" situations where both parties benefit. (Mettler & Rohner 2009, 59) The purpose is to collaborate with a supplier in order to increase the competitive advantage and manufacture products effectively (Park, Shin, Chang & Park 2010, 496). Through carefully implemented SRM practices a buyer can ensure reliable deliveries in today's complicated and dynamic business environment. SRM practices consist of improving suppliers' quality, building trustful relationship, reducing lead times, collaborating and building partnerships. (Al-Abdallah, Abdallah & Hamdan 2014, 192)

Key supplier

Key suppliers are strategic assets for a buying company and key suppliers need to be managed differently in order to utilize their potential for value creation (Ivens, Van de Vijver & Vos 2013, 137). Key suppliers are strategically important to a buyer and improves buyer's competitive advantage. Therefore, it is important to build strong relationships with key suppliers. (Wu & Wu 2015, 185)

1.5 Limitations

Certain limitations regarding the topic of this research have been made due to the aims of this study. This study utilizes risk management process to answer the main research question and other methods are left out from this study. This will ensure that the focus is not too broad. Furthermore, the perspective of this study is on ensuring material availability by risk management and other perspectives are not investigated in this study. Although, the focus is

on risk management in supply chains, the view is on risks which are arising from the supplier-side. This means that the risks which may occur in the end of the supply chain, for example between a buying company and the end customer are left out from this study. Furthermore, the focus of this study is on buying company's perspective.

Different tools for risk management in supply chains have been identified. In this study the main tool will be risk matrix, that helps to identify the significant risks. The risk matrix is developed further to answer the case unit's needs and in the empirical part, the tool will be used both in risk assessment and monitoring. Other tools are not used in this study, as the purpose is to build a simple risk assessment and monitoring tool for the case unit. The focus will be on supply risks which are common for key suppliers because the key suppliers are extremely important for a company's performance. Usually, the key suppliers are able to provide exceptional value and strategic inputs for a buying company (Miocevic & Crnjak-Karanovic 2012, 121). Suppliers, that are not key suppliers, are left out of this study.

This study takes only the case business unit's perspective, which brings its own limitations. This means that the research is limited to only one company from power and automation industry and furthermore it concentrates only on the company's one business unit, after-sales service. However, the larger business unit, factory side, is also mentioned in the empirical part as after-sales service business unit is part of the factory side and affected by factory side's decisions to some extent. The empirical results of this study could be different if the interviews were conducted from different industries or even different business units.

1.6 Research methodology

This study utilizes qualitative research methods in the empirical part. According to Eriksson & Kovalainen (2008, 2) the qualitative methods aim to find answers for "how" questions and find the insight for phenomenon which are less known. The qualitative research method was selected as it was seen to be most suitable for answering the research questions and solving the main issue of this study. Primary data was collected through nine semi-structured interviews. The purpose of the interviews is to discuss with the professionals about the topic and find answers to the research questions. The findings from the interviews will be analyzed and discussed further. In addition, the purpose is to organize one workshop, where the group of interviewees are gathered together. The aim is to build a new tool, which is based on the

risk matrix, for evaluating and monitoring supplier-related risks. The interviews were held in Finnish in order to ensure that the conversation is smooth. Case company websites were utilized when collecting the secondary data. The data for theoretical part is collected from the academical publications and multiple studies from different time periods were utilized.

The focus of this research is on one company and most of the data are collected from the case company's after-sales service business unit. However, as the after-sales service business unit is a part of a factory side, also one interview from the factory side was conducted. The questions vary according to the interviewee's position. The aim of this study is to investigate how SCRM process can be utilized in ensuring material availability. As the number of interviewees are limited and the study concentrates only on the certain business unit, this study covers only limited perspective of the issue. The purpose is to bring up a new perspective of this issue from the point of view of the case business unit which means that this study will not provide a holistic view of the issue.

1.7 Structure of thesis

This study consists of four main parts that are theoretical part, methodology, empirical findings, and conclusion. The theoretical part consists of one main chapter: supply chain risk management. The main chapter is built from three minor chapters that are supply risk, supply chain risk management and ensuring material availability.

The first minor chapter of the theoretical part, supply risks, aims to identify different risks related to supply chain and explains their drivers. The chapter categorizes the identified risks into eight groups and defines their meaning more deeply. The second chapter concentrates on explaining the SCRM and the SCRM process. In this study, the SCRM process consists of four steps: risk identification, risk assessment, risk mitigation and risk monitoring. These process steps are explained in their own chapters. Last minor chapter of the theoretical part introduces how the material availability can be ensured. In this study, ensuring material availability is investigated through risk management process. Especially, the risk mitigation step is highlighted, and the last chapter concentrates on this step. This study utilizes three different risk mitigation strategies that are increasing knowledge, reducing probability and reducing effect. These are explained more deeply in their own chapters.

After the theoretical part, the third chapter will explain the research methods and how the data has been collected and analyzed. At this point, the case study is introduced but the company will stay anonymous. Then the study will move on to the fourth chapter, empirical part. The results of semi-structured interviews are presented, and the empirical findings will be analyzed and discussed. Furthermore, the risk assessment and monitoring tool that will be built in the workshop, will be presented and discussed. The last chapter will conclude the study and introduce the results that were found during the study. This chapter will answer the research questions, present limitations, reflect theory into empirical findings and provide ideas for the future researches.

2. SUPPLY CHAIN RISK MANAGEMENT

Every buying company is exposed to supply chain risks. Risk is related to an event that causes uncertainty, unwanted losses and negative consequences (Tummala & Schoenherr 2011, 474). According to Blos, Quaddus, Wee and Watanabe (2009, 247) risk in supply chain arise from two main areas: supply and demand. Jung, Lim and Oh (2011, 610) stated that supply chain risks may originate from a buying company's own mistake, supplier failure, or external conditions. Buying companies need to implement effective SCRM strategies in order to manage risks and avoid negative consequences. SCRM is related to risk management that concentrates on the risks that arise from a supply chain (Pfohl, Köhler, & Thomas 2010, 40). The focus of SCRM is on avoiding negative consequences that risk events might have in a supply chain (Norrman & Jansson 2004, 435). SCRM can be seen as one of the strategic management activities in a company as it has influences on company's operational, financial and market performance (Narasimhan & Talluri 2009, 114).

2.1 Supply risks

Since the 1990's many companies have aimed to increase revenues and decrease costs by applying different supply chain activities (Sodhi et al. 2012, 2). These activities are related to, for example, outsourcing, globalization and a shorter product life-cycle (Zhao, Huo, Sun & Zhao 2013, 115). Although these supply chain initiatives offer a great opportunity to improve a company's performance, they increase the complexity of a supply chain (Harland et al. 2003, 51) and make a company more vulnerable to uncertainties and disruptions (Mittal, Agarwal & Singhal 2011, 15).

SCRM has become an attractive research topic as the concerns about supply chain risks have increased among the managers. However, the area of SCRM is still emerging (Sodhi et al. 2012, 1). One major research area of past SCRM literature has focused on defining and categorizing supply risks and identifying their sources (Park, Min & Min 2016, 120). Although many researchers have defined supply risks (Zsidisin 2002, 217; Abdel-Basset, Gunasekaran, Mohamed & Chilamkurti 2019, 490; Heckmann et al. 2015, 130; Jüttner et al. 2003, 7) there is no one agreed definition (Heckmann et al. 2015, 122). Risks in a supply chain can be anything that disrupts the flow of material, information or products from the

original supplier to the end customer (Abdel-Basset et al. 2019, 490). Any financial, material or information issue can disrupt supply chain's normal operations (Tang & Musa, 2011, 26).

Before establishing and implementing proper risk management methods, managers must understand the different types of risks that may occur in supply chains. Also, understanding which events and conditions drive these risks is important (Chopra & Sodhi 2004, 54). The main purpose of risk classification is to help managers to identify the groups that cause the highest risk (Wu, Blackhurst & Chidambaram 2006, 351). There exist many studies where supply risks have been divided into two categories. Wu et al. (2006, 352) and Cucchiella and Gastaldi (2006, 307) divide supply risks into internal and external risks. External risks refer to environmental risks such as natural disasters and internal risks are related to for example supplier's quality problems (Abdel-Basset et al. 2019, 490). Tang (2006, 453) categorizes supply risk into operational risk and disruption risk. Operational risks refer to the daily management of a supply chain and disruption risks are related to disasters made by natural or human (Kouvelis, Chambers, and Wang 2009, 462). Risks have been also divided into three groups: environmental, such as natural disasters and political instability, network-related that arise from the interaction between supply chain partners and organizational, such as process or control risk (Jüttner et al. 2003, 10-11). Manuj and Mentzer (2008, 138) categorize supply chain risks in supply risks, operational risks, demand risks and security risks.

As it can be noticed, a lot of different categories exist for supply risks and supply risk can be viewed from different perspectives. Sodhi and Lee (2007, 1431) divide supply risk into supply-related risks and demand-related risks. Supply-related risks can be quite damaging, and they are usually related to disruptions and delays. Supply-related risks arise from the flow of material from an initial supplier to the focal firm (Manuj & Mentzer 2008, 138). Demand-related risks are associated with the final customer's unexpected decrease of demand and they can arise from many sources such as reputation damages, changes in customer's preference and forecast errors (Sodhi & Lee 2007, 1430). Manuj and Mentzer (2008, 139) add one more risk group, operational risk, in addition to supply and demand risk. Operational risks refer to a focal firm's inability to continue to produce goods and services. Operational risks arise from the focal firm's internal operations such as a breakdown of core operations that can decrease the product's quality level and cause delays. Figure 2. illustrates these risks in the extended supply chain.

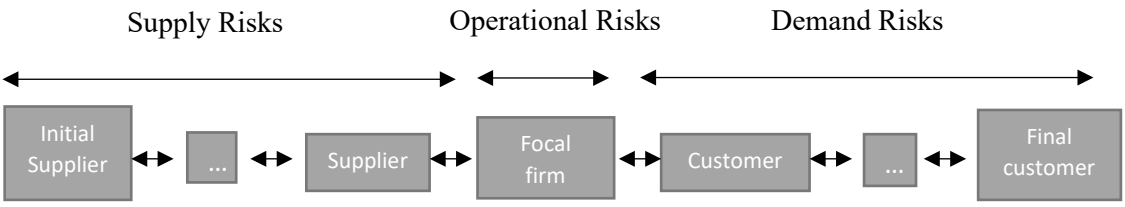


Figure 2. Risk in the extended supply chain (modified from Manuj & Mentzer 2008, 138)

As the purpose of this study is to find ways to ensure company's material availability, this study concentrates only on supply-related risks. Therefore, demand-related risks and operational risks are left out as they are not relevant to this study. This study utilizes the risk classifications from different studies (Chopra & Sodhi 2004, 54; Sodhi and Lee 2007, 1431; Blackhurst, Scheibe & Johnson 2008, 149) and modifies these classifications to respond to the needs of this study. Table 1 presents eight different risk categories and their drivers. These categories are capacity risk, delay risk, logistics risk, disruption risk, intellectual property risk, inventory risk, procurement risk and system risk. Some of these categories encompass the same risks. To make it clearer and reduce duplications, the delay risks in this study refers to any delays that are caused by supplier's operations and disruption risks are related to any external events, that can disrupt the smooth material flow.

Table 1. Summary of supply-related risk categories and their drivers

Risk category	**Risk drivers**	**Previous studies**
Capacity	Cost of capacity; lack of capacity flexibility: forecast errors	Chopra and Sodhi (2004, 54); Sodhi and Lee (2007, 143); Blackhurst et al. (2008, 149)
Delay	Supplier's high capacity utilization; supplier's inflexibility; supplier's poor quality; disruption in production; inability to stay up to date of technological changes and product design changes: supplier's financial health	Chopra and Sodhi (2004, 54); Sodhi and Lee (2007, 1433)
Logistics	Disruptions in transportation; excessive handling due to border crossing and custom regulations; the ruination or destruction of materials; challenges to access inventories; number of brokers and transfer locations; vessel capacity and channel overload;	Blackhurst et al. (2008, 149); Chopra and Sodhi (2004, 54); Cavinato (2004, 385)
Disruption	Natural disasters; wars and terrorism; labor dispute; sole sourcing; alternative suppliers' capacity and responsiveness	Chopra and Sodhi (2004, 54); Sodhi and Lee (2007, 1433); Blackhurst et al. (2008, 149)
Intellectual property	Supply chain's vertical integration; globalization; sourcing from the same supplier as competitors	Chopra and Sodhi (2004, 54); Blackhurst et al. (2008, 149)
Inventory	Cost of holding inventory; uncertainty in demand and supply; product obsolescence rate; value of the product; errors in forecasting	Chopra and Sodhi (2004, 54); Sodhi and Lee (2007, 1431); Blackhurst et al. (2008, 149)
Procurement	Exchange rate fluctuations; only sole source available for a key component; long-term vs. short-term contracts; price of a part	Chopra and Sodhi (2004, 54); Blackhurst et al. (2008, 149);
Systems	Breakdowns of information systems; system integration or too broad systems networking; e-commerce; IT platforms are not compatible among supply chain	Chopra and Sodhi (2004, 54); Sodhi and Lee (2007, 1431)

2.1.1 Capacity risk

Manufacturers' production capacity is limited which can cause problems in situations where demand varies (Zhao et al. 2013, 118). For example, the "bullwhip" effect (Lee, Padmanabhan & Whang 1997, 95) may cause demand fluctuations and cause problems to a manufacturer. According to Christopher and Lee (2004, 4) bullwhip effect describes "increasing fluctuations of order patterns from downstream to upstream supply chains" that can cause chaos to the supply chain. A manufacturer may lack of extra equipment and employees or the capability to acquire necessary inputs to handle consumption peaks (Zsidisin et al. 2000, 188). Increasing capacity is time-consuming and it requires investments (Sodhi and Lee 2007, 1432). Therefore, manufacturers are often facing problems with on-time delivery (Zhao et al. 2013, 118). On the other hand, when demand decreases quickly, attaining profits from excess capacity might be difficult for manufacturers. Limited capacity is one of the reasons why material is not available when needed. (Zsidisin et al. 2000, 188) However, building excess capacity impacts negatively on a company's financial health (Chopra & Sodhi 2004, 59).

2.1.2 Delay risk

Delay risk in a supply chain has been defined as time risk, that has a negative impact on a supply chain's performance (Truong & Hara 2017,1382). Delay risk may result from many reasons and any disruption in a supply chain can cause material delays (Tang & Musa 2011, 26). In this study, the delay risk refers to the disruptions that arise from a supplier's operations or business. Delay risk usually occurs when a supplier is not able to react to demand changes due to its high capacity utilization or another cause of inflexibility. Other drivers for delay risk are problems on a supplier or sub-suppliers side and supplier or sub-suppliers quality issues (Chopra & Sodhi 2004, 55).

Quality issues can arise when there is a lack of training for suppliers according to quality principles and techniques. Also, a supplier's incapability to maintain equipment can lead to quality failures. Buyers are facing a higher opportunity to receive materials that do not meet the expected quality level when the quality focus is not embedded into a supplier's operations. Also, a supplier's inability to keep up with technological changes and product

design changes can cause material delays. As these risks impact on lead-time, they also affect on costs, product competitiveness and customer's satisfaction. (Zsidisin et al. 2000, 188-189) The consequences of material delays are harmful and affect on a whole supply chain. Delays may paralyze production which in turn increases buyer's lead-time to customers, increasing the customers' dissatisfaction. (Zhao et al. 2013, 124).

2.1.3 Disruption risk

Disruption refers to unpredictable events that disrupt the normal flow of materials and components in supply chains (Svensson 2000, 731). Disruptions are rare but usually very damaging and hard to manage (Zhao et al. 2013, 117; Chopra & Sodhi 2004, 55). Disruptions in supply chain may become extremely costly and poorly managed disruption risks can cause major delays. This decreases the customer satisfaction level. (Blackhurst, Craighead, Elkins & Handfield 2005, 4068). According to the research made by Craighead, et al. (2007, 150) at some point all supply chains will face one or more unplanned events that disrupt the smooth flow of materials and components. Disruption risk can be caused by different external events, such as natural disasters and terrorist attacks. The most recent event that has caused major disruptions in supply chains globally is the COVID-19 pandemic. COVID-19 pandemic has showed what kind of impacts disruptions can have globally as individual supply chain nodes have failed. (Golan, Jernegan & Linkov 2020, 222) COVID-19 pandemic is seen as the most severe disruption risk in the last decade (Nikolopoulos, Punia Schäfers, Tsinopoulos & Vasilakis 2021, 101).

Although disruption risks are considered rare, the probability of disruption risks is higher than earlier as the supply chains nowadays are more complex and longer than before (Kleindorfer & Saad 2009, 53). According to Paul, Sarker, and Essam (2016, 3) disruptions can occur in supply, transportation, and production. For example, production can be shutdown because of strikes that can paralyze distribution globally (Sodhi & Lee 2007, 1431). Also, disruptions in transportation can be caused by strikes or natural disasters (Paul, et al. 2016, 3). According to Bode and Wagner (2015, 219) the number of suppliers and supply chain tiers and also the level of global sourcing affect on the occurrence of disruption risk. Large supply base can increase the frequency of disruptions but on the other hand it can decrease the severity of disruptions. Large number of tiers in supply chain increases the

potential for chain reactions especially when upstream suppliers face disruptions. High level of global sourcing increases the complexity of supply chain and the probability of disruption risk.

2.1.4 Logistics risk

Logistics has an important role in delivering goods and materials on time and without damages (Bardi, Raghunathan & Bagchi 1994, 71). As supply chains have become longer and more global, materials are moving over great distances and across more borders. International shipments are harder to coordinate, and they are more vulnerable to disruptions. (Crone 2007, 28) According to Ellegraad (2008, 426) logistics risk is one of the most common supply chain risks as most companies face problems in logistics regularly. Logistics risk can occur during transportation, warehousing, material handling, or processing. Logistics risk may occur as the transportation disruptions, the ruination or destruction of materials and difficulties to access inventories. (Cavinato 2004, 385) Logistics plays a huge role in materials on-time delivery to customers. Any issues in border crossing, custom regulations or infrastructure can cause material delays (Blackhurst et al. 2008, 149).

Sanchez-Rodrigues, Potter and Naim (2010, 62) identify four main factors that may cause risk in transportation operation: delays, demand and information issues, delivery constraints and lack of coordination. Transportation disruptions can arise due to vehicle breakdown, strikes, road work and natural disasters (Paul et al. 2016, 3). For example, flooding can lead to road closures (Sanchez-Rodrigues et al. 2010, 48). Transportation risk can occur in every level of the supply chain, but the highest impact arises when the risk occurs between the first-tier supplier and the warehouse (Paul et al. 2016, 3).

2.1.5 Intellectual property risk

Intellectual property is related to a company's confidential information, such as data, parameters and process of industrial design and manufacturing (Deng, Huet, Tan & Fortin 2012, 632). As supply chains have become global and less vertically integrated and companies are outsourcing from the same supplier as their competitors, the intellectual property risk has increased rapidly. Intellectual property risk has serious and long-term

impacts as the competitive advantage of a company might suffer. Also, the risk is that the key supplier redesigns the parts and establishes own production. (Chopra & Sodhi 2004, 57) Confidential information can leak mistakenly, for example, through the information channels of the supply chain (Deng et al, 2012, 632).

2.1.6 Inventory risk

Companies hold inventory to satisfy customers demand which in turns increase revenues. On the other hand, holding inventory especially under uncertain market situations is risky. (Lai, Debo & Sycara 2009, 811) Excess inventory has a negative influence on a company's financial health. The inventory risk increases dramatically if a product's value and its rate of obsolescence are high and the uncertainty of demand and supply increases. (Chopra & Sodhi 2004, 58) The excess inventory combined with decreasing material prices hurts companies' financial performance. Also, errors in forecasting increases inventory risk. Too high forecast may lead to excess inventories, however, when the forecast is too low, the risk of delays and material unavailability increase. (Sodhi & Lee 2007, 1434-1435) Holding excess inventory for products that are expensive, or their life cycles are short is costly. On the other hand, holding inventory for products that are low valued and have long life cycles is a good way to ensure short-term material availability. Furthermore, inventory risk increases as the variety of products increases. (Chopra & Sodhi 2004, 58-59)

2.1.7 Procurement risk

Procurement risk refers to exchange-rate risk and supplier's price increase. The likelihood of procurement risk and the price increase is higher when a company uses only a single supplier. (Chopra & Sodhi 2004, 57-58) Exchange rate risk has a major influence on a company's net profit and certain operational decisions such as supplier selection (Tang & Musa 2011, 29). The exchange rate risk can increase the price for the material that is purchased from a supplier, who is located abroad or whose suppliers are located abroad (Zsidisin & Ellram 2003, 17). Procurement risk can occur also when a supplier increases prices of the key components or the transportation costs increases unexpectedly (Chopra & Sodhi 2004, 57). The type of contracts with suppliers can influence the procurement price.

In short-term contracts, the market price can be quite volatile, and a buying company can face price increases. By selecting a long-term contract, a buying company can avoid unexpected price increases. (Li, Murat, & Huang 2009, 833) On the other hand, long-term contracts might not reflect the current market prices (Spekman & Davis 2004, 420).

2.1.8 System risk

As companies are more dependent on technology, they are more vulnerable to IT problems or breakdowns. Working in networks increases the probability of IT-system breakdown, which can destroy the highly networked environments. For example, if a supplier's order-entry system goes down, it can disturb the smooth material flow. (Chopra & Sodhi 2004, 56-57) By sharing internal processes and systems to suppliers and customers, a company is exposed to a greater risk of hackers' attacks and data-stealing. The company's IT system integration is as strong as the weakest firewalls of its partner. (Spekman & Davis 2004, 417) Too extensive system networking and a lack of effective integration of systems may increase the probability of system risk occurrence. Also, if the IT platforms among supply chain partners are not compatible, the risk increases. (Tummala & Schoenherr 2011, 475)

2.2 Supply chain risk management process

The knowledge about the importance of SCRM has increased among buying companies, especially as the recent events have demonstrated that any disruption in a supply chain can influence on company's ability to continue its operations (Jüttner et al. 2003, 3). Especially, the increase of global competition, rapid technological change and the endless search for competitive advantage have increased the importance of risk management within the companies. In the last decades, risk management has been considered important for management decisions and control. Risk management evaluates the risk sources and aims to understand the cause of unexpected event. Also, it evaluates how the unexpected event can be managed in order to mitigate or avoid the negative consequences. (Ritchie & Brindley 2007, 303, 306) The aim of SCRM is to decrease vulnerability and ensure business continuity (Abdel-Basset et al. 2019, 491). SCRM is a continuous process where the long-term dedication of supply chain parties is needed (Giunipero & Eltantawy 2004, 703). SCRM

has raised into a central role in purchasing and supply chain management as supply chain managers and purchasers need to make plenty of risky decisions related to business (Ellegaard 2008, 426).

In the last decades, SCRM has gained a lot of popularity among authors and researchers (Sodhi et al. 2012, 1). It is believed that companies are only able to mitigate the supply chain risk but avoiding the loss and damages after a risky event is beyond of companies' capabilities. However, effective SCRM decreases damages and losses. (Blos et al. 2009, 248) As the companies are participating more in supply networks, they need to focus not only on their own risks but also on other risks that can arise from every link in the supply chain (Souter 2000, 26; Faisal 2009, 42). Risk management in networks is important as companies become more dependent on each other and are more exposed to each other's risks (Hallikas, Karvonen, Virolainen & Tuominen 2004, 47). As companies are different regarding to their level of risk appearance and risk acceptance, it is essential to seek common goal setting and planning across the whole supply chain network (Pfohl et al. 2010, 36). Any disruptions in one supply chain may cause interruptions in other supply chain's operations and therefore it is essential to review the entire supply chain when selecting the proper strategy for risk management (Manuj & Mentzer 2008, 133).

The importance of SCRM has increased and already in 2007 46% of companies were planning to implement SCRM techniques (Hillman & Keltz 2007, 1). On the other hand, according to the study of Christopher et al. (2011, 67) most companies do not have clear strategies for supply risk management. Wieland and Wallenburg (2012, 887) investigated the effects of SCRM on the supply chain's performance. The findings suggested that SCRM is crucial for a company's agility and robustness. According to these results, robustness is important when dealing with risks related to the supplier-side, and agility is needed when dealing with risks related to the customer-side. (Braunscheidel & Suresh 2009, 119)

There exist many characteristics that influence on managers' perception of supply risk. These are categorized in table 2. These characteristics may increase the severity of supply risk and therefore affects on the level of supply risk management that needs to be implemented (Giunipero and Eltantawy 2004, 706). Zsidisin (2003, 14, 20) has investigated these characteristics and classifies the characteristics into three categories: item, market and supplier characteristics. For example, managers perceive a higher risk when the unavailability of items has a high impact on a company's profitability. Also, the long cycle

time from a supplier to a buyer is perceived as a great risk. Mitchell (1995, 118) has also investigated the characteristics that influence managers' perception of supply risk. According to the author, these characteristics are, for example, the state of relationship with a supplier, the type of buy and the importance of the item. Also, the author highlights that the technological complexity and value of the item increase the degree of perceived risk. Furthermore, unprofitable suppliers increase the risk. Giunipero and Eltantawy (2004, 701) argue, that managers perceive financially unstable suppliers as a great risk to their business especially when there are no alternative suppliers available in the market.

Table 2. Factors that influence managers perception of supply risk (Zsidisin 2003; Mitchell 1995; Giunipero & Eltantawy 2004)

	Higher perceived risk	**Lower perceived risk**
Item characteristics		
• Impact on profitability	Unavailability of item has a high impact on profitability	Unavailability of item has a low impact on profitability
• Nature of product application	Used for a new product	Used on existing product
• The type of buy	New buy	Rebuy
• The importance of item	Strategic item	Non-strategic item
Market characteristics		
• Global sourcing	Currency fluctuations, regions with natural disaster, long distance	Stable currency rates, regions with no natural disasters, short distance
• Capacity limitations in market	Limited capacity in markets	Excess capacity in market
• Market price increase	Market price increases significantly	Market price is stable
• Number of capable suppliers	Only few available	Many available
Supplier characteristics		
• Supplier's capacity	High capacity constraints	No capacity constraints
• Capability to reduce costs	Low ability to reduce cost	High ability to reduce costs
• Compatible information systems	Incompatible information systems	Compatible information systems
• The stability of lead times	Unstable lead times	Stable lead times
• Volume and mix requirement changes	Inflexible production and low volume/high mix	Flexible production and high volume/low mix
• Quality	Low quality level	High quality level
• Financial stability	Unprofitable supplier	Profitable supplier
• The state of relationship with supplier	Non-collaborative relationship	Collaborative relationship
• Capability to implement technological changes	Low capability	High capability

According to Kiser and Cantrell (2006, 13) a good risk management strategy consists of several key elements. A good risk management strategy takes into account the entire life cycle of each product which a company produces. Also, the financial impact that disruptions can cause should be predicted. Risk management should provide strategies, that mitigate the risk impacts and it should recognize risks that can arise from all tiers of a supply chain – not only from the first tier.

Tummala and Schoenherr (2011, 474) have noticed in their article that by implementing the SCRM process, risks can be managed more effectively. They have developed a coherent and integral supply chain management process and identified different tools and techniques which support this process. Hoffmann, Schiele and Krabbendam (2013, 199) noticed in their findings that applying a risk management process is more critical than implementing only certain risk management methods. Their findings indicate that companies' success in risk management depends on the maturity of their supply risk management process. Berg, Knudsen and Norrman (2008, 296) highlighted the importance of developing companies' capabilities in supply risk management as it increases the efficiency of risk management methods. Pfohl et al. (2010, 40) have also highlighted the importance of developing companies' capabilities by arguing "supply chain risk management does not work simply by applying a number of methods. It rather is a philosophy that is supposed to be deeply rooted within the company and the supply chain." Literature has recognized different steps of supply chain risk management and this study utilizes the following four steps (Hallikas et al. 2004, 52; Harland et al. 2003, 58-59):

- risk identification
- risk assessment
- risk mitigation
- risk monitoring

Before implementing the risk management process steps presented above, a company must identify its internal and external environment. After that, a company can start the risk identification and prioritizing. In risk assessment, the company decides which risks should be involved in the risk management process and which risk should be left out of the process. (Abdel-Basset 2019, 491) Risks are also prioritized according to their likelihood and consequences (Hallikas, Virolainen, & Tuominen 2002, 52). For risk assessment, there exists plenty of different techniques, but this study utilizes a risk matrix that helps to identify

quickly the urgency and importance of different risks. Risk identification and assessment are the key elements of risk management. Understanding the reason for risk occurrence and estimating the probability and the impact of the risk are part of the risk management process. After the risks are identified and assessed the strategy for risk mitigation can be implemented. Risks should be monitored continuously as their urgency may change. (Abdel-Basset 2019, 489, 491) SCRM management process steps are presented more deeply in the next sections.

2.2.1 Risk identification

The aim of risk identification is to recognize all relevant risks (Kern, Moser, Hartmann, & Moder 2012, 63) and future uncertainties. Risk identification helps a company to manage risks proactively. (Fan & Stevenson 2018, 214) Risk identification includes defining the risk sources, the areas where risk impacts, the risk events and their consequences (Gjerdrum & Peter 2011, 10). Risk identification concentrates on searching for new potential risks and classifying already identified risks. The focus is on identifying the relevant risks and assessing the causes of each risk. Risks should be identified in the early phase in order to initiate risk mitigation actions before the risks have caused major harm to a company. (Kern et al. 2012, 64)

There exist many different strategies for risk identification (Fan & Stevenson 2018, 214). According to Kiser and Cantrell (2006, 14) identifying the potential risks should start with understanding the entire supply stream. First, a company should identify each raw material by, for example, building a flow chart for all the raw material inputs. After that, a company should identify the strategic materials for the business. At this point, it is important to identify the factors that make material strategic. When the strategic materials are identified, a company needs to understand its supplier's organization. This includes knowing the location of plants, suppliers' divisions and the operating units. This information can be gathered by for example visiting a supplier's plant.

According to Kern et al. (2012, 64) risk identification is a critical step of the risk management process. Only risks that are identified in the first step of risk management process, can be assessed and managed in the next steps (Berg et al. 2008, 301). Especially, the next step of

risk management process, risk assessment, is highly dependent on this first step (Kern et al. 2012, 64).

2.2.2 Risk assessment

The next step in the SCRM process is to define the criticality of the risks that were identified in the first step (Manuj & Mentzer 2008, 145). Table 2 provides information about the characteristics that have the greatest affect on risk and therefore support managers in risk assessment (Zsidisin 2003, 21). Risk assessment includes the evaluation of the probability of risk occurrence and the possible impact of the risk (Hallikas et al. 2002, 52; Harland et al. 2003, 52; Kleindorfer & Saad 2009, 55; Zsidisin, Ellram, Carter & Cavinato 2004, 398). The aim of risk assessment is to provide information regarding to the identified risks in order to reduce the probability and impact of the risk and implement the best strategies to manage the risk. In risk assessment, it is essential to understand the factors that lead to risk occurrence and the risk drivers (Kern et al. 2012, 65). Risk assessment is an important step in SCRM process as it helps a company to concentrate on significant risks and select a suitable risk mitigation strategy (Hallikas et al. 2002, 53). Supply risk mitigation strategies are effective only if the risk assessment has been done carefully since all risk treatment actions rely on understanding the identified risks (Kern et al. 2012, 65).

In order to identify the most significant risks, a company needs to prioritize the identified risks (Fan & Stevenson 2018, 215). Risk prioritization is an important factor in SCRM, and it helps a company to concentrate on the most significant risks (Hallikas et al. 2004, 53). It is unlikely that a company can implement risk management actions for all identified risks because of the limited amount of risk treatment resources (Fan & Stevenson 2018, 215). Risk prioritization helps a company to decide which risks are urgent and need attention and where the limited amount of risk treatment resources should be allocated (Zsidisin et al. 2004, 399).

There have been identified many supply risk assessment strategies, but the most popular method is the probability-impact risk matrix (Fan & Stevenson 2018, 215). The main purpose of the risk matrix is to prioritize risks according to risk probability and impact in order to help decision-makers. Risk matrix visualizes risk levels in different colors: green represents low level of risk, yellow indicates medium risk and red represents high risk level (Duan, Zhao, Chen, & Bai 2016, 278). Tables 3 and 4 explain the assessment scales for the

probability and consequence of risk events. Figure 3 illustrates the risk matrix that places risks in different colors based on the impact assessment and probability assessment scale.

Table 3. Impact assessment scale (modified from Hallikas et al. 2004, 53)

Rank	Level of impact	Description
1	No impact	Not significant
2	Minor impact	Causes single minor losses
3	Medium impact	Causes short-term challenges
4	Serious impact	Causes long-term challenges
5	Catastrophic impact	Discontinue business

Table 4. Probability assessment scale (modified from Hallikas et al. 2004, 53)

Rank	Level of probability	Description
1	Very unlikely	Very uncommon event
2	Improbable	There is indirect evidence of event
3	Moderate	There is direct evidence of event
4	Probable	There is strong direct evidence of event
5	Very probable	Event occurs regularly

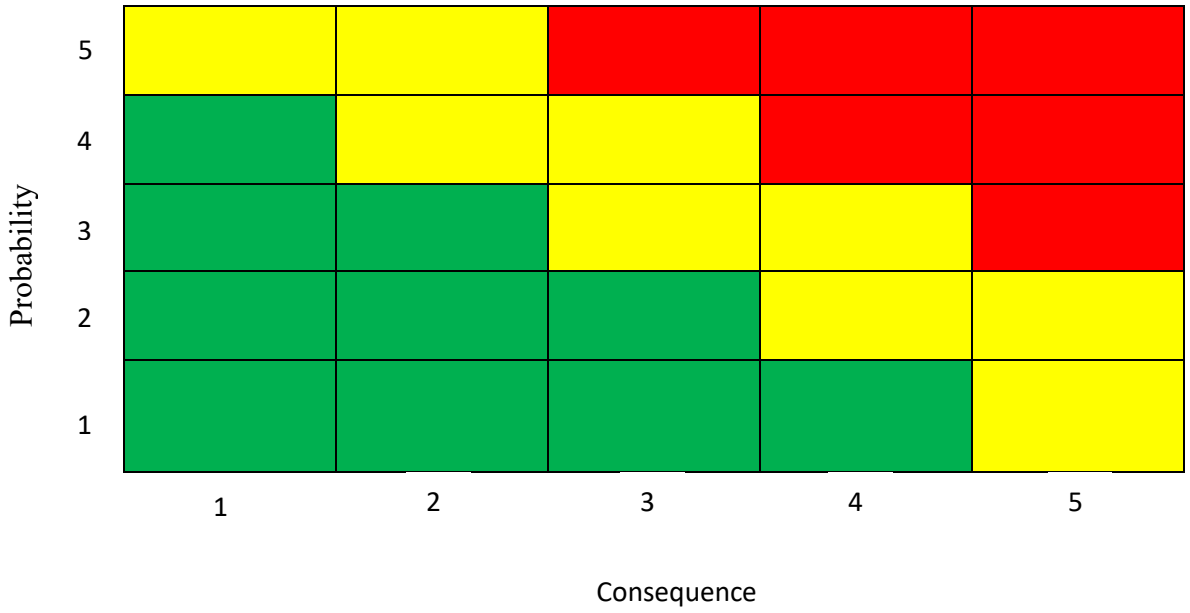


Figure 3. Risk matrix (modified from Dietrich & Cudney 2011, 2824)

The risk matrix offers a visual view of all risks and highlights the most important risks that need attention. When assessing the probability of risk occurrence companies needs to take into account their own experience, other companies' performance and the effect of the network. The consequences of risk need to be assessed from the point of view of the company. Companies must consider the financial consequences, but also the immaterial consequences such as trust and reputation as eventually they can lead to financial losses. (Hallikas et al. 2004, 53)

2.2.3 Risk mitigation

Literature has recognized five risk treatment strategies: risk acceptance, avoidance, transfer, sharing and mitigation (Fan & Stevenson 2018, 216). Several factors, such as the type of risk, the origin of risk, and a company's resources, influence on managers' decision when selecting the proper risk treatment strategy (Aqlan & Lam 2015, 5641). By risk acceptance, supply chain managers do not implement any actions to reduce risk. They simply accept that certain risk event may occur and make a budget for potential damage losses. (Hajmohammad & Vachon 2016, 51) The aim of risk avoidance is to avoid events that lead to risk occurrence (Ritchie & Brindley 2007, 306). These could be, for example, avoiding operating in a specific geographical market or avoiding working with a specific supplier or customer (Manuj & Mentzer 2008, 142). Risks can be transferred to another company which may decrease the total risk if a company that takes the risk can manage the risk more efficiently than the company transferring it (Hallikas et al. 2004, 54). Risk transfer is a suitable risk treatment strategy for risks that occur rarely but are very damaging, such as natural disasters (Aqlan & Lam 2015, 5642). In risk-sharing, some or all risks can be shared with another party. Generally, previous researches have concentrated on risk mitigation (Fan & Stevenson 2018, 216) and this study will also focus on risk mitigation strategies.

Traditionally, companies are focusing on mitigating low-impact risks that occur frequently. However, many recent events, such as natural and man-made disasters, have forced companies to give attention also to the risks that have a high impact but occur rarely. (Faisal, Banwet & Shankar 2006, 536) The aim of risk mitigation is to reduce risk to an acceptable level (Fan & Stevenson 2018, 216). This includes creating an appropriate risk mitigation strategy for each significant risk (Kern et al. 2012, 65). The type of risk and the company's

budget impact the selection of an appropriate risk mitigation strategy (Tummala and Schoenherr 2001, 480). Therefore, a company needs to consider carefully other risk treatment strategies (acceptance, avoidance, transfer, sharing) before implementing risk mitigation strategies (Fan & Stevenson 2018, 216). Collaboration between supply chain partners is essential for effective risk mitigation. Furthermore, it is essential, that company's different functions support the risk mitigation actions. (Kern et al. 2012, 65-66)

Although previous risk management steps are essential for risk mitigation, only implemented risk mitigation strategies have direct impact on a company's risk performance. Risk mitigation strategies that are suitable and well implemented can lower the likelihood of risk occurrence or reduce the risk impact. (Kern et al. 2012, 66)

2.2.4 Risk monitoring

The last step of the risk management process, risk monitoring, has gained at least attention in academics (Hoffmann et al. 2013, 202). However, risk monitoring is an important step of the SCRM process as the company and its environment are not stable and the status of risk might change (Hallikas et al. 2004, 54). Risks need to be monitored regularly in order to react to any need for shifting risk mitigation strategy (Fan & Stevenson 2018, 217). Risk monitoring provides early warnings for increasing risk levels and gives time to react to these changes (Hoffmann et al. 2013, 202). In order to recognize the changes in already identified risks or new appearing risk factors, a company needs to monitor the changes in the network, customers demand, technology, partner's strategies and competitors (Hallikas et al. 2004, 54). However, due to the limited amount of resources, companies are not able to monitor all risks and they are forced to choose the most relevant risks for monitoring (Hoffmann et al. 2013, 202).

Furthermore, regular monitoring of current and potential suppliers for possible supply risks is an important part of risk management (Elkins et al. 2005, 48). There are different ways for how to monitor the supply chain's performance. Monitoring the supply chain's performance can include, for example, the evaluation of the supplier's quality, flexibility, delivery and costs (Talluri & Sarkis 2002, 4257). Also, the accuracy of forecasts can be evaluated (Ramanathan 2014, 212). Ratings are a general way to communicate the supplier's performance. The purpose of the supplier rating is to rate the supplier's performance

according to the criteria that are defined in advance (Choy, Lee & Lo 2003, 91). Buyers can include different tangible and intangible criteria for rating supplier's performance. The total cost of shipments, on-time delivery, the number of bills received without errors, the service quality and reliability are examples of the criteria that can be measured. Providing feedback for suppliers is crucial for the enhancement of the supplier's performance. (Talluri & Sarkis 2002, 4257) According to Krause, Scannell and Calantone (2000, 36) the feedback "serves to clarify the buying firm's expectations and provide the supplier with direction for improvement." Only through feedbacks suppliers will know what actions they need to implement to improve their performance. Monitoring suppliers' performance is critical when selecting suppliers but also after the suppliers are selected. (Talluri & Sarkis 2002, 4259).

Supplier performance monitoring is essential as the supplier's performance reflects directly on a buying company's performance (Krause et al. 2000, 36). One proper way to monitor suppliers is, for example, updating each month the key factors that measure each suppliers' level of risk and then calculate the risk score for each supplier using a weighted scoring system. In the long run, this may show a positive, negative or steady trend in supplier's performance. (Elkins et al. 2005, 48) Also, risk monitoring may consist of figures that indicate if the probability of certain risk events is increasing (Hoffmann et al. 2013, 202).

Also, the current risk management activities need to be repeated, monitored and assessed regularly. Continuous improvement can improve the first three risk management steps and the continuous evaluation of a company's risk management process contributes to identifying the potential improvement areas (Kern et al. 2012, 66). Companies, that have effective risk monitoring systems are more likely to avoid the consequences of uncertainties (Hoffmann et al. 2013, 203).

2.3. Ensuring material availability

The main purpose of a supply chain is to satisfy customers' needs. In order to do so, the availability of resources such as the availability of materials needs to be ensured. (Heckmann et al. 2015, 122-123) Unavailability of materials will impact directly on customers' satisfaction (Kurata 2014, 6739). Material availability is critical for all companies. If companies are facing difficulties to source certain material, market forces may remove the demand for other products and thus other supply chains (Alonso et al. 2007, 6649).

According to Galbreth, Philipoom, and Malhotra (2012, 91) timing and quantity are the main factors that can cause uncertainty in material availability. The uncertainty of material availability is associated with the disruption and scheduling risk as the material availability issues may appear from any supply chain disruption and unreliable lead-time (Hallikas & Lintukangas 2016, 488).

Galbreth et al. (2012, 91) highlight the importance of buffering strategies in ensuring availability for uncertain materials. Kleindorfer and Saad (2005, 56) state that modularity of processes and product design can reduce risk related to raw material availability. According to the study of Gaudenzi and Borghesi (2006, 116), material availability can be enhanced by managing products' lead-times that in turn ensures shorter order cycles. As it can be noticed, there exist different perspectives on how to ensure material availability. This study concentrates on ensuring material availability by mitigating identified risks.

Literature has found various ways to group different supply chain risk mitigation strategies. Generally, supply risk mitigation strategies have been divided into two groups: reducing the probability of risk occurrence and reducing the negative impact of the risk events (Zsidisin & Ellram 2003, 15). This study utilizes risk mitigation strategies from Ellegaard (2008, 426) who has divided risk mitigation strategies into three groups: increase knowledge, reduce the probability and reduce the effect. These three risk management groups are interconnected as one risk mitigation action aiming to reduce certain risk types can influence on other risk types. The optimal risk management strategy starts with increasing knowledge. After gathering information about potential damaging events, companies can develop activities to reduce the risk probability and risk effect. The next sections will review these risk management strategies more deeply.

2.3.1 Increasing knowledge

Gathering information has been seen as an important risk mitigation strategy for a long time (Mitchell 1995, 124). The initiatives that aim to gather information do not directly reduce risk effects. However, gathering knowledge from supplier side is essential to reduce risk probabilities and effects. The reduction of risk probability and effect can be managed effectively when the information about the supply chain's up-stream events is transparent. A buying company can receive supplier-related information from many sources such as

supplier sales representatives, colleagues, other companies' buyers and consultants. (Ellegaard 2008, 426-427) Information can be shared formally between certain time periods or informally between collaborative partners. In quarterly meetings, partners can discuss different topics such as new item development, customer demand and lead times. (Min, Roath, Daugherty, Genchev, Chen, Arndt & Richie 2005, 245) The types of shared information between supply chain partners can be related to for example, inventory level, sales data, order status, sales forecast, schedules of production and delivery, capacity and performance metrics (Lee & Whang 2000, 2-8). Sharing forecasting data, such as demand forecasting and material requirements, is important as the forecasts has huge impact on production, shipping scheduling and inventory management (Min et al. 2005, 245). Another much-used method to increase knowledge is to visit supplier's plant (Hawes & Barnhouse 1987, 291) that in turn may increase the knowledge related to the supplier's capacity, machinery, product lines and quality control systems (Ellegaard 2008, 427).

According to Hunter, Kasouf, Celuch and Curry (2004, 153) e-business can be utilized as an information-gathering tool especially when buying companies are looking for new suppliers or products. Gathering information about suppliers, products and markets from on-line portals and e-marketplaces saves companies resources (Ellegaard 2008, 427). Information can be integrated through the same ERP-systems and intranet network. For example, buyers and suppliers can easily share information with the help of integrated systems, such as the SAP-based system (Sodhi & Lee 2007, 1434). Electronic data interchange (EDI) enables to share information immediately across the whole supply chain. Implementing these technologies has improved the supply chain's performance as the costs and time of order processes have reduced. (Cachon & Fisher 2000, 1032) Hallikas, Puumalainen, Vesterinen and Virolainen (2005, 75) emphasize collaborative learning as a risk management mechanism. Authors argue that buyers and suppliers can lower information asymmetry by mutually learning about each other's behavior and habits.

Knowledge gathering is essential to mitigate a supply risk and it also enhances company's capabilities to ensure material availability. Shared information improves the supply chain's visibility that in turn improves the flow of components and finished goods. (Min et al. 2005, 245-246) Cristopher and Lee (2004, 391, 395) argue that supply chain visibility can be improved by sharing information with supply chain members. They emphasize that shared information increases a supply chain's performance and reduces uncertainty and the need

for safety stock. According to Chopra and Sodhi (2004, 56) increasing the visibility of demand across the supply chain decreases the supply risk. Visibility improves responsiveness, planning and replenishment capabilities, decision making and materials' quality (Barrat and Oke 2007, 1218).

Although information sharing between supply chain partners is essential for effective risk management, some companies avoid sharing information. The amount of shared information may depend on different relational characteristics such as trust, power and conflicts (Kähkönen & Tenkanen 2010, 824). The lack of trust, fear of opportunistic behavior or one-sided commitment impact on companies' willingness to share information with their partners (Pfohl et al. 2010, 41). Nevertheless, Yigitbasioglu (2010, 565-566) argues that uncertainty related to demand and environment provides incentives to share information between partners. The author highlights that information sharing reduces the bullwhip effect that in turn leads to improved customer satisfaction and on-time delivery.

A company's internal information sharing and visibility between different functions are also important in risk mitigation (Speckman, & Davis 2004, 420). Carr and Kaynak (2007, 350) argue that information sharing within a buying company has a positive impact on information sharing between a buyer and its key suppliers. Effective information sharing between functions can be achieved with internal integration (Baihaqi & Sohal 2013, 747). In order to integrate externally with key suppliers, companies need to strengthen their internal integration (Narasimhan & Kim 2001, 60). For example, different cross-functional teams such as engineering, purchasing, marketing and production, can solve together the issues arising from the supplier side such as quality issues (Kaynak, 2002, 208). Sharing information internally helps a company to identify critical issues (Bhatt 2000, 1339). Poor internal information sharing might be a root cause for supply risk occurrence (Speckman, & Davis 2004, 420). When departments share information about supply and demand status, production processes, logistics and quality the production can be managed better (Chen, Sohal & Prajogo 2013, 2190).

2.3.2 Reducing probability

Reducing a probability that certain risk event causes loss to a company can be achieved in many ways. With certain supply decisions, the risk can be eliminated. (Ellegaard 2008, 427)

These kinds of decisions are related to avoiding buying from certain suppliers, in certain geographical markets and avoiding certain materials, technologies, currencies and products (Jüttner et al. 2003, 19). A buying company can also reduce the risk probability by influencing directly to the risk source (Ellegaard 2008, 427). Zsidisin and Ellram (2003, 18) have defined such initiatives as behavior-based risk management techniques. Behavior-based management techniques focus on improving suppliers' processes, thereby reducing the probability of risk occurrence (Anderson & Oliver 1987, 78). According to the findings of Zsidisin and Ellram (2003, 17, 25) companies are implementing behavior-based techniques, that lower information asymmetries, align goals and develop supplier performance when a certain supply risk occurs frequently. The authors point out four behavior-based techniques: implementing quality management programs, supplier development, supplier certification and developing target costing. According to Chen et al. (2013, 2189) the activities that affects directly on a supplier's processes and capabilities requires close collaboration between a supplier and a buyer. Therefore, collaboration can be seen as one main behavior-based technique for risk mitigation. In fact, the literature argues that only through close collaboration with supply chain members, early and effective risk mitigation can be attained (Kern, et al. 2012, 65-66).

Modern supply chains are required to adopt more integrative and collaborative efforts as they are operating in a dynamic environment. Collaboration with suppliers has been seen as an important strategy to mitigate uncertainty. (Chen et al. 2013, 2189) According to Tang (2006, 453) SCRM refers to "coordination or collaboration" among the supply chain members. Also, Blos et al. (2009, 248) have stated that supply risks can be managed through collaboration among supply chain members that in turn ensures business continuity. Simatupang and Sridharan (2002, 19) have defined a collaborative supply chain as "two or more independent companies work jointly to plan and execute supply chain operations with greater success than when acting in isolation." In a collaborative relationship a supplier and a buyer communicate openly and work together in order to achieve common goals (Min et al. 2005, 245). Collaboration between a supplier and a buyer requires joint efforts in improving supply chain visibility, sharing information related to risks and developing supply chain continuity plans (Jüttner et al. 2003, 20). Developing a target costing is one example of the collaboration action that requires information sharing from both sides. Through close collaboration and information sharing, partners are able to determine ways to reduce costs.

Effective communication ensures a better understanding of the supplier's cost structure and cost drivers. (Zsidisin & Ellram 2003, 18)

Certification is one way to improve suppliers' processes and reduce the risk probability. Suppliers are awarded of meeting regularly the goals that are related to quality, cost, delivery, finance and volume. In the certification process, a buyer receives a lot of information about the supplier's performance and ensures supplier's capability to produce materials. Supplier's behavior becomes more aligned with the behavior of a buyer as the behavior that meets certification criteria is standardized. (Zsidisin & Ellram 2003, 18) This in turns enhances supplier's processes and leads to cost reduction, quality improvements, increased trust and communication and a higher level of performance (Larson & Kulchitsky 1998, 76). Through the certification process, a buyer is able to engage a supplier for a long-term relationship (Zsidisin & Ellram 2003, 24).

Supplier development decreases the probability of risk occurrence (Zsidisin & Ellram 2003, 23). Supplier development means that a buying company will invest in developing suppliers' capabilities and performance in order to help suppliers to meet the buying company's short-term and long-term supply demand (Krause & Ellram 1997, 21). Supplier development includes, for example, enhancing supplier's process capabilities, educating supplier's personnel, placing buyer's personnel to work for a certain period in supplier's facilities (Ellegaard 2008, 427) and implementing quality management programs. The implementation of quality management programs in suppliers' facilities reduces the risks related to suppliers' quality issues and develops suppliers' quality performance. The purpose of the quality management programs is to increase suppliers' capabilities so that suppliers are able to meet a buying company's quality requirements. (Zsidisin & Ellram 2003, 18)

Risk and uncertainty can be reduced through increased trust between a buyer and a supplier (Ganesan 1994, 3). Moorman, Zaltman and Deshpande (1992, 315) have defined trust as "the willingness to rely on an exchange partner in whom one has confidence." Building long-term and deep relationships with supplier requires trust from both sides (Meehan & Wright 2011, 33). A trustful relationship with a supplier reduces the probability of risk occurrence as the more sensitive information is shared, communication is effective and both parties are committed to the relationship (Spekman & Davis 2004, 423). In addition to trust, commitment affects positively on supplier-buyer collaboration (Hudnurkar, Jakhar & Rathod 2014, 192). Suppliers are more committed when the relationship is strong and are

less likely to behave opportunistically (Ellegaard 2008, 428). Trust and commitment are essential for building a long-term relationship and for achieving successful collaboration (Morgan & Hunt 1994, 24). A trustful and deep relationship can mitigate the risk of competitors acquiring a supplier. In addition, the deep relationship can reduce the lead times and the threat to miscommunicate the orders thereby making the supply chain more efficient. Sometimes the relationship can become so deep that the core suppliers are almost part of a buying company. In some cases, a buyer has even provided financial and technological support and human-resource training to their core suppliers. (Sodhi & Lee 2007, 1432)

According to Zsidisin and Smith (2005, 44) early supplier involvement reduces the likelihood of supply risk. Also, Spekman and Davis (2004, 415) highlight the benefits of involving a supplier in new product design and processes. With the help of early supplier involvement, buyers can manage different supply risks such as high costs, quality issues, supplier capacity constraints and extended product development times. For example, sharing forecast information and ensuring supplier production flexibility in the early phase reduces the capacity risk. Also, sharing development information, resources and design changes in an early stage with suppliers lowers the risk of extended product development times. (Zsidisin & Smith 2005, 50)

According to Zsidisin et al. (2000, 190) it is not possible to eliminate all supply risks even though the supplier's processes have been improved. The authors argue that buying companies are not able to control all risks. Therefore, companies need to be prepared against unexpected risk events and implement strategies that reduce the risk effects. The next section describes the techniques that reduce the risk effect.

2.3.3 Reducing effect

Companies need to prepare for events that cause loss and thus practices that reduce risk effects are significant (Chopra, & Sodhi 2004, 53-54). Zsidisin and Ellram (2003, 18, 23) referred to such practices as outcome-based management techniques. Outcome-based management techniques focus on outcomes when dealing with supply risk. These techniques concentrate more on reducing the effects of supply risk events than reducing the probability of risk occurrence. Outcome-based techniques are usually implemented when it is not worthwhile to investigate on supplier's capabilities and process. Outcome-based techniques

include buffer-oriented techniques such as multiple sourcing and building buffer stocks. Also, increasing flexibility and responsiveness are considered as outcome-based techniques. (Zsidisin and Ellram 2003, 18, 23) These strategies are discussed next.

The effect of supply risks can be managed by using buffers such as buffer stocks (Spekman & Davis 2004, 426). Buffer stocks protect a company from the negative effects of risk events (Pagell & Krause 1999, 321). It provides only a short-term solution for managing supply risks and it concentrates on reducing the negative impact of the supply risk event. In the long run, extensive use of buffer stocks can become costly to a company as the inventories and potential obsolescence rate increase. Buffer stocks refer to, for example, a buyer's internal safety stocks. With the help of internal safety stock, the short-term material availability can be ensured. Internal safety stocks are effective if they are located in or close to production facilities. Requiring a supplier to keep a buffer stock is another way to utilize buffers. On the other hand, this increases the supplier's inventory costs that might lead to price increases. (Zsidisin & Ellram 2003, 18) Holding internal inventories reduces the risk of manufacturing interruption even when a company receives poor-quality components (Ellegaard 2008, 428). Although, the use of buffer stocks can ensure the short-term material availability, Spekman and Davis (2004, 420) stress that buffer stock only "mask the problem and does not address the underlying reason for this set of risks." Holding inventory can become costly but still, it makes sense when the risk event can be predicted or the material is low-valued, and its rate of obsolescence is low (Chopra & Sodhi 2004, 56).

Multiple sourcing is another buffer-oriented technique that reduces the effect of a risk event. Multiple sourcing utilizes one or more active sources (Zsidisin & Ellram 2003, 17) and it is more beneficial when supplies' lead times are different (Tomlin 2006, 642). Multiple sourcing creates a more competitive environment among the suppliers and decreases the risk of material unavailability and price escalation. With the help of multiple sourcing strategy, the smooth flow of materials can be ensured. (Tullous & Lee 1992, 6) Multiple sourcing strategy is seen effective in managing large-scale risks (Ellegaard 2008, 428). For example, a fire accident in a supplier's plant can cause material availability issues for a buyer that uses a single sourcing strategy. In this situation, a buyer does not have other active sources and its production can be disrupted for several months. (Sodhi & Lee 2007, 1433) Generally, companies implement single sourcing strategy in order to decrease costs. However, single sourcing strategy increases the risk of material unavailability. (Chopra & Sodhi 2004, 58) It

has been argued that multiple sourcing strategy is not used only for ensuring material availability but also to reduce the risk of excessive control, opportunistic behavior and lack of technical innovation (Zsidisin & Ellram 2003, 19). Although multiple sourcing is an effective way to reduce risk effects it increases the management costs such as cost of negotiation, managing contracts and monitoring quality and therefore, lowers the economies of scale (Ellegaard 2008, 428).

Flexibility and responsiveness from both sides, buyer and supplier, may reduce the effects of risk (Chopra, & Sodhi 2004, 60). These may include for example flexible and responsive manufacturing and transportation. (Ellegaard 2008, 428). Postponement is one mode of flexibility. A company can postpone the decision to manufacture, configure, label or deliver a product to a certain destination. With the help of postponements, companies are able to respond to variable demand and disruptions. Postponements also reduce companies' dependencies on forecasts. Another example of flexibility is local sourcing that enables short lead-times and quick responses. (Jüttner et al. 2003, 20-21) Flexibility can be also used for lowering excess capacity. This means that the same capacity can be used for producing different products. (Chopra & Sodhi 2004, 59) The flexible capacity in a supplier's plant or a buying company's plant can reduce the risks related to delays. Also, the responsive capacity and responsive supply chain can reduce the delay risk. For instance, a responsive capacity can refer to having a capacity near important customers which decreases the risk of delays. A responsive supply chain refers to, for example, using high-cost transportation to get high-valued components as soon as they are needed or having integrated plants with suppliers. (Sodhi & Lee 2007, 1433-1434) Table 5 summarizes different strategies to reduce the effects of supply risks that were categorized in the chapter 2.1.

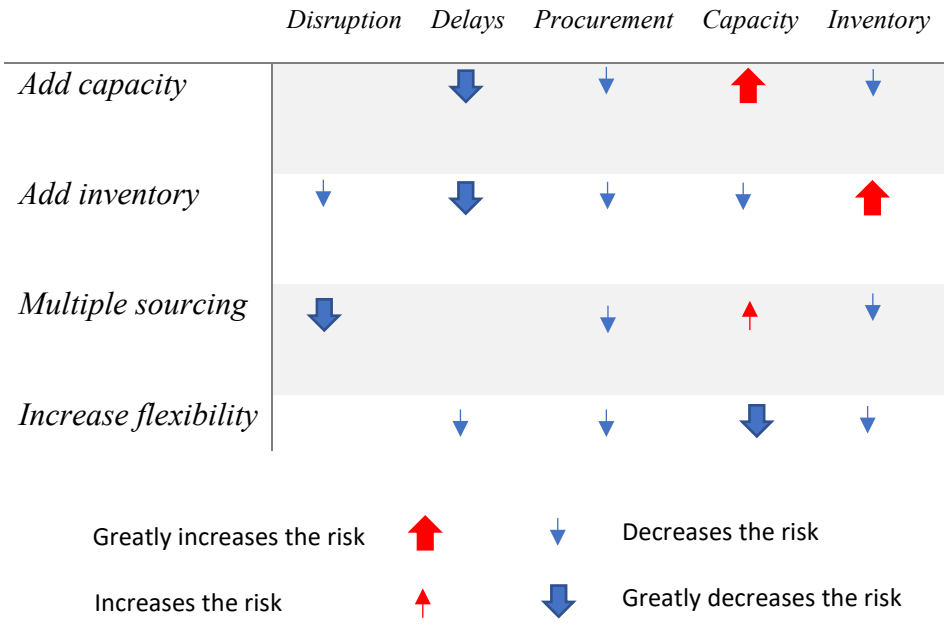
Table 5. Strategies to reduce the risk effect of each risk category (Chopra & Sodhi 2004; Sodhi & Lee 2007; Zsidisin & Ellram 2003; Crone 2007)

Risk category	**Risk mitigation**	**Previous studies**
Capacity	Flexible capacity; serving customers from the same location	Chopra and Sodhi (2004, 59); Sodhi & Lee (2007; 1432)
Delay	Flexible capacity; responsive capacity; responsive supply-chain; balancing between capacity and inventory	Chopra and Sodhi (2004, 55); Sodhi & Lee (2007; 1433)
Logistics	Reduce transport content; efficient use of transportation; alternative modes of transportation	Crone (2007, 33); Chopra and Sodhi (2004, 55)
Disruption	Multiple-sourcing strategy; holding inventories	Chopra and Sodhi (2004, 55); Zsidisin & Ellram (2003, 18-19)
Intellectual property	Holding some production in-house or under the direct control; reduce the flow of intellectual property to the countries with poor legal protection	Chopra and Sodhi (2004, 57); Sodhi & Lee (2007; 1433)
Inventory	Pooling the inventory; developing common components across products; postpone the last production phase until orders are confirmed; working with responsive supplier; keeping excess capacity	Chopra and Sodhi (2004, 59); Sodhi & Lee (2007; 1434)
Procurement	Developing financial hedges, balancing the flow of cost and revenue by region; building flexible global capacity; multiple sourcing; long-term contracts; holding inventory	Chopra and Sodhi (2004, 58)
Systems	Strong backup; effective recovery processes; utilizing reliable vendor that can protect against system risk	Chopra and Sodhi (2004, 56); Sodhi & Lee (2007; 1437)

Supply risk management is challenging as the risks are usually connected with each other. This means that by reducing one supply risk, the other supply risk may increase. Also, one risk mitigation strategy can reduce more than just one risk type. From table 6 it can be seen

that for example adding capacity, decreases the delay, procurement and inventory risk but increases the capacity risk. Furthermore, one partner's risk mitigation actions may increase the risk for any other partner who's participating in the same supply chain. (Chopra & Sodhi 2004, 55)

Table 6. The effects of risk mitigation strategies (modified from Chopra & Sodhi 2004, 55)



The use of different risk mitigation strategies depends on the situation (Mitchell 1995, 130). Now as the supply chain environment has changed, the traditional buffer practices for risk management are not sufficient in long run. Buffers may reduce the operational performance and have a negative impact on competitive advantage. (Giunipero & Eltantawy 2004, 699). Buffers should be used only as a short-term solution for ensuring material availability, as they increase costs, create inefficiency into production processes and can cause other types of risks. Buffers can either act as a driver to increase risk or as a strategy to reduce risk. For example, some authors have seen that single sourcing reduces the risk as buyers have fewer suppliers to deal with and the communication is more efficient. (Khan, & Burnes 2007, 209) On the other hand, it has been argued that single sourcing increases the risk as the dependency only on one supplier increases (Zsidisin et al. 2000, 196).

3. METHODOLOGY

After describing the supply chain risk management theory, the empirical part is conducted. In order to find out the most appropriate results, every study needs to consist of a clear, disciplined, and systematic data analysis methodology (Mohajan 2018, 1). The purpose of this chapter is to describe the methods that were used to carry out this study. This chapter starts with presenting the chosen research methodology and strategy and moves on to explain how the data was collected. After that, the data analyzing process is described in detail. Then, the reliability and validity of this thesis are discussed. Lastly, the background of the case is presented.

3.1 Research methodology and strategy

In general, research methods can be divided into qualitative and quantitative methods. Both methods are needed as it is not possible to solve all research questions with the same method. Several issues, such as the nature of the problem and the objectives of a researcher effect which method is more applicable. Sometimes, both methods are needed to solve certain research questions. Quantitative methods are more objective, while qualitative methods take more subjective approaches. (Näslund 2002, 321, 323-324) Quantitative research collects numerical data and utilizes mathematically based methods for data analysis. The data of the qualitative study is usually collected from interviews, documents, or other forms of observations, and the results are expressed verbally. Qualitative methods have been historically the primary data source (Lach 2013, 89) and unique approach as it is capable to study issues of description, interpretation, and explanation (Bluhm 2011, 1869). This study utilizes the qualitative research method as it is more suitable for answering the research questions and solving the main issue of this study.

This study is based on the case study, more precisely on a single case study. A case study is one option that can be selected when executing a qualitative research (Kähkönen 2011, 31). According to Ellram (1996, 99) case studies "focus on holistic situations in real life settings, and tend to have set boundaries of interest, such as an organization, a particular industry, or a particular type of operation." A single case study is suitable when the study includes only one unique case, for example, one company or one business unit (Saunders, Lewis &

Thornhill 2016, 186). A single case study allows for achieving a deeper understanding of the research topic (Gustafsson 2017, 11). As the focus of this study is only on one company, more precisely on one business unit, after-sales service, and the aim is to investigate the real-life phenomenon, the strategy of a single case study was seen most applicable for this study.

3.2 Data collection

This study utilizes semi-structured interviews to collect the data for the empirical part. A semi-structured interview is one of the methods to collect qualitative data. In semi-structured interviews, the interviewer asks questions related to the predefined themes. Semi-structured interviews allow interviewees the freedom to talk about the themes extensively. The questions may vary dependent on the interviewees' positions and also the question order may vary from interview to interview. The additional questions can be asked in order to receive a deeper understanding of the research questions. Semi-structured interviews differ from structured interviews, which is also one method to collect qualitative data, as the structured interviews consist of exact and standardized questions. (Saunders et al. 2016, 391) Semi-structured interviews were seen most suitable data collection method for this study, as the interviewees' positions vary and therefore the interview questions might vary. Semi-structured interviews allow the conversation between an interviewer and an interviewee that in turn generates a more detailed understanding of the research topic.

The interviewees were selected based on their experience and knowledge about supply chain risks and risk management. Totally nine interviews were conducted, and the interviewees were from different positions. The positions of interviewees can be seen in table 7. Not all interviewees were from the same team and therefore the interviewees see the SCRM from different perspectives. They also have varying experience in SCRM. Only one interviewee is from the factory side and the rest are from after-sales service business unit. The after-sales service business unit is a part of the factory side and is more or less dependent on the factory side and its decisions. Therefore, the factory side is also included in this study to some extent. This enables to receive as a broad picture of the topic as possible with limited time and resources. The interviewees stay anonymous that enables open discussion.

The interviews were held between November and December 2020 via Teams. The duration of interviews varied between 20 minutes to 80 minutes. All interviews were held in Finnish that ensured the smooth conversation. The interview questions were divided into four topics: key suppliers, supply risks, supply risk management, and availability. Questions are based on the theoretical part. The asked topics varied based on the interviewees' position. Additional questions were also asked as interviewees brought up new perspective of these topics. During the interview process, all questions were seen as relevant so there was no need to change the questions. All interviews were recorded for further analysis and in some interviews also notes were taken. Table 7 presents the list of interviewees, their position, the business unit, duration of each interview and topics that were asked.

*Table 7. List of interview*s. *Topics: 1 = key suppliers, 2 = supply risks, 3 = supply risk management 4 = availability*

Position in the company	**Business unit**	**Duration of the interviews**	**Topics**
Team leader	After-sales service	80 min	2, 3
Supply inventory manager	After-sales service	70 min	2, 3
Sourcing team leader	Factory side	63 min	3, 4
Inventory planner	After-sales service	41 min	1, 2, 3
Category manager	After-sales service	45 min	3, 4
Inventory planner	After-sales service	37 min	1, 2, 3
Inventory planner	After-sales service	57 min	1, 2, 3
Sourcing manager team leader	After-sales service	70 min	3, 4
Quality manager	After-sales service	28 min	2, 3

The empirical part is based on the interviews, but also secondary data is utilized. The aim of the secondary data is to support the interviews and strengthen the study's validity and reliability. The secondary data is gathered from the case company's own web pages and documents. The primary data for the theoretical part was gathered from academic publications. The theoretical part consisted of different articles from different journals. This allowed to receive a wider picture of the topic.

3.3 Analyzing the data

After the data was gathered from the interviews, each interview was transcribed by using the word-to-word technique. This technique was seen as most suitable as it ensures that none of the relevant information is excluded from the study accidentally. The data transcription can be seen as the first step of the data analyzing process (Saunders et al. 2016, 572). The data transcriptions were read through few times in order to ensure that the answers were fully understood.

After the data transcription, the data was analyzed. For analyzing data, this study utilizes a content analysis method. Content analysis is one of the most used methods for analyzing qualitative data (Hsieh & Shannon 2005, 1277). The content analysis method can analyze different types of data, such as recorded communication, transcribed interviews, and written documents. The content analysis aims to describe the phenomenon in a condensed and general form. (Tuomi & Sarajärvi 2018) It has been argued that the content analysis method is suitable for case study research as it offers a "rule-based, theory guided method for analyzing interview transcripts" that is the principles of case study research (Kohlbacher 2006, 26).

Content analysis can be executed as an inductive or a deductive way (Elo, Kääriäinen, Kanste, Pölkki, Utriainen & Kyngäs 2014, 1). Inductive content analysis is a proper way when there are no previous studies that could be utilized, or the previous studies are limited or fragmented. Deductive content is based on previous studies and aims to test it in different situations or compare different time periods. (Cho & Lee 2014, 4) This study utilizes the combination of these two approaches in data analysis. The combination of deductive and inductive approaches is called the abductive approach (Cho & Lee 2014, 4). The purpose of the abductive approach is to utilize theory in data analysis, but the analysis is not directly based on theory. In this approach, the theoretical and empirical findings are compared with each other. (Tuomi & Sarajärvi 2018) In practice, the interview questions were built based on the current literature and the data was analyzed based on the interviews. Also, the comparison of theory and empirical findings was executed.

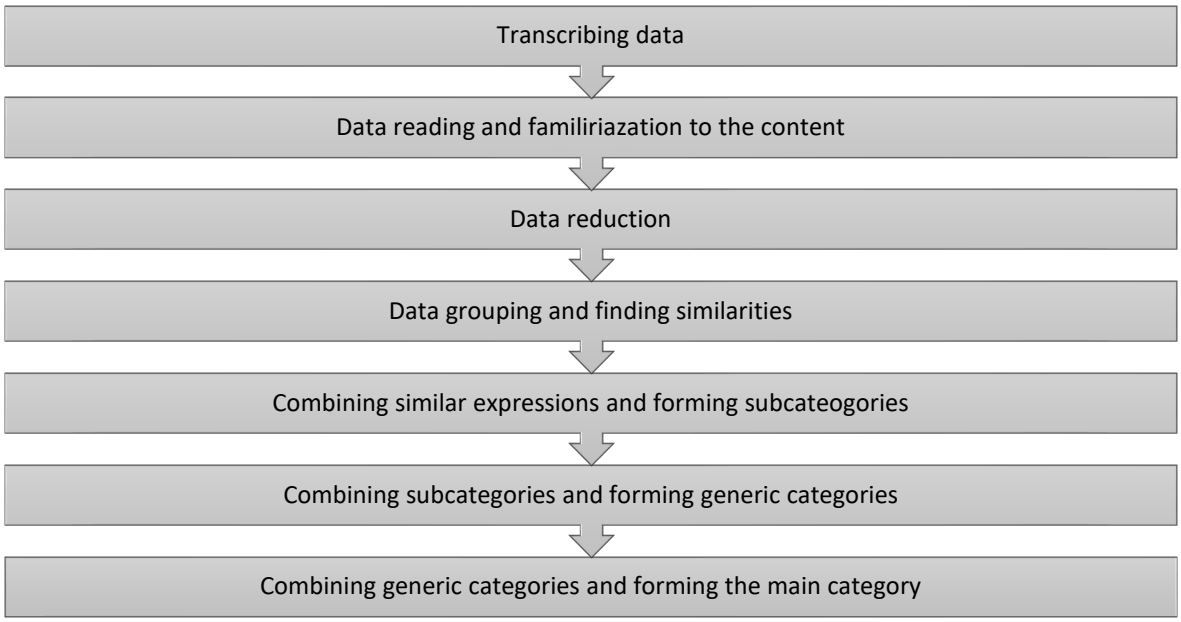


Figure 4. Data analyzing process

Figure 4 illustrates how the data was analyzed. The content analysis starts with data reduction. The purpose of data reduction is to exclude all irrelevant data from the study. (Tuomi & Sarajärvi 2018, 110) In this study, the reduction was done by coding expressions that describe the same phenomenon with the same color. The next step was to group the data and find the similarity and differences among different expressions. The similar expressions were combined into the same group that formed subcategories. The subcategories were combined as generic categories and the generic categories formed the main category. (Tuomi & Sarajärvi 2018, 110-114) As this study utilizes the abductive approach in content analysis, the subcategories were formed from the data that was gathered from the interviews, but the generic and the main categories were already given from the theory.

3.4 Reliability and validity

Generally, the reliability and validity assessment are the most important issues in research (Kähkönen 2011, 38). Reliability and validity evaluate the quality of the study. Reliability evaluates the consistency and replicability of the study. In other words, reliability evaluates is it possible to repeat the study by using the same methods and achieve the same results and findings. In turn, validity means that the researcher is able to measure what was intended to measure. Also, validity evaluates how truthful the results are. (Saunders et al. 2016, 202)

Typically, the evaluation of reliability and validity are more suitable for quantitative researches. However, it has been argued that there is a lack of accuracy in case studies and therefore reliability and validity should be included also in case studies. (Stuart, McCutcheon, Handfield, McLachlin & Samson 2002, 429)

As the nature of this study is qualitative, and the data was collected through semi-structured interviews, the probability that the exact same study could be repeated is low. The data was collected through multiple interviews which increases the reliability of this study. Also, the interviewees' positions and their business units were informed in this study that also increases the reliability. Choosing interviewees with varying position enables to receive different perspectives of the research issues. However, as the data is collected only from one company the results can not be standardized for all industries. Therefore, the results could be different if this study would be repeated to other companies and industries. For example, if this study was conducted in the food industry, the findings would be probably quite different. Conducting research only for one company influence significantly on the external validity, that refers to the ability to generalize the research results to other relevant setting or groups (Saunders et al. 2016, 204). This study enables the reader to evaluate the validity and reliability by providing as detail and transparent research and research process as possible.

3.5 Background of the case

The case company of this study is a leading global power and automation technology company. The case company operates in over 100 countries and has totally about 110 000 employees. The case company aims to create a more productive and sustainable future by energizing the transformation of society and industry. In Finland, the case company serves its customers in over 20 different locations where the production sites are located in Helsinki, Vaasa, Porvoo, and Hamina. In Finland, the case company is one of the largest industrial employers that has about 5000 employees.

The case company consists of four customer-focused business areas and this study is conducted to a business area that supplies drives and motors globally. This business area designs and manufactures drives, generators, electrical motors, and services. The revenues

in 2019 were over 6,5 million dollars. The business area serves a wide range of customers such as manufacturers, process industries, and end customers.

This study is conducted on one of the case company's business units, after-sales service and the focus is on its purchasing operations. The main focus of the business unit is in after-sales related services, such as spare parts, repairs, maintenance, extensions, upgrades, retrofits, service agreements and trainings. After-sales service is a part of a factory side, that is a larger business unit. Therefore, also factory side is included in this study. Factory side and after-sales service business unit share common suppliers but after-sales service business unit sources materials for spare part needs while factory side sources materials for manufacturing.

In the after-sales service business unit the responsibilities are divided into different teams and roles. After-sales service's purchasing department is responsible for ensuring short-term material availability while the sourcing department's responsibility is ensuring long-term material availability. Supply planners in purchasing department interact with their suppliers on daily basis aiming to enhance the short-term collaboration. The purpose is to make operations more transparent to suppliers' direction. When there are long-term issues that can not be solved, the purchasing department receives support from the sourcing team. The sourcing team is responsible for supplier selection and ensuring that suppliers' financial healthiness, tools, and processes are at an appropriate level. The sourcing team has a more long-term and wider perspective on the development of suppliers' operations. The sourcing team manages long-term operations with suppliers and executes yearly checks and price negotiations. Suppliers' quality is followed by a quality manager. A quality manager is responsible for executing auditions, going through the quality cases, evaluating the suppliers' tools and quality, and ensuring that suppliers' equipment maintenance is at an appropriate level.

4. EMPIRICAL FINDINGS

This study was conducted on a leading power and automation technology company and concentrates on its after-sales service business unit. In this chapter, the empirical findings are presented. First, the empirical findings are discussed starting with presenting the identified supplier-related risks. After that the findings related to risk management are discussed. Also, the development of risk assessment and monitoring tool is described.

4.1 Supplier-related risks

The main supply risks that were recognized when conducting the interviews, were material delay risk, logistical risk and disruption risk. However, the empirical part concentrates on finding supplier-related risks that are common in after-sales service business unit. Identifying the most common supplier-related risks, the appropriate risk management actions can be implemented. There were identified five risk categories: supplier's responsiveness, supplier's production capabilities, relationship management, supplier's material planning capability, and product's complexity. The five risk categories consist of different characteristics that are presented in the next chapters. The characteristics have a significant influence on material availability and therefore the evaluation of each key supplier in terms of the characteristics is important. The risks affect the after-sales service business unit's material availability and therefore the identification and assessment of the risks are significant.

4.1.1 Responsiveness

Suppliers' responsiveness was recognized as one supplier-related risk categories. Responsiveness refers to suppliers' capabilities to serve the case unit flexibly and react to the case unit's needs. Responsiveness consists of four characteristics that are lead time, logistical capabilities, raw material availability, and sole source products. Products that have long lead times are seen as riskier than short lead time products. In the case unit, long lead times refer to over two months. Long lead time products complicate maintaining material

availability and planning optimal inventory level. With long lead time products, reacting to the unexpected demand peaks is inflexible. Long lead time products are not easily available and any mistake in the supply chain such as broken product during the transportation is critical. Supplier's unstable supply chain can be one reason for long lead times.

Logistical capabilities refer to suppliers' geographical location and logistical skills. Suppliers that are located in the high-risk countries are seen as riskier than suppliers that are located in low-risk countries. A country's risk is defined by evaluating its characteristics, working conditions, and environment. Countries where frequently occur natural disasters and political instabilities are seen as high-risk countries. The risk increases if the distance between a supplier and the case unit is high. It might be difficult to work with suppliers that are geographically far away. In urgent cases, the costs of express deliveries are high. The COVID-19 pandemic has highlighted the importance of supplier location as some countries have gone into lockdowns, face difficulties in dispatching the materials, and freight prices have increased. Especially the air freight delivery times from the USA and China have increased during the pandemic. Normally, it takes few days to receive materials from those countries, but during the pandemic, it might have taken several weeks. Also, communication with a supplier is more complicated if a supplier is located in a different time zone. It was found that working with suppliers that are located in Europe is simpler than with suppliers that are located in Asia because of the different time zones. Urgent needs can be communicated immediately to a supplier and relationship management is easier when there is a minor time difference.

Suppliers' low logistical skills, such as packing skills, can cause challenges. Poorly packed delivery can lead to quality issues. Although a product is well-manufactured, it can arrive broken if the product has packed poorly. Besides the packing skills, poorly marked products or packages can cause challenges as they are hard to recognize. This causes extra work in the case company's warehouse and in the worst case may lead to delayed deliveries for customers.

Suppliers' raw material availability has a huge impact on the case unit's material availability and therefore suppliers' capability to manage their raw material availability is critical. Suppliers' weak raw material management capabilities reduce their responsiveness. Raw materials might not be available on time from sub-suppliers or the quality level of raw materials might not reach the expected level. These affect suppliers' capability to deliver

orders on time. Suppliers' own supplier selection and supplier base management impact on the availability of raw materials. If a supplier is selecting only the cheapest suppliers, the probability of raw material availability issues increases. Suppliers' weak supplier base management might be related to, for example, lack of appropriate indicators that measure suppliers' performance and help to follow the deliveries.

Sole source products are available only from one supplier and thus are seen riskier than the products that have alternative sources. A supplier might be the only one available in the market and a supplier might have intellectual property rights that prevent changing a supplier. Mainly, standard products have alternative sources available, but design products, that are case company-specific, are available only from one source. This increases the case unit's dependency on a supplier. The flexibility of sole source products is low, as a supplier may not be switched in the situations where a supplier is not able to fulfill orders on time. This decreases the responsiveness.

4.1.2 Production capabilities

The second risk category recognized from the empirical study is the supplier's production capabilities. This category consists of four characteristics that are supplier's production planning, quality management, equipment maintenance management, and financial healthiness. Production planning refers to suppliers' capabilities to plan their production and fulfill orders on time. Production planning includes reserving enough staff, machines, and raw materials so the orders can be fulfilled on time. Production planning should be started early enough as there usually occur problems such as lack of staff or raw materials if the production planning is done too late. Supplier's poor production planning causes material delays and unavailability. There might not be enough capacity to deliver orders on time if the production planning is done poorly or too late. Also, the reason behind the production planning errors might be that a supplier has received inaccurate forecasts and did not have a chance to plan production properly.

Suppliers' quality management is related to suppliers' capabilities to deliver materials that reach the expected quality level. Often, the reason behind the material availability issues is the poor quality of a material. Therefore, supplier quality management is critical. Suppliers

that supply poor-quality materials continuously should improve their quality management capabilities. Especially the quality issues are general if a supplier orders raw materials and components from the cheapest sub-suppliers.

Equipment maintenance management refers to suppliers' ability to maintain and repair their equipment and machinery. Suppliers need to take care of their equipment and machinery and implement maintenance plans in order to minimize the risk of machinery breakdown. Some suppliers have testers, tools or molds in their facility that are owned and provided by the case company. These need to have a clear owner from the case company's side who is responsible of implementing maintenance plans. The risk is high, if there have not been defined a clear owner or it is not generally known. Breakdown of a supplier's own machinery or the case company's tools delays the orders and causes material availability issues.

Supplier financial healthiness refers to the supplier's financial status. A supplier who has financial difficulties is seen as a risk supplier. Supplier's poor financial status might lead to an inability to purchase raw materials or keep enough staff that in turn causes material delays and availability issues. In the worst-case scenario, poor financial healthiness may eventually lead to supplier's bankruptcy. Especially with the sole source suppliers, bankruptcy might lead to long term material availability issues and cause significant losses. Therefore, spotting suppliers' financial difficulties and instabilities in the early phase is important.

4.1.3 Relationship management

Relationship management was recognized as a third supplier-related risk category. In this context, relationship management consists of four characteristics: supplier's reliability, organizational culture, information sharing and communication, and business continuum. Effective communication and open information sharing enable to react to the challenges immediately and minimize the risk of material availability issues. A supplier that does not communicate openly and hides its challenges is seen as a risk supplier. It is important that a supplier communicates openly about its challenges as the challenges can be solved together and thus the major damages can be minimized. The challenges should be started to solve as soon as they appear, not afterward. Building a trustful relationship where both parties communicate openly and share information is important in ensuring material availability.

The importance of regularly held SRM meetings in building relationships and effective information sharing was highlighted. Regularly held SRM meetings increase the knowledge about supplier's situation and usually, challenges are discussed more openly in the meetings. However, organizing SRM meetings does not always guarantee effective information sharing as it depends on the supplier's willingness to share information. Also, the supplier's internal communication issues can reflect on the level of communication and information sharing. When the relationship is trustful, the information is shared more openly. Usually, lack of communication and information sharing decreases the supplier's reliability that in turn causes uncertainty in material availability. A supplier is not reliable if the supplier can not keep promises or does not respond to the buyer's requests.

A supplier that has a weak internal organizational culture is identified as a risk supplier. Organizational culture reflects on supplier's performance and ability to fulfill orders on time. A weak internal organizational culture and a disorganized company increase the likelihood of material availability issues. In this context, a weak organizational culture is related to the supplier's weak internal communication and processes, lack of performance indicators, and disorders in facilities. The internal disorders are recognized and followed through audition. Also, the safety in supplier's facility is evaluated; is it safe to visit the facilities and are there enough guides and warning signs. In some cases, a supplier has promised to improve the facilities, but no improvements were noticed in the next auditions. This decreases the supplier's reliability. Supplier's weak organizational culture can act as a barrier to the improvements and no good results can be achieved. A supplier is acting in its own way and the change is very slow.

Business continuum refers to a supplier's willingness to collaborate with the case unit and the case unit's willingness to collaborate with a supplier. In some cases, the willingness to continue business is low from both sides or the willingness is on a different level. The assessment of the willingness to collaborate and continue to do business together should be done, especially with the significant suppliers. The mismatched product portfolios affect the supplier's interest to respond to the case unit's needs. For example, if a supplier's portfolio is mainly low mix high volume but the case unit's portfolio is high mix low volume, the case unit's portfolio does not fit with the supplier's portfolio. The supplier's product lines might not be made for low volumes that can cause problems. Especially, declining volume for the products brings challenges. After-sales service business unit's volumes are notably lower

than factory side's volumes. Suppliers might not have the interest to manufacture raw materials for the after-sales service business unit in the same way as for the factory side.

4.1.4 Product complexity

Product complexity affects how easily a product is available. The more complex a product is, the more risk is related to it. A product is complex when the level of its design complexity is high. Complex design means that a product consists of many subcomponents which in turn increases the size and complexity of the bill of material (BOM). As a complex BOM consists of many subcomponents, the probability of a product's availability issues increases. Especially, if the product consists of sole source components, that are available only from one sub-supplier, the risk increases. If a sub-supplier has problems in manufacturing the subcomponents or other availability issues, the risk of product delays increases. Therefore, the products that consist of sole source components are seen as more complex and riskier than products where the subcomponents can be sourced from alternative sources.

After-sales service business unit can face a challenge with products lifecycle which can increase the complexity of a product. There are four life cycle phases: active, classic, limited, and obsolete. When a product enters the market and is actively sold to new projects and installations the lifecycle phase of a product is "active". The components that are purchased for active phase products are used in manufacturing and are purchased mainly by the factory side. The product's life cycle phase changes from active to classic when the product is available as a spare part and it is not used in manufacturing anymore. Mostly after-sales service business unit purchase components that are used in classic phase products. The volume declines when the product's lifecycle changes from active to classic. This can decrease suppliers' interest to produce the components, although these are extremely important for the after-sales service business unit. The availability of components is not at the same level anymore and the technology may become old. After the classic stage, the component changes to a limited phase. In this phase, the spare parts are available as long as components can be acquired. The last phase of a product's life cycle is "obsolete". The spare parts that are in the obsolete phase are not available anymore. The development of technology can affect the availability of the components. Generally, the lifecycle of the case unit's products is longer than the lifecycle of the components that is a huge risk factor. This

means that for some products, there need to be done component changes during some lifecycle phases.

Also, the after-sales service business unit's product family might be at the end of its lifecycle and it needs to be ramp down. This can lead to suppliers' excess stock for a component that was used to produce the product. The component might not be needed anymore after a ramp down. The excess stock might become very costly and it might not be clear who is responsible for the excess stock. In some cases, the case unit is responsible to purchase the excess stock from a supplier and the costs might get high.

4.1.5 Material planning capabilities

Supplier's material planning capabilities were recognized as a fourth risk category in the empirical part. This category consists of three characteristics that are suppliers' material management, forecast accuracy, and consignment stock management. Supplier's material management refers to the supplier's internal capabilities to plan activities that ensure material availability. Especially, with sole source suppliers, any material planning failure can cause delays and serious problems in material availability. Supplier's material management capabilities are at a good level if a supplier is able to plan new orders and order raw materials on time, reserve materials for the case unit's needs, manage materials appropriately, and optimizes the inventory level. Also, the materials should be stored properly to ensure a good quality level. One reason for material planning errors is inaccurate forecasts. A supplier might have forecasted its raw material needs inaccurately to its suppliers or a supplier might have received inaccurate forecasts from the case unit. These lead to errors in material planning. Weak transparency in the whole supply chain increases the forecast errors. Unpredictable customer orders and unexpected consumption peaks are hard to predict and cause fluctuations in demand. When a supply chain's transparency is weak, providing accurate forecasts is complicated and there occurs more often forecast errors.

As some suppliers might keep materials in a consignment stock, the management of the stocks needs to be evaluated. Consignment stocks consist of materials that are case company's property. Generally, consignments stocks are kept for the last time buy (LTB)

materials, but also for materials that are critical or not easily available. The risk is high if the supplier has only one consignments stock location for the materials. Therefore, there should be at least two consignment stock locations to reduce the stocking related risks. If one stock location is destroyed, there are still materials left in the other location. Implementing consignment stocks is an important action to ensure material availability for the case unit. Therefore, consignment stocks should be implemented correctly, and the materials stored appropriately and in the right conditions to ensure a good quality level.

4.2 Ensuring material availability

Ensuring material availability by managing risks is important to maintain customer satisfaction and business continuity. Material unavailability or delays can lead to loss of customers and sales. The risk is that the customer cancels the whole project if one material is delayed and the case company loses sales. Also, future orders might be canceled. Customers may not buy anymore from the case company and switch to the competitors. Especially, as the after-sales service business unit is working in the spare part business, the unavailability of some spare parts for the customer is critical. The customer's production line or whole factory might wait for a spare part in order to continue normal operations. The costs might increase on the customer's side if the orders are delayed. It is extremely important to keep promises and agreed delivery times in order to ensure continuity of customer relationships and business. There is also a risk of losing reputation if the promises can not be kept. The aim is to have 100% OTD (on-time delivery) to the customer side but if there are continuously missing components or delays, the OTD percentage decreases. Also, the case unit's costs might increase if there is a need to utilize express services or spot buying, provide overtime and weekend working, and in some situations, the case unit might be fined if the sales order can not be delivered to the customers on time.

First of all, to avoid major risks and material availability issues, supplier selection should be done carefully. The sourcing team together with the product engineers are responsible for supplier selection and ensure that the after-sales service business unit and factory side have capable suppliers. Risk analysis is executed in supplier selection. The sourcing team evaluates the supplier's ability to stay in the market and respond to the case company's needs. Also, the risks in the supplier's location, the supplier's financial stability, standards,

and processes are analyzed. If a company has capable suppliers, there will be less problems in material availability. Price should not be the only criteria in supplier selection. As one interviewee mentioned, if always choosing the cheapest suppliers, there will definitely be more challenges. However, it was highlighted that the supplier selection is not easy. Sometimes, despite the carefully implemented supplier selection, the risks can not be avoided, and the risk management strategies need to be implemented. The risk management process in the case is described next.

4.2.1 Risk identification and assessment

Risk identification and assessment are the first steps of the risk management process. Carefully executed risk identification and assessment are important steps as only by understanding the types of risks and their impact on the company's performance the risks can be managed effectively. Both the after-sales service unit and factory side utilize data reports in identifying risks. Data reports are up to date and followed on daily basis. By following and analyzing different indicators in the data report, the supplier performance can be monitored. The indicators enable to notice easily changes in supplier's performance that can lead to material availability issues. As mentioned in one interview, the identification of availability issues is always related to identifying the changes. The reports include different indicators, such as suppliers OTD, materials' daily availability, order confirmations, the number of reclamations, and supplier's order postponements. These can provide an early warning of upcoming issues in material availability. For example, if a well-performed supplier postpones unexpectedly orders, it can be the first sign of material availability issues. Also, the inaccurate order confirmations from a supplier can indicate that the supplier's supply chain is not stable and a high number of reclamations may be a sign of the supplier's poor-quality management level.

The factory side has implemented buffer stock agreements with its suppliers and follows the buffer stock levels from the data reports. If the buffer stock level drops and a supplier does not fill the stock it can indicate that a supplier is facing challenges in raw material availability or production. Buffer stocks will be discussed in more detail later. When the early warning of upcoming risk is noticed through data reports, the next step is to contact a supplier or organizes a meeting in order to find out the reason behind the decreased performance. A few

interviewees mentioned that data reports allow seeing quickly “at a glance” the overall situation of suppliers’ performance that enable to react immediately to any unusual performance. The data is coming directly from the SAP system every night and no resources are spend on manual data retrieval.

A new report that has been implemented, partly because of COVID-19, and is used by both business units is a forward-looking material availability survey. The purpose of this survey is to identify any risks in material availability in the future. Every week, suppliers are supposed to answer for a short survey how they see their material availability situation in the next four months. The answers are reported through traffic light colors; yellow and red color indicates future availability issues. Suppliers need to provide a reason why they see availability issues in the future and if needed suppliers are contacted. It must be noted that some suppliers answer to the survey more actively than others. One interviewee highlighted that in order to provide accurate information about the future material availability, the supplier must look more deeply into their processes. The reports that were mentioned earlier focus more on the present and history, but the material availability survey concentrates on the supplier’s future ability to supply components. The main difference between the availability survey and previously presented indicators is that the availability is not estimated by the case company but by suppliers. Suppliers give direct answers on how they see their availability for the next months.

There is also another type of database that enables to follow the availability of different components in the world’s market. This database provides information about the components life cycle phase and their availability. For example, the current and future availability of certain components can be checked from the database. The availability of older components can be critical and therefore the availability should be reviewed regularly. In some situations, the after-sales service business unit needs to consider last time buy (LTB) purchase for older components in order to ensure their availability. This is critical as the case unit has promised to their customer to support them and supply spare parts through the device’s classic and limited phase. Life cycle management is an important part of ensuring material availability for the after-sales service business unit.

In addition to the data following, the risks can be identified through SRM meetings. Usually, issues in supplier’s material availability or production come up in the SRM meetings. Most suppliers communicate more openly about their challenges in the meetings than through e-

mail. However, it must be noted that not all suppliers share information or communicate openly even in the meetings. Usually, the indicators that measure supplier's performance, such as OTD, late orders, and postponements are presented in the meetings and discussed. Also, the open orders are discussed to find out if there are any challenges related to them. The aim is to invite to the meetings those workers that are responsible directly for the production and are able to answer the questions immediately. In this way, the information regarding, for example, delivery times, can be received immediately. Through SRM meetings the visibility of the supplier's component situation increases, and the risks can be identified and reacted in the early phase.

Although it is hardly impossible to predict the external events, few interviewees mentioned that risks can be also identified through following global events and megatrends. Reacting to global events and megatrends is important in order to be more prepared for external disruptions. When the recent pandemic, COVID-19, started to spread globally the development of logistics situation in different countries were followed closely. This allowed to react immediately before the countries went into lockdown and components could be purchased in stock in advance. One interviewee mentioned that by being aware of what happens in the world the risks can be more predictable. Also, the economy's overheating was seen as a sign of possible challenges in material availability. When the economy is overheating, some components might run out quickly.

The after-sales service business unit does not have any specific tool for risk assessment. The severity of risk is assessed mainly due to five factors: availability of alternative sources, the nature of a sale, the nature of a material, lost revenues, and the number of customers affected by the risk. These are explained in more detail in table 8. Also, the analysis is made of how long the current stock level lasts with the same consumption level. These factors are analyzed when assessing the impacts and damages that risks can cause. It was highlighted that the impacts of risks should not be evaluated only through the lost revenues.

Table 8. Risk assessment factors

	HIGHER RISK	LOWER RISK
AVAILABILITY OF ALTERNATIVE SOURCES	Sole source	Alternative sources
THE NATURE OF A SALE	Component is missing from a warranty sale	Component is missing from a standard sale or the component is for covering the safety stock
NUMBER OF CUSTOMERS	Unavailability of a component or material effects on large number of customers	Unavailability of a component or material effects on one or few customers
THE NATURE OF A MATERIAL	The consumption and the importance of material is high	The consumption and the importance of material is low
LOST REVENUES	Causes major loss of revenues for the company	Causes minor loss of revenues for the company

Every two years the factory side executes a business impact analysis. The purpose of the business impact analysis is to review the largest suppliers per production line and assess the damages that a risk event, such as a fire accident in a supplier's facilities, could cause. The assessment consists of several factors such as the duration of the risk event, the availability of alternative sources, time to have another supplier ready to produce a component, and the number of inventory locations. Components that are used in the factory side and the after-sales service business unit are included in the analysis. The purpose is to recognize the most significant risks and evaluate their impact on the business performance.

4.2.2 Risk mitigation through SRM

SRM was seen as one of the most important strategies to mitigate supply risk and ensure material availability in both case company's business units. Implementing SRM practices is important especially with the suppliers that supply critical components. A component is critical when it is company-specific or there is only one active source available for a component. According to the interviews collaborating and building a relationship or even a partnership with a supplier are part of SRM practices. The aim is to build a partnership with a supplier that supplies critical components. As there are different types of suppliers in terms

of their criticality, supplier relationships are managed in a different way. Critical suppliers require more strategic management and deeper relationship than non-critical suppliers.

SRM meetings are one of the main SRM actions in the after-sales service business unit. As already mentioned in the previous chapter open communication in the meetings enables the identification of risks in the early phase. As the risks are identified in the meetings, the risk management actions can be implemented together with a supplier. As one interviewee mentioned when a supplier communicates openly about their challenges and receives help from the case unit a supplier has more courage to communicate about its challenges also in the future. Regularly held meetings motivate a supplier to share information. Through the meetings, the actual hurry of each material can be communicated more effectively. A supplier receives information about orders that need to be prioritized. This in turn helps a supplier to plan their production. In other words, if the case unit has many orders that should be delivered to the customer, the supplier's production capacity is moved to focus on those orders. On the other hand, if the materials are ordered only for covering the safety stock these orders can be postponed.

SRM meetings are also utilized for implementing development actions with suppliers. Development actions are suggested in the meetings. Suggestions can be related to, for example, packing concepts or lead times. A supplier takes the development idea forward and in the next meeting, the development idea is discussed further. The development actions can be executed through collaboration where both parties work together in order to increase performance, for example, finding solutions to how lead times could be decreased. SRM meetings have been seen also as a great way to share knowledge about good practices with each other.

It was also noted that SRM meetings are organized even though a supplier's performance is already at a very good level. The importance of building and maintaining personal relationships with a supplier was highlighted and SRM meetings were seen as one way to build personal relationships. Maintaining a good relationship with key suppliers is an important and efficient way to ensure material availability. In addition to the meetings, key suppliers are also visited regularly. Supplier visits not only help to build and maintain personal relationships but also enable to see supplier's facilities and production. Visits and face-to-face meetings might be a more efficient way to solve challenges with a supplier than through meetings that are held via Teams. Trust was recognized as one important factor in

building a relationship with suppliers. The aim is to create “win-win” situations with a supplier where both parties can trust each other. A trustful and personal relationship with suppliers was seen as a significant way to ensure material availability and maintain open information sharing.

Mainly, in the after-sales service business unit the meetings are held with key suppliers once a month or quarterly. However, if the supplier’s performance is decreasing unexpectedly, the meetings are organized more often until the performance returns to the normal level. The type of risk affects how often the meetings should be organized. Sometimes, when there occur major challenges on the supplier side, the meetings are organized once a week until the challenges are solved. On the other hand, if a supplier’s performance continues to decrease, meetings can be organized more often. In the quarterly meetings, supplier performance ratings are reviewed together with a supplier. Ratings are executed quarterly and the factors that are included in the ratings are level of co-operation, quality of the products and deliveries, and on time delivery performance. Quarterly meetings are also a good place to share information and communicate about challenges. Meetings are held through Teams or face-to-face. Mainly, meetings via Teams are enough and face-to-face meetings are organized less often. Especially when the COVID-19 started to spread worldwide, the meetings are held only via Teams.

After-sales service business unit started to implement regular SRM meeting practices at the beginning of the year 2020, in order to monitor more closely and systematically open orders and identify any challenges in the early phase. SRM meetings are seen as useful and the performance of few suppliers has improved after the meeting practices have been implemented. For example, one interviewee in the after-sales service business unit mentioned that after the implementation of weekly meetings the supplier’s OTD percentage increased from 50 to over 80. SRM model has been seen as helpful in keeping the customers' promises and delivering orders on time that in turn increases the business profitability in the higher level and reduces additional turbulence in the organization, production, and in the whole supply chain.

4.2.3 Risk mitigation through buffer-oriented techniques

The importance of buffer-oriented techniques was highlighted in the interviews. Increasing inventories and using multiple sources are the main buffer-oriented techniques that were mentioned. Implementing these techniques was seen as important especially for the critical components that are supplied from the risk countries. By implementing buffer-oriented techniques major disasters can be avoided and more time for reacting is left.

Increasing the level of internal inventories when supplier's lead times are unstable is one way to ensure material availability in the case unit. This means that if the agreed lead time with a supplier is two weeks, but the actual lead time is between two and five weeks, the internal inventory level should cover the longest possible lead time which in this situation is five weeks. The worst-case scenario is used when estimating the optimal internal inventory level. However, keeping internal safety stocks for finish goods is not desirable. As one interviewee mentioned, the aim is to increase supplier's performance, but by increasing the internal safety stocks, supplier's weak performance is "accepted", and extra inventory costs are paid. Another way to manage unstable lead times is to review together with a supplier if the material consists of a certain raw material that causes fluctuation in lead times. Implementing a consignment stock for these kinds of raw materials is used to manage the delay risk. Consignment stock is owned by a buyer, but it is located in the supplier's facilities and the supplier is using the raw materials when manufacturing materials for the buyer. Consignment stock is a good solution in situations where the missing raw material is expensive, there is only one source available for it or the raw material can be used only for the case unit's products. Usually, suppliers do not have an interest to stock these kinds of raw materials as there is a high financial risk if the demand stops. Through the consignment stocks, the production of a material can be ensured.

The case unit has also internal allocation stocks which are utilized when the case unit is aware of the supplier's difficulties to supply certain material. The case unit may already have stock for the materials and when a supplier has major difficulties, the whole stock can be moved to this allocation stock. The materials that are in allocation stock have limited availability to customers and materials are used only for critical sales orders. Mainly, the warranty sales and line stop cases are covered through allocation stocks as they are usually more critical than standard preventive maintenance sales.

The interviews revealed that the factory side has executed buffer stock agreements with its suppliers, but the after-sales service business unit has not. Buffer stock means that a supplier stocks components in its own facilities. These components are owned by a supplier, but the factory side has the responsibility of them. The factory side's purchasing together with a supplier defines the maximum and minimum levels for the materials that a supplier should keep in the buffer stock. The material level should stay between the defined levels. If the buffer stock level drops a supplier should fill the stock. The decrease buffer stock level can be the first sign of material availability issues. The factory side has a tool that enables to review the buffer stock levels. A supplier is responsible for the buffer stock level that exceeds the defined maximum level. This means, that if the demand stops for the component the factory side is still obliged to buy all the components until the maximum level – the excess level is on the supplier's responsibility. Buffer stock agreements are done only for the high-volume products. Although, the after-sales service business unit has mainly low volumes, the buffer stock agreements might be implemented also in the case unit in the future as it is seen as a good way to manage risks. Through the buffer stocks, long lead time components can be managed better.

It was highlighted in the few interviews that internal inventory levels should be defined and calculate carefully for avoiding too high inventory costs. The inventory levels should be optimized as small as possible because too high inventory level is expensive. If the inventory level is too high, the inventory risk increases. On the other hand, if the inventory level is too low, the risk of material unavailability increases. The case unit keeps higher safety stocks for the risk materials. Also, higher stock levels are kept for components, that are used in many devices because the unavailability of the component will impact on many customer orders. Inventories give more time to react to disruptions. It was seen that inventories and buffers are extremely important, and they are the first ones to save a company from unexpected disruptions.

Building multiple sources is another buffer-oriented technique. The factory side aims to have alternative suppliers for most of the components. Especially, having alternative sources for high-volume components is important. If one supplier faces challenges, the component can be sourced from an alternative supplier. Also, the after-sales service unit aims to have more alternative sources but mainly components are purchased from one supplier as the volumes are lower than the factory side's volumes. It is not profitable to keep two sources if the

volumes are low. The availability of alternative sources is better when a component is a standard item. However, if a component is company-specific, the alternative sources are hard to find.

Although having an alternative source is important in ensuring material availability, it is seen quite challenging to maintain a second source. The general challenge is that when there are ten thousand active materials that have multiple configuration chances for the customer and if the aim is to keep two sources for all materials, it would be very hard to accept and maintain the second source for each material. Usually, the alternative sources are priced differently: one source is more expensive than another source. It would be very expensive to maintain two sources for materials if the risk event actualizes once in a ten year. It needs to be carefully estimated which option would be better: to manage the risk when it occurs and receive higher profits or pay continuously a little bit extra for securing availability for some component. The approach is to select the most critical and high-volume components and ensure that those have alternative sources. For the low volume components, the challenges are solved as they occur.

4.2.4 Risk mitigation by increasing transparency

As was mentioned in the interviews by increasing internal and external transparency risks can be managed effectively or even entirely avoid. It was mentioned that transparency can be increased through providing more accurate forecasts, organizing internal meetings, and keeping master data updated.

One important internal risk management activity that came up in the interviews was providing forecasts of material requirements to suppliers. Both factory side and after-sales service business units send forecasts to their suppliers. This helps to communicate the material requirements to suppliers. Suppliers reserve capacity and raw materials according to the forecasts that have been provided to them. After-sales service business unit sends forecasts to their suppliers monthly or quarterly. It must be noted that some suppliers do not receive forecasts although they could benefit from them. Providing accurate forecasts is extremely important, but if the forecasts differ from the actual demand, the risk increases. As one interviewee mentioned that a company is not giving a chance to a supplier to succeed if the forecasts differ from actual demand. The aim is to provide as accurate forecasts as

possible, however, unexpected demand peaks are nearly impossible to forecast. It is also important to inform suppliers about major orders as soon as possible. Generally, the after-sales service business unit has provided quite accurate forecasts to its suppliers, although sometimes the unexpected demand peaks cause variation in the forecast accuracy.

In order to provide accurate forecasts, transparency inside the case company and also in the whole supply chain should be as good as possible. Good transparency enables to forecast the unpredictable demand spikes to suppliers much better. A supplier can order raw materials well in advance as the reliability that the raw materials will be used is high. The importance of having a transparent supply chain all the way from the first-tier supplier to the final customer was highlighted. The transparency in the whole supply chain enables risk identification and management in the early phase. The importance of having a real-time knowledge of material availability issues was highlighted. After-sales service's purchasing department does not know the supply chain and the second-tier suppliers quite well. The purchasing department trusts that their suppliers managed the second-tier suppliers and implements necessary actions to ensure the raw material availability.

As already mentioned, external meetings with suppliers were seen as important in the case unit. However, also the importance of internal meetings was highlighted. Internal meetings increase the transparency inside the different departments and enable to share important information easily. When there has been recognized a major supply risk the information should be shared with the supply planners, sourcing, and category managers. The issues should be escalated to other departments and together the problems can be solved. Mainly, the after-sales service business unit has twice a week internal meeting where the availability cases are reviewed. One meeting is with the customer service and warranty team and another meeting is with the factory side. Internal meetings increase the transparency inside the different departments and the knowledge about the availability and customers' needs can be shared.

When a supplier faces a major risk event and is not able to deliver components, the internal task force project is implemented. Task force projects involve representatives from different teams such as from sourcing team and operation team. The purpose of task force projects is to find alternative components and ensure their reliability. A typical example when a task force project is implemented is a fire accident in a supplier's facilities that leads to the unavailability of a component. The task force project is closed as soon as the problem is

solved. This is usually after the reliability of alternative component or supplier have been ensured and approved and prices have been negotiated.

The importance of keeping master data, such as vendor's material number and inventory balance, up to date was highlighted in the interviews. Case company's other business units can act as second sources in some situations and therefore it is extremely important that the master data is harmonized across different business units. Harmonized master data across all case company's units enables to react quickly and increases the transparency between different units. Appropriately managed master data was seen as a base for ensuring material availability.

4.2.5 Developing a risk assessment and monitoring tool

The after-sales service business unit does not have any specific tool for risk monitoring, although according to few interviews, there is a clear need for that. Risks are monitored and followed mainly through data reports and in SRM meetings. In the meetings, the development of risks can be discussed, and supplier's performance reviewed. Also, through analyzing data reports and the development of the key indicators such as OTD percentage, supplier's performance can be monitored. Supplier ratings, which are executed quarterly, enables to monitor supplier's performance development. In quality cases, after the improvement actions are implemented, next deliveries are monitored more closely to ensure the improved quality level. Factory side monitors also suppliers' buffer stock levels and requires a recovery plan if the levels have dropped. The buffer stock levels are monitored closely in operational meetings with suppliers until the buffer levels increase to the normal level.

One of the main tasks of this study was to build a risk assessment and monitoring tool for the after-sales service business unit. As already mentioned, the after-sales service business unit does not have any specific tool for risk assessment and monitoring. There was recognized a clear lack of a tool that enables to evaluate, and monitor risks. The risk monitoring tool enables to monitor risks of each case unit's key suppliers. The risks, that were identified from the interviews, were grouped and added to the monitoring tool. The severity of risks was evaluated with certain color; green color indicates low risk, yellow

medium risk, and red color indicates that the risk is high. Each supply planner went through their key suppliers and mapped the risk severity with the colors. The assessment of risk severity is based on the planners' own experience. The tool has been also reviewed together with the after-sales service business unit's purchasing team and the category manager. The risk monitoring tool is based on the risk matrix, but it is modified to respond to the case unit's needs. The main benefit of the risk monitoring tool is that it enables to quickly review the overall situation with the key suppliers and guides to implement necessary actions to manage the risk. It provides information on which suppliers to focus in terms of risk management. In figure 5 the risk assessment and monitoring tool is illustrated as a picture. Suppliers are marked with numbers as the companies' names are sensitive information.

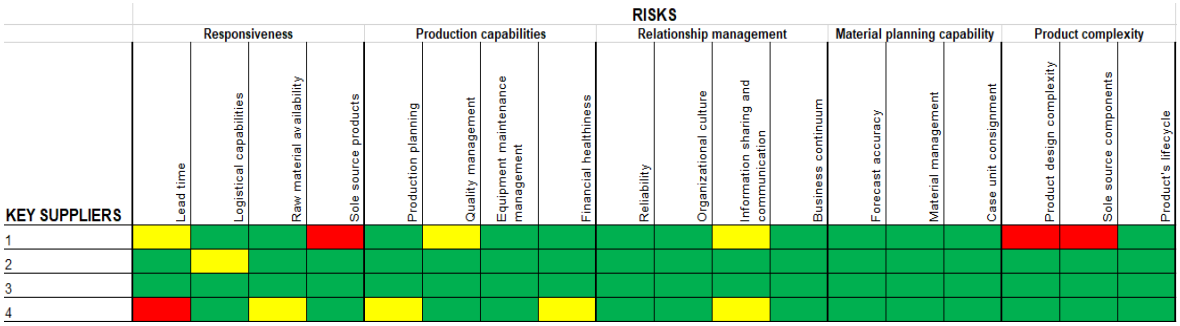


Figure 5. An illustration of the risk assessment and monitoring tool

The risk categories that are utilized in the tool are defined in chapter 4.1. These categories are supplier responsiveness, production capabilities, relationship management, material planning capabilities, and product complexity. Each category consists of several characteristics that are explained in the same chapter. These characteristics were recognized as the most common and significant risks that occur in the after-sales service business unit. The tool is dynamic and can be reviewed and updated at certain time periods. The success of each improvement actions can be estimated, and the color can be changed if the risk situation improves or gets worse. Also, new risk categories or characteristics can be added if needed and the current one removed if seen as unnecessary.

5. DISCUSSION AND CONCLUSION

The final chapter of this study summarizes the study and discusses the main findings. First, the theory is reflected to the empirical findings and the similarities and differences are presented. After the reflection, the research questions are answered. Then the limitations are discussed and suggestions for future research are presented. Last part discusses the conclusions.

5.1 Reflecting theory into empirical findings

Both theoretical and empirical part highlighted the importance of SCRM in ensuring companies' material availability. In the theoretical part, the implementation of an integrated and coherent SCRM process was seen as important to ensure effective management of supply risks. The literature found four main SCRM process steps that are risk identification, risk assessment, risk mitigation, and risk monitoring (Hallikas et al. 2004, 52; Harland et al. 2003, 58-59). Although these process steps are implemented in the case business unit to some extent, there was no mention of the integrated SCRM process that is executed and followed on regular basis.

Sharing information and knowledge were seen as effective ways to identify risks in both the theoretical part and empirical part. The literature suggested that information sharing is essential for mitigating risk although it does not decrease risk effects directly (Ellegaard 2008, 426-427). However, the importance of information sharing in effective risk management was highlighted in both parts. The information can be shared through meetings (Min et al. 2005, 245), visits (Hawes & Barnhouse 1987, 291), and electronic data interchange (Cachon & Fisher 2000, 1032). Meetings and visits were seen the most important ways to identify risks in the case business unit. In addition, the case business unit highlighted the importance of following data reports in order to identify potential risks. There was no mention of this in the theoretical part. Although information sharing is important, not all suppliers are willing to share information (Kähkönen & Tenkanen 2010, 824). This was also recognized in the empirical part.

It was found that in order to implement the most suitable risk mitigation strategies, the identified risks should be evaluated and prioritized (Kern et al. 2012, 65). Literature has suggested the risk matrix as one good tool for risk assessment and prioritization. However, the empirical part reviled that the case business unit does not have any specific tool for risk assessment and prioritization. The severity of risks is assessed mainly through five factors: availability of alternative sources, the nature of a sale, the nature of a material, lost revenues, and the number of customers affected by the risk.

Both parties mentioned similar strategies for effective risk mitigation. Improving supplier's processes and implementing buffer-oriented techniques were seen as the most efficient strategies for risk mitigation. Implementing buffer-oriented techniques were seen as significant in reducing risk effects and improving supplier's processes in reducing risk probability (Ellegaard 2008, 426). It was mentioned that buffer-oriented techniques are applicable only as a short-term solution (Giunipero & Eltantawy 2004, 699). Also, the empirical part revealed that improving supplier's performance is a more efficient way to ensure material availability in the long run. However, buffer-oriented techniques, such as internal safety stocks, provide more time to react to a crisis and therefore are extremely important. It was mentioned that they are the first ones to save the company when there are major availability issues. Increasing the transparency inside a company and in the whole supply chain was recognized also as an efficient way to mitigate risk. This was not directly mentioned in the theoretical part. However, providing accurate forecasts to suppliers, increasing the supply chain visibility (Min et al. 2005, 245), and sharing information internally (Speckman, & Davis 2004, 420) were mentioned as important actions to mitigate supply risks.

Risk monitoring is an important step in the risk management process (Hallikas et al. 2004, 54) and supplier ratings were recognized as a common way to follow the performance (Choy et al. 2003, 91). Current risks, future uncertainties (Hallikas et al. 2004, 54), suppliers' performance (Krause et al. 2000, 36), and current risk management process (Kern et al. 2012, 66) should be monitored regularly. The case unit monitors suppliers' performance daily through data reports and quarterly through ratings. Also, future uncertainties are identified and monitored by following megatrends and external events. It was found that there is not any specific tool for monitoring risks in the case business unit. Also, the theoretical part did not mention any particular tool that would enable monitoring risks and uncertainties.

The theoretical part identified eight different supply risk categories: capacity risk, delay risk, disruption risk, logistics risk, intellectual property risk, inventory risk, procurement risk, and system risk. These were seen impacting negatively on the smooth material flow. Only four of these risk categories, capacity risk, delay risk, disruption risk, and logistics risk, were mentioned in the empirical part. These were seen as the most common risks in the business unit as these have a direct and damaging impact on material availability. However, the empirical part concentrated more on the supplier-specific risks that might cause delays and disruptions in a normal material flow.

5.2 Discussion of the research questions

This chapter discusses the research questions and finds an answer for each question. Both theoretical part and empirical part are utilized in finding the answer. To find answers to the research questions, an overall understanding of SCRM concept is necessary. Therefore, this study investigated SCRM concepts, such as supply risk and risk management process. In addition to that, the data collection from the case company was necessary. This study consists of one main research question and three sub-questions.

How to ensure material availability by using risk management process?

The main research question aimed to investigate how material availability can be ensured by using the SCRM process. Both the theoretical part and empirical parts provided an answer to the main question. According to Tummala and Schoenherr (2011, 474) implementing the SCRM process is essential in effective risk management. Hallikas et al. (2004, 52) have recognized four steps in the risk management process: risk identification, risk assessment, risk mitigation, and risk monitoring.

All the risk management steps are implemented in the case business unit to some extent, although there was no mention of the integrated risk management process. The empirical part emphasizes that when supply risks are managed appropriately, the material availability can be ensured. To manage supply risks appropriately, the implementation of the SCRM process and steps is necessary (Hoffmann et al. 2013, 199). The first step of the SCRM process aims to identify all risks and the second step evaluates the identified risks. The purpose of the third step is to find and implement the appropriate risk mitigation strategies.

The last step, risk monitoring, monitors the development of risks, evaluates the effectiveness of current risk mitigation strategies, and follows the development of supplier's performance. Also, the current risk management process steps need to be monitored and improved if needed. As an answer to the main research question "by carefully implementing all risk management process steps and continuously monitoring the process, risks can be managed effectively. Well managed risk management process helps to identify risks in the early phase and evaluate which risks need to be prioritized. This helps to concentrate on the most significant risks and implement appropriate risk management strategies. As the appropriate risk management strategies are implemented, the development of risks and supplier performance needs to be monitored. Through these steps, the material availability can be ensured."

Which supply risks may influence on company's material availability?

The purpose of the first sub-question was to find out which supply risks might cause material shortages for a company. Identifying and categorizing supply risk were recognized as essential in order to implement the most appropriate risk mitigation strategies. Supply risks were divided into supply-related risks, demand-related risks, and operational risks (Manuj & Mentzer 2008, 138). As this study concentrates on risks that occur between a supplier and a buyer, the focus was on identifying supply-related risks. In the literature, the risks were categorized into eight groups: capacity risk, delay risk, disruption risk, logistics risk, intellectual property risk, inventory risk, procurement risk, and system risk (Chopra and Sodhi 2004, 54). However, only four of these risk groups were seen as relevant in the case business unit. Capacity risk, delay risk, disruption risk, and logistics risk were seen most common supply risk in the case business unit as these have a direct impact on material availability. Other risk groups were not mentioned as relevant for the case business unit.

Delay risk was seen as one of the most common supply risks in the case business unit. Delays are the primary reason for material shortages and are usually caused by any inefficiency on the supplier's side. Logistical risks, capacity risk, and disruption risk are connected to delay risk as all of them causes material delays. External disruptions were seen rare but very damaging. Although the external disruptions are rare, the recent pandemic, COVID-19, and its impacts on material availability were highlighted in the interviews. The pandemic has affected the case business unit's performance as it has caused raw material delays and uncertainty. Also, the pandemic has had a major impact on logistics as some countries went

into lock-down and freight prices have increased. Supplier's capacity issues were seen more as a supplier-related risk in the case business unit and therefore it was recognized as a part of supplier's production capabilities risk.

The other four risk categories that were recognized in the literature were not seen as relevant in the case business unit. The reason for not mention of these risks might be that these occur very rarely, or they are not impacting directly to the case business unit's material availability. For example, procurement risks affect a buying company's net profit and on the certain decision related to supplier selection (Tang & Musa 2011, 29), but it was not seen as a reason for material shortages. Also, inventory risk was not highlighted as excess inventory only increases costs (Chopra & Sodhi 2004, 58), but does not cause material unavailability. However, declining inventory levels can be a sign of material unavailability issues. Also, it was mentioned in the empirical part that supplier's IP rights might prevent to change supplier and therefore lead to a single source situation that increases the risk of material unavailability. However, the literature highlighted more a buying company's protection of its own intellectual properties against the data leaks (Chopra and Sodhi 2004, 57).

In summary, it can be said that delays, disruptions, and logistics issues are the most relevant supply risks for the case business unit. In order to receive a deeper understanding of the supply risks and the reasons for their occurrence, the supplier-related risks were identified. Capacity risk is one of the supplier-related risks and is related supplier's production capabilities. Therefore, in this context, this can be considered more as a supplier-related risk than supply risk.

How to identify the most significant supplier-related risks and risk suppliers?

The second sub-question aimed to find out how to identify the most significant supplier-related risks and risk suppliers. After recognizing the most common supplier-related risks, the risk suppliers can be recognized. Risk suppliers need more attention, and they need to be managed in a different way than suppliers that are not seen as risk suppliers. The supplier-related risks were identified in the empirical part. However, also the literature has suggested supplier characteristics that increase managers' perception of supply risks. For example, supplier's financial status (Giunipero & Eltantawy 2004, 701), quality of deliveries (Zsidisin 2003, 20), and the state of the relationships (Mitchell 1995, 118) are these kinds of characteristics. These characteristics can be seen as the cause for supply risk occurrence and also these characteristics were recognized in the empirical part. The supplier-related risks

were recognized in the interviews and grouped into five main groups: responsiveness, production capabilities, relationship management, product complexity, and material planning capabilities. These groups consist of different characteristics, such as supplier's lead time, which were evaluated in terms of their impact on material availability and supply risk occurrence. Each key supplier was evaluated from the point of view of these characteristics.

As the supplier-related risk groups are mapped into the risk assessment and monitoring tool and each characteristic is evaluated, the most significant supplier-related risks can be identified. In other words, the characteristics that are seen as risky (yellow or red color) and that appear with most suppliers can be seen as the most significant supplier-related risks in the case business unit. This helps to also identify the risk suppliers. A supplier is seen as a risk supplier if many of its characteristics are evaluated as a risk characteristic (yellow or red color) that increases the overall risk and impacts the case unit's material availability. Besides identifying the most significant risks and risk suppliers the tool allows monitoring the development of risk and supplier's performance. To answer shorty to the sub-question, with the help of the risk assessment and monitoring tool, that was developed in this study, the most significant supplier-related risks and risk suppliers can be identified.

What kind of actions and strategies are used to manage supplier-related risks?

The third sub-question aimed to found out what kind of actions can be utilized in managing supplier-related risks. When each key supplier is evaluated in terms of their risks, the appropriate risk management strategies and actions can be implemented. The theoretical part emphasizes three risk mitigation strategies: increasing knowledge, reducing probability, and reducing effect. Probability is reduced by improving supplier's processes and effect is reduced by implementing buffer-oriented techniques. (Ellegaard 2008, 426) Also, in the empirical part, these came up and were seen as important strategies in risk mitigation. It was found that the risk effect is reduced in the case unit with buffer-oriented techniques, such as building internal safety stocks and implementing consignment stocks. These were seen as essential for ensuring short-term material availability. However, it was noted that the most efficient way to manage supplier-related risks is through SRM practices. The aim of SRM practices is to improve supplier's processes. The theoretical part revealed that SRM practices consist of collaboration (Chen et al. 2013, 2189), building a trustful relationship (Spekman & Davis 2004, 423), developing suppliers' capabilities, implementing quality management

programs, and supplier certification (Zsidisin & Ellram 2003, 18-23). The first three of these SRM practices were also mentioned in the empirical part, however, there were no mentioned about the quality management programs and supplier certification. These would need more investigation.

In addition to SRM practices and buffer-oriented techniques, the importance of transparency inside the whole supply chain and within the company was mentioned in the empirical part. This can be seen as one of the risk mitigation actions. Increasing transparency in the whole supply chain helps to provide more accurate forecasts and leads to more efficient information flow in the whole supply chain. Through the efficient information flow any issues that can cause material unavailability can be noticed in the early phase. To summarize, the main actions that mitigate the supplier-related risks are building effective SRM practices, implementing buffer-oriented techniques, and increasing transparency.

5.3 Limitations and suggestions for future research

Although the research gap was covered in this study, there are still few limitations and future research is needed. First, the focus of this study was on the power and automation industry and only one company participated in the study. The study concentrated only on the case company's one business unit and the number of interviews was limited to nine interviewees. The supplier-related risks and risk management strategies can be different in other business units, companies, and industries. Therefore, this research topic could be investigated in different business units or companies. For example, future research of the topic could be executed by investigating a larger number of companies from the same industry. Also, the topic can be covered by investigating different industries to receive a wider perspective of the topic.

Building a risk assessment and monitoring tool was one of the main tasks of this study. However, the tool can be developed further. Currently, the tool evaluates the severity of risks based on the interviewees' experience. However, there could be applied methods that would support the risk assessment step. This kind of method could be, for example, a checklist. A checklist enables to record how often a failure has been caused by a certain risk event. For example, the number of late deliveries from suppliers can be recorded and utilize when

evaluating the severity of a risk. (Tummala & Schoenherr 2011, 476) Also, as the risk assessment and monitoring tool is new and dynamic, further research might be needed.

The theoretical part revealed that risk monitoring has received at least attention in the academics, although it is a critical step in the risk management process. Risk monitoring has received attention only from few previous studies and it needs to be investigated more deeply. Typically, managers are combining risk monitoring with other existing routines, such as combining risk monitoring with risk evaluation and monitoring risks through data reports and indicators. (Fan & Stevenson 2018, 217) The empirical part was in line with this. The new tool that was built for the case unit combines risk assessment and monitoring, and risks are currently monitored mainly through data reports and SRM meetings. These are also used in the other risk management process steps.

5.4 Conclusions

Every buying company has faced supply disruptions at some point and the importance of SCRM has increased. Through effective SCRM strategies, the risk probability and effects can be decreased. This study suggested a risk management process for effective risk management. All four risk management process steps are essential in effective risk management. Through risk identification, the supply risks can be identified in the early phase. Risk assessment enables to evaluate the severity of the risk and helps to move focus on the most significant risks. Risk mitigation decreases the risk probability and risk effects. This study identified three main risk mitigation strategies: implementing SRM methods, building buffer-oriented techniques, and increasing transparency. The last step, risk monitoring, monitors continuously the development of risks and supplier's performance.

Material availability is essential for buying companies. Any disruptions in a supply chain can damage the normal material flow. Especially, as most supply chains are working globally, the probability of material shortages and delays increases. Material shortages and delays can lead to customers' dissatisfaction, loss of revenues and eventually can threaten the business continuum. Therefore, the buying companies need to recognize and react immediately to any threats that arise from the external events or supplier's actions. As COVID-19 has demonstrated, an external event can paralyze the whole supply chain and

cause large scale damages in supply chains. Therefore, it is essential to prepare for any disruption and have clear strategies for managing risks. As a conclusion, the careful implementation of all four risk management process steps, the risks can be managed effectively. Through effective risk management, material availability can be ensured.

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