The Connections Between Proactive and Reactive Supply Chain Risk Management

A Case Study at Axis Communications

Camilla de Verdier & Cecilia Olsson

April 2017

Andreas Norrman – Supervisor, LTH
Jan Olhager - Examiner, LTH
Robert Lindroth, Company Supervisor
Stefan Nilsson, Company Supervisor
Mats Thulin, Company Supervisor

ACKNOWLEDGEMENTS

This master thesis is the final part of our Master of Science degree in Industrial Engineering and Management. The research is conducted for the Division of Engineering Logistics which belongs to the Faculty of Engineering at Lund University. Besides the theoretical influence from the division of Engineering Logistics, the master thesis is conducted at Axis Communications AB from which the industrial insights were provided.

During the conducting of the thesis, several different people have helped in the creation of it. Our supervisors from Axis Communication AB - Robert Lindroth, Mats Thulin and Stefan Nilsson - were always there to answer our questions, larger ones as well as smaller ones. Moreover, several other employees at Axis Communication AB were gracious enough to lend their time to us in being interviewed, attending the workshop and answering the survey. In addition to this, all Axis employees were helpful and supportive along the way, for which we are truly grateful.

Finally, our supervisor Andreas Norrman provided guidance on the master thesis on numerous occasions. Through his criticism and analytical comments, the quality of the study was ensured. For this, we wish to express our appreciation.

Lund 2017

Camilla de Verdier and Cecilia Olsson

ABSTRACT

Background

Axis is a network surveillance company, based in Lund, Sweden. Axis has outsourced its production to contract manufacturers which are positioned in different parts of the world. Axis' suppliers are also spread across the globe. During the last years, Axis has experienced several supply disruptions from its suppliers and contract manufacturers, due to natural and technological disasters. This has put stress on the organization and delayed several new products to the market.

Problem Formulation

To handle supply disruptions, extensive resources from Axis have been required. Beside the reactive supply chain risk management, proactive supply chain risk management has also continuously been conducted. Although having worked with both proactive and reactive supply chain risk management, no evaluation of this has been conducted. Axis has hence expressed a desire for evaluating the efficiency of the proactive supply chain risk management actions in regard to the reactive supply chain risk management actions.

Purpose

To create guidelines for how Axis could work efficiently with its proactive supply chain risk management of major supply disruptions to be effective in its reactive supply chain risk management.

Method

The study has followed a constructive approach. A literature review and a multiple case study were conducted to create a pre-understanding of the research area. The chosen cases were major supply disruptions which have affected Axis between 2010 to 2016. The construct of the study were guidelines on how Axis should work proactively with supply chain risk management. The guidelines were validated through a workshop and a survey within the Axis organization.

Conclusions

The study has added to theory through new actions, methods and strategies to conduct in proactive and reactive supply chain risk management. A new reactive supply chain risk management process has been proposed. Several new connections between proactive and reactive supply chain risk management have been identified. It is recommended to Axis to conduct the proactive supply chain risk management actions suggested by the created guidelines. These guidelines can be seen as two-fold; (1) guidelines on actions not currently conducted at Axis; and (2) guidelines on actions currently conducted at Axis. The first category of guidelines mainly concerns structuring the proactive supply chain risk management. These are advised that Axis implement. The second category of guidelines should emphasize the importance of that Axis continues to conduct the concerned actions.

Keywords: Proactive supply chain risk management; Reactive supply chain risk management; Supply disruptions; Connections; Natural hazards; Technological hazards

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1 INTRODUCTION

This chapter introduces the study, both its theoretical background and the motivation to why it is relevant. The company where the study is conducted, Axis Communications AB, is presented and the problem, the purpose and the research questions are formulated.

1.1 Theoretical Background

Compared to the 20th century, producing organizations today are faced with shorter lead-times and more complex flows of goods (Mishra et al., 2016). Due to efforts in trying to minimize costs, including minimizing inventories and reducing supply bases, supply chains are experiencing increased risks. (Wagner and Neshat, 2012) In addition to this, a rise in natural disasters and technological disasters (Smith, 2013, p. 31) contributes to an even more augmented risk situation. A natural disaster is defined as a *natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage* while a technological disaster is a *hazard originating from technological or industrial conditions, including accidents, dangerous procedures, infrastructure failures or specific human activities, that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.* (UNISDR, 2009, p. 20, 29)

Global supply chains are exposed to numerous risks, hence, being able to handle disruptions well has increased in importance as it now can be considered a competitive advantage. Supply chain risk management is therefore given incresed attention. (Varzandeh et al., 2016; Wagner and Neshat, 2012) The definition of supply chain risk management varies, but according to Norrman and Lindroth (2002) it is defined as: *Supply chain risk management is to collaboratively with partners in a supply chain apply risk management process tools to deal with risks caused by, or impacting on, logistics related activities or resources*.

Figure 1.1: A proactive supply chain risk management process as adapted by Manuj and Mentzer (2008a)

Regarding supply chain risk management, two approaches exist. These approaches are (1) proactive supply chain risk management, which handles, plans for, and tries to minimize the risk before it occurs and (2) reactive supply chain risk management, which is the actions taken after a risk has happened. (Grötsch et al., 2013) If the proactive supply chain risk management has aided the reactive supply chain risk management, the link between the actions has in this study been referred to as a connection.

1.1.1 Proactive Supply Chain Risk Management

The theory on proactive supply chain risk management is vast, and many authors have described processes of how companies can organize their proactive supply chain risk management. Manuj and Mentzer (2008b) propose a five-step process designed to analyze and mitigate potential risk as seen in figure 1.1. Ghadge et al. (2013) argue for proactive supply chain risk management being a continuous process with a six-step, iterative process, covering risk identification, risk assessment and risk mitigation. This process is similar to one presented by Kleindorfer and Saad (2005), who also, in addition to this process, have created a proactive supply chain risk management process designed specifically for disruption risks. Knemeyer et al. (2009) have also presented a process focused on a specific type of risk, namely risks which have low probability and high impact.

Alongside these frameworks, frameworks for a specific type of proactive supply chain risk management are found, which are the concepts of business continuity. Differentiating these concepts from other proactive supply chain risk management concepts is mainly that they start with identifying the impact before investigating the potential causes (Stanton, 2005). Business continuity management aims at ensuring that a company can deliver in an environment entailing risk (Gibb and Buchanan, 2006) and includes business continuity planning (Stanton, 2005; Hiles, 2011, p. 32). For this concept, five elements of business continuity management have been introduced (Swedish Standards Institute, 2013) alongside a nine-step implementation process (Gibb and Buchanan, 2006). A further description of the business continuity processes can be found in section 3.2.1.

1.1.2 Reactive Supply Chain Risk Management

Reactive supply chain risk management is not as frequently discussed in theory as the proactive concept. Some reports focus on what could be conducted if a disruption happens, for example Hopp et al. (2012), Musson (2001) and Bland (2013). However, cases examining what actions were taken post a disruption are few. In the light of this, some aspects have still been found. Hopp et al. (2012) propose five concrete actions to take reactively:

1. Recognize and Initiate
2. Create a Team
3. Develop an Initial Plan
4. Revise the Plan
5. Analyze and Learn

Musson (2001), on the other hand, presents seven strategies for reactive supply chain management to take under consideration once a disruption has happened. In addition to these frameworks, Bland (2013), Ponis and Ntalla (2016) and Tang (2006a) focus on single aspects which are important in the reactive phase (see section 3.3.4).

1.1.3 Connections Between Proactive and Reactive Supply Chain Risk Management

Connections between proactive and reactive supply chain risk management have been difficult for the authors of this study to find in the studied theory. However, if reading reports focusing on other parts of supply chain risk management, fragments can be found. Besides existing activities being scarce, it has been hard to find if proactive activities not made could have facilitated the reactive work.

1.2 Axis Communications

Axis Communications AB (hereafter referred to as Axis) has shown an interest in improving its supply chain risk management and has initiated this study.

1.2.1 General Company Description

Axis is an international company that offers network surveillance solutions, with headquarters in Lund, Sweden, in which most internal functions, apart from regional sales, are located. Axis' primary focus, as of today, lies within network cameras and video encoders where they have a market leading position in Europe and the Americas. In 2015 Axis was acquired by the Japanese company Canon Inc. (hereafter referred to as Canon). The aim is that Axis will remain as an independent actor, though with strong support from its owner. (Axis Communications AB, 2016)

Axis has three core values which run through its business and company culture: *Always Open*, *Think Big* and *Act as One*. (Axis Communications AB, n.d) Quality has been described to be very important by Axis and as something that is not compromised with.

1.2.2 Axis' Supply Chain

Axis' supply chain is strongly aligned with its strategy to only perform its core business; innovating network-based surveillance solutions. Consequently, Axis has chosen to outsource all manufacturing to contracted manufacturers around the world and the final assembly is conducted in the so-called *Configuration and Logistics Centers* (CLCs), which all except one are operated by 3PLs. The downstream supply chain is designed with many intermediators, where the distributors are responsible for most of the storage of finished products. An overall map of the supply chain is depicted in figure 1.2.

Figure 1.2: An overview of Axis' supply chain

1.2.3 Axis' Problems with Natural and Technological Disasters

Many of Axis' contracted manufacturers and sub-suppliers are located in Asia in regions that during the last years have experienced different natural disasters. This, together with technological disasters, has led Axis to having had four major disruptions in their upstream supply chain between the years of 2011 to 2016, as seen in figure 1.3.

Japan was in March 2011 hit by an earthquake followed by a tsunami that affected many regions. This affected Axis since several of its sub-suppliers of critical components had factories that were affected. Later the same year, Thailand experienced heavy rain that flooded many areas. One of Axis' major contract manufacturers, SVI Plc (hereafter referred to as SVI), found its facility severely damaged and faced several weeks of rebuilding before production could be restarted. In November 2014, SVI was yet again damaged as a fire broke out on one of their sites which resulted in limited production capacity. This disruption was not a natural disaster but a technological one. However, the situation for Axis was highly similar to the situations of the natural disasters mentioned.

The most recent disaster that Axis has had to manage was an earthquake in Japan, in April 2016, where a factory producing sensors, a strategic and critical product in Axis' cameras, suffered serious damages which caused a disruption to the flow of goods of several months.

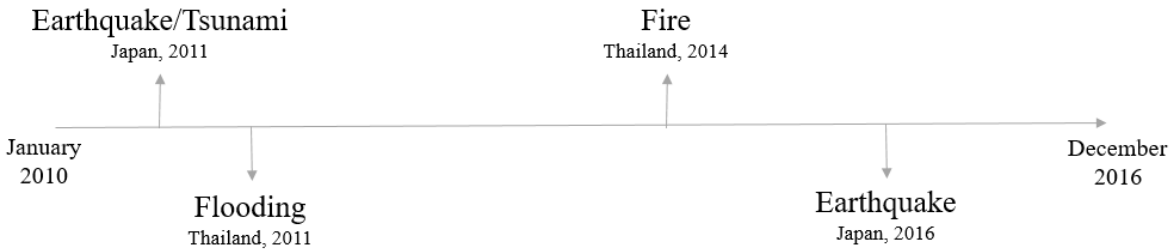

Figure 1.3: A timeline of the above mentioned disruptions at Axis

1.3 Problem Formulation

Axis has been exposed to a number of disruptions throughout the years and has reacted to them. Especially natural hazards have shown to be disruptive to the supply chain and have required extensive resources from Axis to be handled. Beside the reactive supply chain risk management, proactive supply chain risk management has also been conducted.

Although believing to have managed the disruptions well, Axis is not certain if this is correct. No extensive evaluation has previously been made of the effectiveness of (1) Axis' proactive work or (2) Axis' reactive work in regard to the disruptions. However, Axis does not feel a need to excel at these separate concepts. The desire is to perform the proactive work that is needed to facilitate the reactive work. Hence, the focus lies on the connections.

In order to improve its supply chain risk management, Axis desires to get a better understanding of these connections. This understanding is partly about discovering what connections can be found from its previous supply chain risk management, and partly what theory says on the matter. Regarding what type of incidents Axis desires to limit this to, natural and technological disasters are seen as the most interesting since these categories are the categories in which Axis has had major problems. However, a focus is to be on incidents with a major impact, sine these types incident of consequently have the largest impact on Axis and hence are prioritized when exploring ways of mitigating or in other way handling risks.

In order to convert the understanding into practice, Axis has expressed a need for guidelines for the proactive supply chain risk management. These guidelines are supposed to aid Axis to manage future disruptions better than they currently would. To ensure the quality of the guidelines, Axis wishes that theory and previous studies are considered.

The system that will be investigated is complex. An overall system can be seen as the proactive and reactive supply chain risk management, together with the connections between these. However, sub-systems are needed in order to fully examine the overall system. These sub-systems are (1) the proactive supply chain risk management; (2) the reactive supply chain risk management; and (3) the connections between these, as seen in figure 1.4. These sub-systems are present throughout the report, for example is the literature review is divided accordingly.

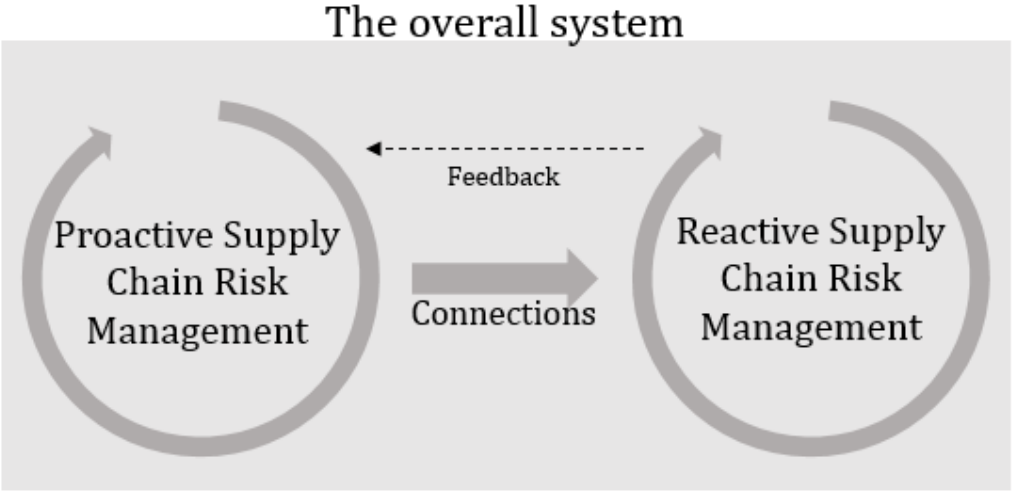

Figure 1.4: A description of the studied system and sub-systems.

1.4 Purpose

The purpose of the study is to create guidelines for how Axis could work with its proactive supply chain risk management of major supply disruptions to be effective in its reactive supply chain risk management.

1.5 Research Questions

The overall research question to be answered is:

RQ_1: How can proactive supply chain risk management aid reactive supply chain risk management?

To answer this, four sub-questions have been investigated:

RQ_2: How should companies work with supply chain risk management according to theory?
RQ_3: How has Axis worked proactively with supply chain risk management of supply disruptions?
RQ_4: How has Axis worked reactively with supply chain risk management of supply disruptions?
RQ_5: Which proactive factors facilitated the reactive work at Axis?

1.6 Focus and Delimitations

When conducting this study, certain focuses and delimitations existed. These helped form the study.

1.6.1 Directives

Axis has mainly desired to receive a mapping of the reactive supply chain risk management of the earthquake in 2016. This means focusing on the actions taken after the disruption with the aim of securing supply. Besides mapping of that specific disruption, guidelines regarding how to work proactively are desired. This desire is, however, not explicit to receiving guidelines, but could equally be a framework, a process, a model or similar. The focus is on obtaining something which could aid Axis in its future supply chain risk management.

1.6.2 Delimitations

Since being a master thesis, the timeframe of the study is 20 weeks. The scope of the study hence had to be limited to accommodate this. While studying the proactive and reactive supply chain risk management, together with the connections between these, some restrictions are made. These are (1) to only focus on the upstream supply chain; (2) to limit the scope of disruptions to natural and technological disasters; and (3) to choose more severe disruptions because of the constrains regarding the timeframe of disruption and strategic importance of the supply. In addition to this, having Axis as a principal company means that the thesis necessitated a focus on Axis.

1.7 Outline of the Report

The remaining report is structured into six parts.

Next, the methodology of the study will be described. The overall approach, the research approach and the research method will all be presented and motivated. The chapter ends with a discussion on reliability and validity in order to strengthen the credibility of the study.

Thereafter, the theoretical framework is presented. The chapter functions as a foundation of the study, where important concepts and frameworks are presented within the area of supply chain risk management. This chapter aims to answer RQ_2.

The report continues with the empirical findings. This chapter discusses the collected data for the selected four cases and focuses on RQ_3, RQ_4 and RQ_5.

Further, the analysis of the data is presented. The analysis will contain both an analysis of each case individually, a so called within-case analysis, and an analysis between the cases, so called cross-case analysis.

A modified research model is then proposed, based on the findings of the case study.

Next, the results from the analysis are used to develop guidelines for Axis that will aid their future supply chain risk management. The results of the case study are discussed, and the validation process, in terms of a workshop and a survey at Axis, is presented.

Lastly, the conclusion and contribution section summarizes the findings of the study. Also, the generalizability is examined to conclude how the study contributes to the general body of knowledge.

2 METHODOLOGY

In this chapter, the methodology used to conduct the study is presented. The chapter describes the overall approach, the research approach and the research method. It also discusses measures taken to increase generalizability, reliability and validity.

2.1 Overall Approach

When conducting research, the choice of methodological agenda is important. Gammelgaard (2004) argues that the choice of a methodological framework ensures that the research approach has been contemplated and not randomly adjusted. The systems view will be used as overall approach for this report. While the analytical view and the actors view are the opposite regarding the objectivity of knowledge, the systems view can be seen as somewhat in between. This view corresponds best with the authors' view on knowledge.

When analyzing supply chain risk management, the systems view is also seen as the most applicable. Persson (1982) argues that the systems view takes the effects of different sub-systems on the overall system and the other sub-systems into consideration. It has a holistic view, something which becomes appropriate since the study contains several sub-systems (see figure 2.1). Due to Axis desiring guidelines which can be implemented, the systems views way of seeking a pragmatic problem solution rather than an actual truth is also desirable. (Gammelgaard, 2004)

The preferred method in the systems view is case studies; a concept which will be discussed further below. A case study can namely incorporate both quantitative and qualitative methods, something which enables the study to make use of both approaches. (Gammelgaard, 2004)

While the overall system in this study is defined as the connections between proactive and reactive supply chain risk management, there are sub-systems as well. The system and sub-systems can be seen in figure 2.1.

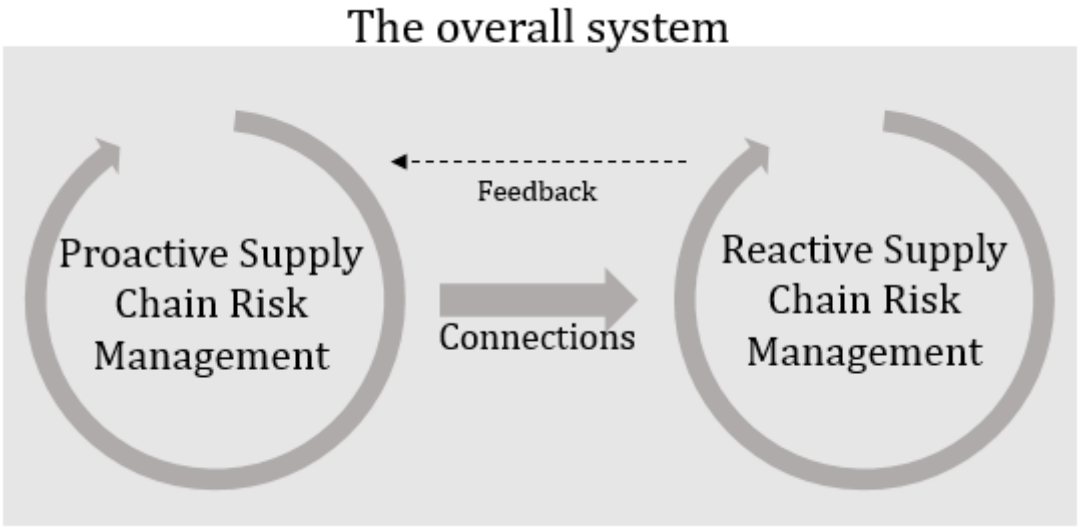

Figure 2.1: A description of the studied system and sub-systems.

2.2 Research Questions

In order to fulfill the purpose of the study, the following five research questions were developed:

RQ_1: How can proactive supply chain risk management aid reactive supply chain risk management?
RQ_2: How should companies work with risk management according to theory?
RQ_3: How has Axis worked proactively with supply chain risk management of supply disruptions?
RQ_4: How has Axis worked reactively with supply chain risk management of supply disruptions?
RQ_5: Which proactive factors facilitated the reactive work at Axis?

The research questions were constructed in order to study proactive and reactive supply chain risk management individually, but also to focus on their connections to each other as well as to theory.

2.3 Research Approach

For this study, a constructive research approach has been chosen. The main reason for this choice is the close connection to practice though still having an ambition to also be theoretical. (Kasanen et al., 1993; Lukka, 2000). One of the main parts of the constructive approach is to innovate new solutions to practical problems (Kasanen et al., 1993; Lukka, 2000), which makes it suitable as this study aims to develop new guidelines for supply chain risk management.

The constructive approach follows six main steps, as depicted in figure 2.2 (Lehtiranta et al., 2015). It can be argued that the constructive approach uses both the deductive logic and the inductive logic (Lehtiranta et al., 2015). To shortly summarize the two logics, it can be said that the deductive logic refines already existing theory, while the inductive logic results in new theory (Carson et al., 2001). In the constructive approach, the two logics are used during different stages of the process, as seen in figure 2.2 (Lehtiranta et al., 2015).

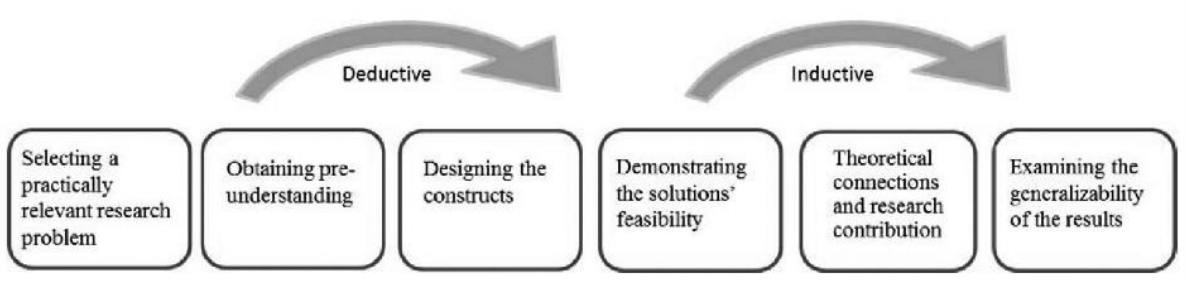

Figure 2.2: The six steps of the constructive approach (Lehtiranta et al., 2015)

Following the suggested approach, the process of this study began with developing a knowledge in the area of supply chain risk management. This was first done through a literature review, and was then further extended through a multiple case study. The cases were analyzed, both individually and cross-case, in order to find connections between the proactive and the reactive supply chain risk management. From the findings of the analysis and with the knowledge from the literature review, guidelines were constructed. To be able to evaluate the feasibility of the guidelines, a workshop and a survey were conducted (see section 2.6).

2.4 Research Method

The research has been designed as a multiple case study. The case study approach was chosen since it is especially suitable when answering *How* and *Why* questions (Voss et al., 2002; Yin, 2009, p. 8-9). Case studies also have an advantage when developing new theory and when creating validity with practice. Disadvantages with a case study include that it is often very time-consuming and researchers have to be careful when drawing generalized conclusions. (Voss et al., 2002).

A case study can involve both a single case as well as multiple cases (Voss et al., 2002; Yin, 2009, p. 46). This study is conducted through the use of multiple cases. The main advantage with studying multiple cases is that the possibility of drawing generalized conclusions increases (Voss et al., 2002; Yin, 2009, p. 53).

The unit of analysis defines the research cases. The unit of analysis is specific to each case study and can for example be individuals and organizations, but also communities, decisions and projects. (Yin, 2009, p. 29-33) The purpose of the case study is to answer RQ_3, RQ_4 and RQ_5. These questions are then used to help answer RQ_1. As these research questions have different focuses, each research question has been assigned a specific unit of analysis:

RQ_1: Facilitation of the reactive supply chain risk management through the proactive supply chain risk management at Axis directed at disruptions

RQ_3: Proactive supply chain risk management at Axis directed at disruptions

RQ_4: Reactive supply chain risk management at Axis directed at disruptions

RQ_5: Connections between proactive and reactive supply chain risk management at Axis regarding disruptions

The case study was conducted using a method suggested by Yin (2009, p. 57), summarized in figure 2.3. The figure shows how the first step should be the development of theory and that every case should be handled individually before being compared. The dashed feedback loop is a central part of the process. It describes the importance of being open to redesigning the direction of the research if new information during the case studies makes it necessary. (Yin, 2009, p. 56-57)

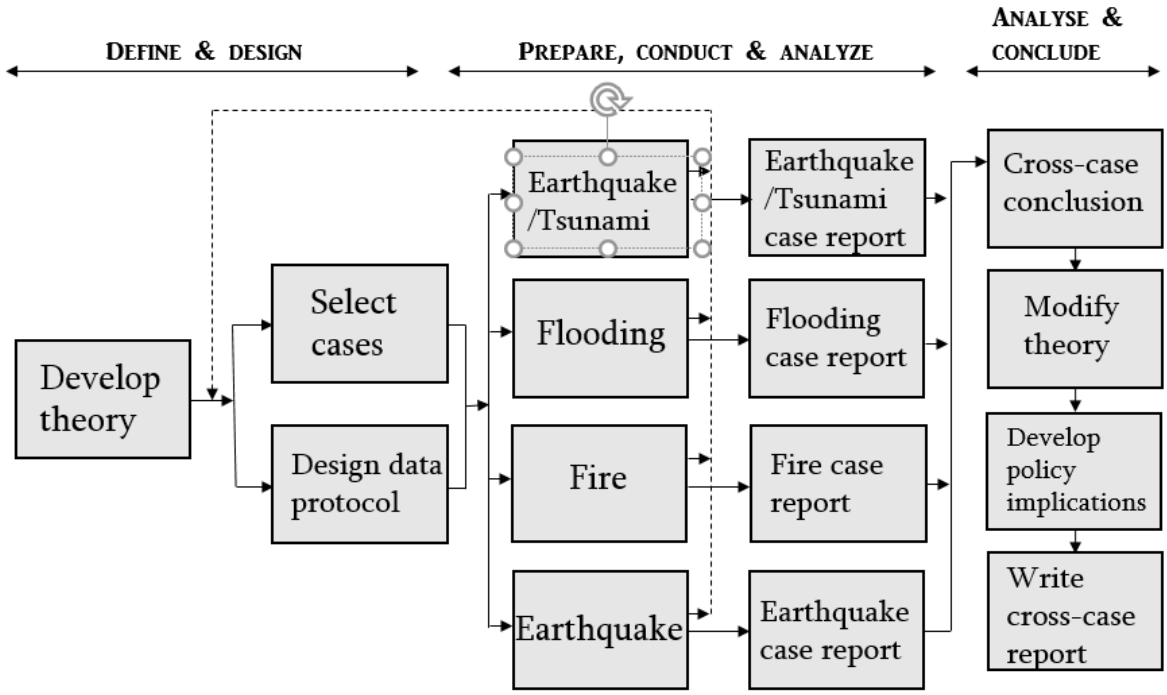

Figure 2.3: The case study process as adapted from Yin (2009)

2.4.1 Development of Theory

Since case studies often focus on theory development, it is particularly important to begin the study with a thorough literature review (Voss et al. 2002). Conducting the literature review serves several purposes. It creates an understanding of the research area, supports the chosen topic of research and is helpful when conducting the analysis. (Rowley and Slack, 2004)

The creation of the literature review followed a five-step approach as suggested by Rowley and Slack (2004):

1. Scanning documents
2. Making notes
3. Structuring the literature review
4. Writing the literature review
5. Building a bibliography

The step-wise approach served as a base and a guideline when the literature review was conducted. However, the actual approach was not as linear, since the process iteratively returned to step one when new resources were found. Also, scanning documents and making notes were done simultaneously as it was considered the most time-efficient method. All steps are described in more detail below.

2.4.1.1 Scanning Documents

The scanning of documents followed the citation pearl growing strategy. The scanning began with a handful of supply chain risk management articles. These articles were found by doing a search on the term *supply chain risk management* and were chosen from the top results. The initial articles are presented in table 2.1. The search continued by using the information from the articles in three ways: (1) by finding key terms that allowed more focused article searches

(Rowley and Slack, 2004); (2) identifying relevant articles in the reference lists; and (3) reading literature reviews. This strategy enabled both a wide understanding of the research area, as well as a deep knowledge of key concepts and frameworks. If the article was found through a search of key terms (1), the decision on reading the article was based on if the title and the abstract was focusing on a relevant concept.

Table 2.1: The articles that were initially read

Author(s)	Title of the article	Journal	Publication year
Berg, E., et al.	Assessing Performance of Supply Chain Risk Management: A Tentative Approach	International Journal of Risk Assessment and Management	2008
Desai, K.J., et al.	Supply Chain Risk Management Framework: A Fishbone Analysis Approach	SAM Advanced Management Journal	2015
Franck, C.	Framework for Supply Chain Risk Management	Supply Chain Forum: International Journal	2007
Ghadge, A., et al.	A Systems Approach for Modelling Supply Chain Risks	Supply Chain Management: An International Journal	2013
Hallikas, J., and Lintukangas, K.	Purchasing and Supply: An Investigation of Risk Management Performance	International Journal of Production Economics	2014
Kilubi, I.	Investigating Current Paradigms in Supply Chain Risk Management – A Bibliometric Study	Business Process Management Journal	2016
Wiengarten, F. et al.	Risk, Risk Management Practices, and the Success of Supply Chain Integration	International Journal of Production Economics	2016

Articles were considered relevant when they covered concepts that were generally applicable and were of a qualitative nature. Also, definitions and descriptions of concepts and terminology were considered relevant. Most relevant were articles that described processes or strategies that could be used to handle supply risk, both proactively or reactively, as well as descriptions on how proactive and reactive supply chain risk management are connected. Tables with the articles included in the literature review, categorized according to subject, can be found in Appendix I.

2.4.1.2 Making Notes

Making notes is an important step in order to have the most central messages and concepts easily accessible (Rowley and Slack, 2004). This was primarily done by highlighting important

passages in the articles. Sometimes, though, this was not possible, for example in library books, and in those cases the concepts were summarized in separate documents.

2.4.1.3 Structuring the Literature Review

When structuring the literature review, the identified key concepts should be logically organized. Rowley and Slack (2004) stress the fact that there is no specific disposition that should be used in a literature review. Instead, the organization of ideas has to be developed from the read documents. Still, they offer a sample structure to use as inspiration. The suggested structure is divided in four parts: (1) basic definitions; (2) arguments to why the chosen subject is of interest; (3) previous research on the topic; and (4) a summary of possible research areas that can be identified from the literature.

The structure of the literature review in this report has focused on part one and three; basic definitions and previous research. In order to create clear connections to the research questions, the previous research is divided into the parts proactive supply chain risk management, reactive supply chain risk management and the connections between proactive and reactive supply chain risk management,

2.4.1.4 Writing the Literature Review

As the writing of the literature review begins, Rowley and Slack (2004) suggest that the researcher should begin with setting the headings and including some key concepts to each heading, before the actual writing begins. This advice was followed in the construction of the literature review of this study, as the literature was summarized below each heading to create an overview before starting to write.

2.4.1.5 Building a Bibliography

The building of the bibliography should be continuous throughout the literature review process (Rowley and Slack, 2004). In order to keep track of read documents, they were all saved either in printed versions or as files on the computers. The citations were included simultaneously as the writing of the text progressed. Around 80 articles for the literature review were read. Of those, 48 articles were included in the literature review of this report.

2.4.2 Selection of Cases

It was decided that all cases in this study were to be selected within Axis. Focusing on previous disruptions within Axis' supply chain was considered most appropriate, since the purpose of the study is to develop guidelines customized to Axis' business and since risk management strategies should be designed according to a companies' specific needs (Kleindorfer and Saad, 2005). The selection of cases only within Axis is in line with the units of analysis presented in section 2.4. This selection of cases decreases the generalizability of the study, though it still contributes to the body of knowledge as it gives examples on how proactive supply chain risk management can affect reactive supply chain risk management, as well as further developing existing theories.

Axis also has an interesting setting to conduct this type of study in for several reasons. First, Axis has been awarded for their supply chain management competence (Silf, 2016). This does not necessarily mean that they have a high knowledge in supply chain risk management, but it suggests that its Operations department has a strong position within the company. Second, Axis has had several major supply disruptions during the last years which are highly relevant for the research and allows the study to follow the development of risk management within the

organization. Thirdly, Axis has their headquarters in Lund, Sweden, while a large portion of their suppliers are located in Asia. This means that Axis' own facilities were never affected by the same disasters as their suppliers. Lastly, Axis has been very willing to share its experiences and information.

When selecting cases for a multiple case study, a researcher can choose two strategies. The first choice is to select cases in which similar results are predicted, called replication. The second choice is to select cases which are predicted to give different results, but for expected reasons, called theoretical replication. (Yin, 2009, p. 54)

In this case study, the aim was to be able to find patterns among the chosen cases. The cases were therefore selected according to the replication strategy. Based on this, criteria number 1, 2 and 3 in the list below were developed. In addition to this, in order to accommodate Axis' desire to delimit the type of incidents to major disruptions, criteria which ensured this delimitation were created. The criteria focused on the delimitation to major disruptions are number 4 and 5 in the list below. The selection of cases was hence done using the following criteria:

1. *The disruption was caused by a supplier's inability to deliver*. This criterion was set in order to limit the study to the upstream supply chain.
2. *The incidents occurred after 2010.* Since data accuracy has a negative correlation with the time past, this requirement was chosen in order to increase the data accuracy.
3. *The supplier was hit by a natural or technological disaster.* This provided a limitation to the nature of the studied disruptions.
4. *The supply was disrupted for more than a month*. By having a restriction on the timeframe, the purpose is to find cases which have had a high impact on Axis' business.
5. *The disruption of supply was on strategic components or the disruption of a contract manufacturer*. This criterion was also chosen in order to ensure a high impact of the selected cases.

Axis has experienced several disruptions, however, not all of them fit the selected criteria. For example, one supplier decreased its capacity after the recession in 2008, which led to Axis experiencing component shortages in 2009, hence not fulfilling criteria 2. Another example occurred in 2010, when eruptions of the volcano Eyjafjallajökull caused transportation problems of Axis' finished goods for a few days, hence not fulfilling criteria 1, 4 and 5. One last example was a product that was wrongly designed by Axis in 2012 which caused failures at certain temperatures. Axis spent more than six months to identify the issue and to redesign the product. This event does not fulfill criteria 1, 3 and 5.

The selected cases are briefly presented in table 2.2.

Table 2.2: The selected cases

Type of Natural Disaster	Time of the Disaster	Length of Disruption[1]	Plant(s) affected	Strategic Component/Service
Earthquake/Tsunami	March 2011	8 months	Several sub-suppliers. Most notably Hitachi Ltd. Corporation and Sony Corporation[2]	Various camera components
Flooding	November 2011	6 months	SVI (Contract Manufacturer)	Manufacturing
Fire	November 2014	6 months	SVI (Contract Manufacturer)	Manufacturing
Earthquake	April 2016	9 months	Sony's sensor factory in Kumamoto, Japan	Sensors

2.4.3 Design Data Collection Plan

When conducting a case study, developing a protocol is useful. A case study protocol can serve many purposes. These purposes include to organize the interview questions, provide focus in the data collection process and to document the actions taken, hence increasing the reliability of the study. (Stuart et al., 2002) The design of the protocol can vary, and for this case study the, by Yin (2007, p. 94) proposed, sections of a protocol were used:

- An overview of the case study project
- Data collection procedures
- The questions to which the case study wants data
- An outline for the case study report

A protocol for the case study can be found in Appendix II.

2.4.4 Data Collection

For this case study, the data collection was done through a number of different sources. Since there was no single individual in charge of the actions taken during each case, different informants had to be interviewed. In addition to this, internal data was collected through meeting notes, emails and Axis' internal network. The reason for why multiple sources were used in the data collection was to increase the construct validity (Yin, 2009, p. 41-42).

The types of sources that were used to collect data are described further below.

1. *Literature review*
   The purpose of the literature review was to find information on supply chain risk management overall, and in particular possible proactive and reactive actions regarding it as well as possible connections between these actions.

[1] The length of the disruption is defined from the time of the natural disaster until the supply was fully recovered
[2] Hereafter referred to as Sony

2. *Interviews*
   The purpose of the interviews was to see whether the patterns formed from the studied theory could be confirmed through pattern matching in the analysis, as well as if any new connections could be found, in which they would be so through explanation building. One problem with the pattern matching is that connections which derive from proactive actions not conducted at Axis cannot be confirmed solely due to the proactive actions not having been conducted. In order to compensate for this, imagined connections were asked for. These connections will be formed from proactive actions which were thought to be possible in aiding reactive actions, hence forming connections.

3. *Meeting protocols, e-mails and Axis' internal network*
   These sources will partly serve as (1) a complement to the interviews in which missing information can be derived and (2) as a control mechanism to the interviews in which details can be validated.

When conducting data collection from an old incident, there will be an increased risk of loss of data. Informants might not recall certain events, and might alter the data remembered. (Voss et al., 2002) Although the cases chosen for this multiple case study are maximum six years old, a limitation with the aim to reduce the likelihood of distorted data, additional mitigation strategies were created. When presented with new data, validation from an independent source was always sought. If interviewing an interviewee who was relevant for all four disruptions, the oldest disruption was asked about first, in order to avoid contortion of the memory with newer memories. Probing questions outside of the questionnaire was also employed if the interviewee showed signs of clinging to a specific thought instead of trying to remember a wider picture.

When conducting the interviews, a pre-determined structure was followed. The interviewees were contacted through email and given a briefing on the interview topic. The timeframes for the interviews were decided through a trade-off between the desire from the authors to attain as much information as possible, and the interviewees inability to spend too much time on it. The timeframes hence landed on 1-2 hours. The interviews were conducted face to face, with the exception of one which was held over the phone. Both authors attended the interviews, alternating the roles as the secretary and interviewer. The reason for this is that if employing different roles, more perspectives on the interview will be attained (Eisenhardt, 1989). The interviews followed a semi-structured approach (Yin, 2007, p. 117) with both closed and open-ended questions (Voss et al., 2002). All interviews were recorded to give support if the notes were found to be incomplete. Once an interview was done, the notes were summarized into a more complete script. During the summarization, the interviewers discussed the potential different interpretations made, in order to find the one most true to the interviewee.

The interview guide can be found in Appendix III. All interviews are listed in Appendix IV.

2.4.5 Case Analysis

When conducting a qualitative analysis, one of the focus areas is to find patterns in the data. It is very important that the analysis methods are considered in the design of the case study to know that the collected data will be possible to analyze. (Yin, 2009, p. 127-128)

Firstly, a within-case analysis was conducted since this is helpful to do before the cross-case analysis (Eisenhardt, 1989). The benefits of within-case analysis are that unique patterns of

each case can be found while it also requires the researcher to become more familiar with the cases. In this, pattern matching and explanation building were employed.

Pattern matching is one of the most useful techniques for case study analysis. The technique necessitates the creation of one or multiple predicted patterns, to which an empirically based pattern can be compared. If the patterns show similarities, the internal validity is strengthened. Predicted patterns should be created so the empirics can be compared to them, and discrepancies found (Yin, 2009, p. 136-144). The pattern was created through summarizing the concepts found in the literature review, and can be found throughout chapter 3.

Once this was complete, explanation building was conducted. This technique is a specific type of pattern matching, however, more difficult. It analyses through building an explanation about the case based on the empirics. This has previously primarily been done using a narrative form, in which causal links, or *how* and *why* something happened have been described. In order to conduct this explanation, a predicted pattern should be created and this served as the base of the explanation building. (Yin, 2009, p. 141-144) The explanation building used the same pattern as was created for the pattern matching.

When both pattern matching and explanation building were completed in the within-case analysis, cross-case analysis was begun. In the cross-case analysis, Eisenhardt (1989) proposes three ways of analyzing the cases: (1) through selecting categories or dimensions and looking for similarities and differences within these between the cases; (2) through selecting pairs of cases and looking for similarities and differences between them and (3) through, data source by data source, looking for similarities and differences between the cases. This report employed the first alternative and investigated similarities and differences between cases within the categories. In figure 2.4, an overview of the case analysis approach, including the within-case analysis and cross-case analysis can be seen.

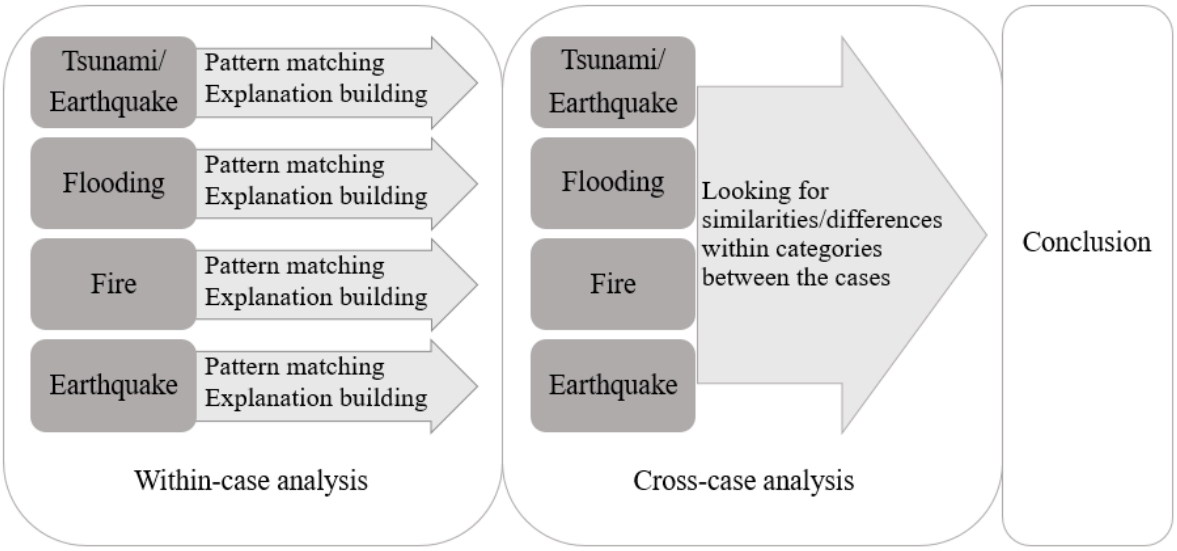

Figure 2.4: The case study analysis approach

2.5 Designing the Constructs

The results of the analyses were used to modify the, by theory, suggested framework, which was then used to develop guidelines for Axis' proactive supply chain risk management. Worth noticing is that this study has not had the aim to refute connections suggested by theory, but merely confirm and augment theory if found necessary.

When forming the guidelines, certain steps were taken. First and foremost, all proactive supply chain risk management actions found through, or derived from, literature and interviews were gathered forming the first version. In particular, all found connections between proactive and reactive supply chain risk management were taken into consideration, to fulfill the purpose of creating guidelines of efficient reactive supply chain risk management. For more detailed information about the creation of the first version of the guidelines, see section 8.1. Secondly, this version was reduced into a number of actions seen as possible for Axis to implement, while at the same time providing good supply chain risk management. A more detailed description of how this was conducted is presented in section 8.2. The reduced list formed the second version, which was presented to Axis. How this was done will be further discussed in section 2.6. After a validation process, the third and final version was created.

2.6 Demonstrating Solution Feasibility

In order to verify that the guidelines proposed would work, implementation of them at Axis was sought. This ensured validity, as further discussed in section 2.8.1 Since the timeframe of the case study was limited, a full implementation where the guidelines were adopted and the result after a supply chain disruption analyzed could not be conducted. Instead, a workshop was held and a survey was sent out in order to get the interviewees' thoughts on different aspects concerning the guidelines.

The focus of the workshop was to discuss the applicability of the guidelines from the second version that Axis at the time did not conduct. All interviewees were invited to the workshop, however, only a third was able to attend. More detailed information on the workshop is presented in section 8.3.1.1.

After each interview, the interviewees were asked which out of four pre-selected aspects (use of resources, user-friendliness, comprehensiveness and communication) that could be the most useful to Axis. After the workshop, the interviewees were asked to rate each guideline of the second version according to the four proposed aspects, which were weighted together to find which guidelines were thought to bring the most value to Axis and which hence should be a part of the third and final version of the guidelines. More detailed information on the survey is presented in section 8.3.1.2.

2.7 Generalizability

For a case study, the generalizability will not be statistical as with other, more quantitative studies. Instead, case studies seek analytical generalizability. (Yin, 2009, p. 43-44) The generalizability will hence apply for the created patterns and not populations or similar groupings. One aspect which affects the concept of generalizability is the number of cases. The more cases, the wider the generalizability. (Ellram, 1996) In this case study, multiple cases were analyzed which increases the generalizability, as mentioned in section 2.4. However, the amount of conditions related to the study will have a negative correlation to the concept (Ellram,

1996). The fact that the study only analyses cases from one company, Axis, hence lowers the generalizability.

2.8 Reliability and Validity

This section describes tactics to ensure reliability and validity of the study and defines which ones that are employed in this study.

2.8.1 Constructive Approach

For the constructive approach, one way of ensuring validity is through demonstrating the practical application of the construct. This can be achieved through conducting a pilot study, however, this can propose difficulties. (Oyegoke, 2011) Due to not being able to implement the construct at Axis during the timeframe of the master thesis, the construct will instead be tested at Axis during a workshop, as mentioned in section 2.6. This workshop will not provide the same validity as an implementation would have had, but is still an evaluation of the construct's practical application.

An alternative way of increasing validity for a proposed solution is through triangulation. Different triangulation approaches can be used depending on the work at hand, and should demonstrate that the solution works. Four main types of triangulation exist:

1. *Data source triangulation.* With this approach, the data is expected to remain the same independently of the context.
2. *Investigator triangulation.* With this approach, several investigators examine the same phenomenon.
3. *Theory triangulation*. With this approach, investigators with different points of view interpret the same results.
4. *Methodological triangulation.* With this approach, several approaches are utilized in order to increase confidence in the interpreted and synthesized concept.

(Oyegoke, 2011)

In this study, the triangulation approaches employed are (1) data source triangulation and (2) investigator triangulation.

2.8.2 Case Studies

For case studies, there are a number of different ways to judge the quality of the research design. Since research designs represents a logical set of statements, logical tests can be used to judge their quality. In this report, the focus will be on the four concepts adapted for social research. Since case studies belong to this type of research, the four concepts become applicable. The four concepts are construct validity, internal validity, external validity and reliability, and will be discussed further below. (Yin, 2009, p. 40-41)

2.8.2.1 Construct Validity

Construct validity is about the correctness of the operational measures developed for the concepts being studies. To obtain construct validity, two steps needs to be incorporated into the study. The objective of the study needs to be related to known concepts and for these concepts operational measures should be chosen. If desiring to secure good construct validity, mainly three tactics can be used. First of all, multiple sources of evidence may be used. Secondly, a

chain of evidence may to be found. Thirdly, key informants may assess the report draft. The concept of construct validity is considered the hardest one of the four different ones to secure in a case study. (Yin, 2009, p. 41-42) The ones employed in the report are (1) multiple sources of evidence and (2) key informants used to validate the report draft.

2.8.2.2 Internal Validity

Internal validity strives to find the links between conditions, that is causal relationships which show how one condition leads to other conditions. Since the concept aims to find causal relationships, it is applicable only for explanatory case studies. A problem with internal validity is how to judge causal relationships found by deduction of the researcher of the case study. Deductions are needed every time a relationship cannot be directly observed. Since not being able to observe it, there will be a risk of failing to notice factors of the relationship which in turn can affect the deduction made. Tactics to secure good internal validity concern the data analysis phase of the report process, and there are mainly four. First of all, the analysis method of pattern matching may be done. Secondly, explanation building may also be considered. Thirdly, rivaling explanations may be addressed. Fourthly, logic models may be used. (Yin, 2009, p. 41-43) The ones employed in the report are (1) pattern matching and (2) explanation building.

2.8.2.3 External Validity

External validity focuses on the generalizability of the study conducted, and more specifically of in what field of study the results are representable. While some studies, for example survey studies, rely on statistical generalization, case studies rely on analytic generalization. Tactics of securing good external validity are mainly focusing on the research design. For single case studies, theory may be used. For multiple case studies, replication logic may instead be used. (Yin, 2009, p. 41, 43-44) The one employed in the report is replication logic due to having multiple cases.

2.8.2.4 Reliability

Reliability judges whether the results are repeatable, that is if the study could be performed once again and find the same results. Here, a distinction should be made between repeat and replicate. Reliability is about doing the same case once again and finding the same results, that is repeating it, while replicating relates to conducting another case study, expecting to find the same results. In order to make the study reliable, as many steps as possible need to be well documented. Tactics of securing good reliability are mainly focusing on the data collection phase of the research design. The tactics recommend that case study protocols are used, and that a case study database is developed. (Yin, 2009, p. 41, 45) The ones employed in the report are (1) a study protocol and (2) the development of a case study database.

Information bias is a concept which case studies have been criticized for, due to the involvement of interviews in the data collection. Triangulation of data is a way of avoiding this. (Ellram, 1996)

2.8.3 Tactics to Ensure Reliability and Validity Employed

Below in table 2.3 is a summary of all the tactics mentioned in section 2.8.1 and 2.8.2 with the aim of ensuring reliability and validity. The ones employed in this report are marked with an ‘X’ in the column furthest to the right.

Table 2.3: The tactics employed to ensure reliability and validity

Constructive Approach		
	Demonstration of practical applicability	X
	Data source triangulation	X
	Investigator triangulation	X
	Theory triangulation	
	Methodological triangulation	
Case Studies		
Construct Validity	Multiple sources of evidence	X
	A chain of evidence	
	Key informants assessing the report draft	X
Internal Validity	Pattern matching	X
	Explanation building	X
	Addressing rivaling explanations	
	Logic models	
External Validity	Use of theory for single case studies	
	Use of replication logic for multiple case studies	X
Reliability	Case study protocol	X
	Case study database	X

3 THEORETICAL FRAMEWORK

This chapter is divided into five main parts. In the first part, general concepts and definitions are presented. In the following three parts, previous research on proactive supply chain risk management, reactive supply chain risk management and the connections between them are presented. In the end of the chapter, the discussed concepts are summarized into a research model.

3.1 General Concepts

This section describes and defines concepts that are used in other parts of the theoretical framework and aims to create a better understanding of the relevant theoretical concepts of this study.

3.1.1 Supply Chain Management

This section describes and defines the concepts of supply chain, supply chain management and supply chain strategies.

3.1.1.1 Definition of Supply Chain

A supply chain is defined as *a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer* (Mentzer et al., 2001).

3.1.1.2 Definition of Supply Chain Management

Many authors have defined supply chain management. Mentzer et al. (2001) define supply chain management as *the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*.

Lambert and Cooper (2000) define supply chain management as *the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders*.

Christopher and Peck (2004) give attention to the links between the involved organizations as they define supply chain management as *the network of organizations that are involved through upstream and downstream linkages, in different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer*.

In Tang's (2006b) definition, emphasis is put on the types of flows and the need of collaboration. He defines supply chain management *as the management of material, information and financial flows through a network of organizations that aim to produce and deliver products or services for the consumers. It includes the coordination and collaboration of processes and activities across different functions within the network of organizations*.

Christopher (2011, p. 3) presents the definition: *supply chain management is the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole*.

Common for these four definitions is that they all state that supply chain management includes several organizations within the supply chain who collaborate to achieve the common goal to

serve and bring value to the end customers. There is also a large focus on the interorganizational processes.

3.1.2 Risk Management

This section describes and defines the concepts of risk and risk management.

2.1.2.1 Definition of Risk Management

Risk management can be defined through a number of different definitions. Hutchins and Gould (2004) propose one in which *the essence of risk management is controlling variability from an objective, target, specification or standard*. Complementary to controlling, other important strategies include anticipation and mitigation of variability. Risk management can, however, also be about handling trade-offs, namely the one between risk and expected return (March and Shapira, 1987). When reviewing risk management definitions, Singh and Wahid (2014) found how the definitions mainly addresses uncertainty and vulnerability through the focus on various risks, management and technique aspects. If used correctly, risk management can lead to, as well as be seen as, a competitive advantage (Hutchins and Gould, 2004).

3.1.2.2 Definition of Risk

Vital to the notion of risk management are the concepts of risk and uncertainty. Although being of importance, no general definition of the two terms exist (Miller, 1992). It has also been indicated that risks are viewed differently in theory and in practice. Furthermore, the view on risk situations can be seen differently by individuals. (Kahneman and Tversky, 1979) Risk can, however, be seen as the difference in the *distribution of possible outcomes, their likelihoods, and their subjective values* (March and Shapira, 1987). Uncertainty can be described as the factor which, together with impact, leads to risk, which in turn leads to vulnerability for an organization (Franck, 2007; Zsidisin et al., 2005).

Several authors are dividing risk into two parts, which are illustrated in a risk matrix figure 3.1 (Manuj and Mentzer, 2008b; Norrman and Jansson, 2004; Knemeyer et al., 2009). The first part describes the impact of the potential risk and how large consequences it would cause the organization. The second part is the probability of the risk being realized.

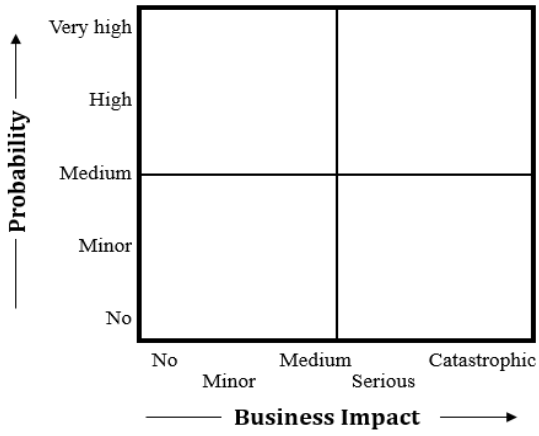

Figure 3.1: A risk matrix as adapted from Norrman and Jansson (2004)

3.1.3 Supply Chain Risk Management

This section describes the concept of supply chain risk management.

3.1.3.1 Definition of Supply Chain Risk Management

The risks of a supply chain are described by Yu et al. (2009) as something, either within or outside of the supply chain, that could affect the business negatively. To handle these risks, the concept of supply chain risk management is commonly used.

Norrman and Lindroth, (2002) and Norrman and Jansson (2004) both state that *supply chain risk management is to collaboratively with partners in a supply chain apply risk management process tools to deal with risks caused by, or impacting on, logistics related activities or resources*. Tang (2006b) and Jüttner (2005) both have a very similar focus on collaboration, though Tang (2006b) stresses the importance of securing continuous profitability and Jüttner's (2005) definition includes risk identification as a part within the supply chain risk management concept.

Lavastre et al. (2013) take another perspective as they define supply chain risk management as *the management of risk that implies both strategic and operational horizons for long-term and short-term assessment. It refers to risks that can modify or prevent part of the movement and/or efficient flow of information, materials and products between the actors in a global supply chain*. Ghadge et al. (2013) have yet another perspective as they discuss supply chain risk management with the objective of finding innovative risk mitigation strategies.

Two approaches to supply chain risk management exist: (1) proactive supply chain risk management, which handles, plans for, and tries to minimize the risk before it occurs and (2) reactive supply chain risk management, which includes the activities conducted after a risk has happened. (Grötsch et al., 2013)

3.1.4 Supply Chain Risk Classifications

Supply chain risks have been classified in various ways and perspectives. Below are four of the found classifications presented.

Mason-Jones and Towill (1998) propose that the sources of risk can be put into five categories: (1) supply risk; (2); demand risk; (3) environmental risk; (4) process risk; and (5) control risk (see figure 3.2). These risks have been discussed in further detail by both Christopher and Peck (2004) and Jüttner (2005). Christopher and Peck (2004) describe process and control risks to be found internally within the focal company. Process risks are connected to the robustness and reliability of value-adding activities. Control risks are uncertainties related to decision rules and policies. (Christopher and Peck, 2004; Jüttner, 2005) Supply risk and demand risk are found outside of the focal company, though within the supply chain (Christopher and Peck, 2004). Supply risk includes all uncertainties connected to the upstream supply chain, both in terms of a material flow disruption and loss in the information flow. Demand risk, on the other hand, concerns the downstream supply chain, including risks in the flow of finished goods as well as forecasting product demand. Lastly, environmental risk includes factors external to the supply chain, and includes natural disasters and political decisions. (Christopher and Peck, 2004; Jüttner, 2005)

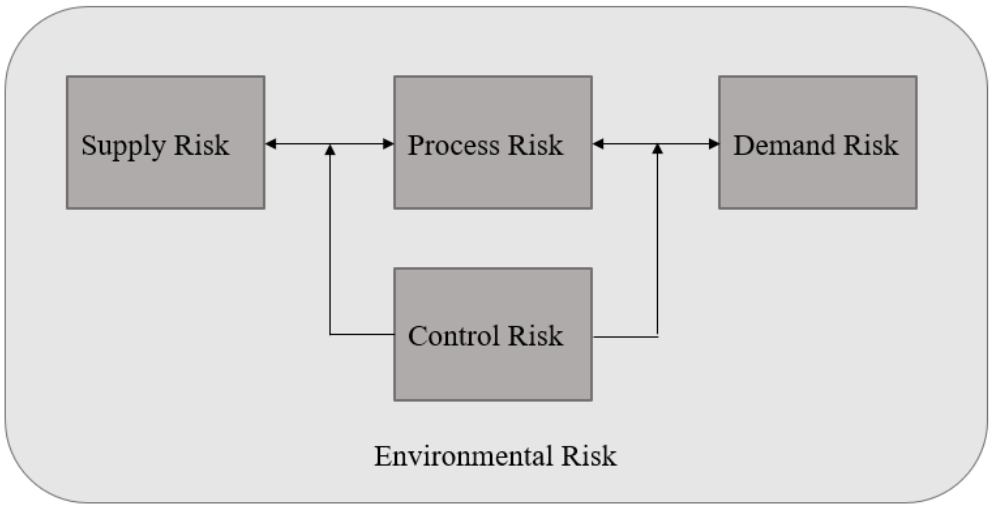

Figure 3.2: Supply chain risks as adapted from Christopher and Peck (2004)

Wagner and Bode (2008) suggest five different categories: (1) demand risks; (2) supply risks; (3) regulatory, legal and bureaucratic risks; (4) infrastructure; and (5) catastrophic. Demand risks and supply risks are defined similarly to their equivalent in the classification of Mason-Jones and Towill (1998). Regulatory, legal and bureaucratic risks are external to the supply chain and includes changes in laws and policies. Infrastructure risks includes all failures and breakdowns of equipment, both in terms of machine and IT system errors and disruption in water and electricity supply, and these risks are internal to the focal company. Catastrophic risks have a high impact on the business and are most commonly natural disasters or epidemics found externally of the supply chain.

Manuj and Mentzer (2008a) present a classification that is divided into eight categories which means that each category contains a narrower portion of the potential risks. The suggested risk categories are: (1) demand risks; (2) supply risks; (3) operational risks; (4) security risks; (5) macro risks; (6) policy risks; (7) competitive risks; and (8) resource risks. The definitions of Manuj and Mentzer (2008a) of demand risk and supply risk are very similar to the previously presented classifications, with the addition that they specify that demand risk includes chaos caused by the bull-whip effect. The operational risk could be compared to the process risk of Mason-Jones and Towill (1998), while policy risk is closely related to the category of regulatory, legal and bureaucratic risks discussed by Wagner and Bode (2008). Security risks is a risk that was not specifically addressed by previously mentioned authors and include the risks of sabotage, vandalism and crime. Macro risks are mostly related to the financial risks of changing wage and interest rates as well as changing prices. Competitive risks are the lack of information on competition and resource risks concern unexpected resource requirements.

Kleindorfer and Saad (2005) have focused their classification on disruption risks and present three categories within this area. Their first category is *operational contingencies* which includes both machine failures and blackouts (compare to the infrastructure risk of Wagner and Bode (2008)) and financial issues of a supplier that causes a disruption of supply. The second category is called *natural hazards* and comprises all potential natural disaster, for example earthquakes and storms. The third category is *terrorism and political instability*. The common factors within this category are events caused by humans external to the supply chain and that the risk should cause a severe impact.

3.1.4.1 Summary of Supply Chain Risk Classifications

The above mentioned risk classifications give an understanding of the characteristics of natural and technological disasters, which are the focus of this study.

In Mason-Jones and Towill's (1998) classification, natural disasters are considered to be external to the supply chain. Wagner and Bode (2008) characterize them as catastrophic. In Manuj and Mentzer's (2008a) classification, there is not one single category that is most suitable for natural disaster. Instead, it depends on where the disaster has occurred. If it is on the supplier's facilities, it becomes a supply risk. However, if the focal company's own facilities are affected, it becomes an operational risk.

The classification of technological disasters according to Mason-Jones and Towill's categorization varies depending on where they occur. They are supply risks if they occur at the supplier's facilities whereas if they occur at the focal company's own premises, they are process risks. For similar reasons, they could either be supply risks or infrastructure risks according to Wagner and Bode (2008). However, if the impact is great, they could also be classified as catastrophic. In Kleindorfer and Saad's classification, the most suitable category is operational contingencies.

3.2 Proactive Supply Chain Risk Management

Proactive supply chain risk management handles, plans for, and tries to minimize risks before they occur (Grötsch et al., 2013). The area includes general supply chain risk management, but also the business continuity concepts.

Business Continuity (BC) and Business Continuity Management (BCM) are two concepts regarding proactive supply chain risk management which are closely linked. What differentiates the business continuity concept from the other proactive supply chain risk management concepts is that it starts with identifying the impact before investigating the potential causes.

BC is a broader concept than BCM, and is defined as *the capability of the organization to continue delivery of products or services at acceptable predefined levels following disruptive incident* (Swedish Standards Institute, 2014a). This concept is hence focused more on the companies' capabilities rather than processes or plans.

BCM has the aim of ensuring that a company can deliver in an environment which contains risk (Gibb and Buchanan, 2006). The Swedish Standards Institute (2014b) defines BCM as the *holistic management process that identifies potential threats to an organization and the impacts to business operations those threats, if realized, might cause, and which provides a framework for building organizational resilience with the capability of an effective response that safeguards the interests of its key stakeholders, reputation, brand and value-creating activities.*

3.2.1 Proactive Supply Chain Risk Management Process

Many authors have described stepwise processes on how companies can organize their proactive supply chain risk management.

Figure 3.3: A proactive supply chain risk management process as adapted by Manuj and Mentzer (2008a)

Manuj and Mentzer (2008a) present a five-step process designed to analyze and mitigate potential risks, as seen in figure 3.3. The first step of the framework is to identify possible sources of risk for the specific organization and to categorize them depending on the type of risk (see section 3.1.4). A more detailed description of *Risk Identification* methods can be found in section 3.2.3. Next, all identified risks should be evaluated on their probability and their impact on the business, in order to ensure that the most critical risks are given the most attention (for details, see section 3.2.4). This information is also used in the third step of the process in which each risk is paired with an appropriate risk mitigation strategy (see section 3.2.5) according to the needs of the organization. In the fourth step, the chosen strategies are implemented. To gain the largest effects on the implementation, Manuj and Mentzer (2008a) argue that it is important to address the complexity of the supply chain, as well as the organization's internal learning capabilities. The final step of the suggested process is to prepare for risks that are not handled by the implemented strategies. Another part of the last step is the arrow that leads back to the first step of the process. This arrow indicates that the process should not be conducted just once, but feedback on the implemented strategies should be used as an input to continuously improve the risk management work.

Norrman and Jansson (2004) describe a proactive supply chain risk management process that was implemented by Ericsson in the early 2000s. Their process begins, just as the process suggested by Manuj and Mentzer (2008a), with *Risk Identification* and *Risk Assessment*. The third step is called risk treatment and in this step, the company has to decide whether they want to avoid, reduce, transfer, share or take the risk and then choose appropriate strategies to accomplish this. The last step of the process is risk monitoring. Central to the process are incident handling and contingency planning which are conducted parallel to the four main steps.

Ghadge et al. (2013) depict their suggested process as a circle (see figure 3.4). Their proposed process is divided into three major steps; *Risk Identification*, *Risk Assessment and risk mitigation*. The six steps are very similar to the process described by Manuj and Mentzer (2008a), but with a larger focus on the *Risk Assessment* and a more detailed description on how the steps in the risk analysis should be conducted.

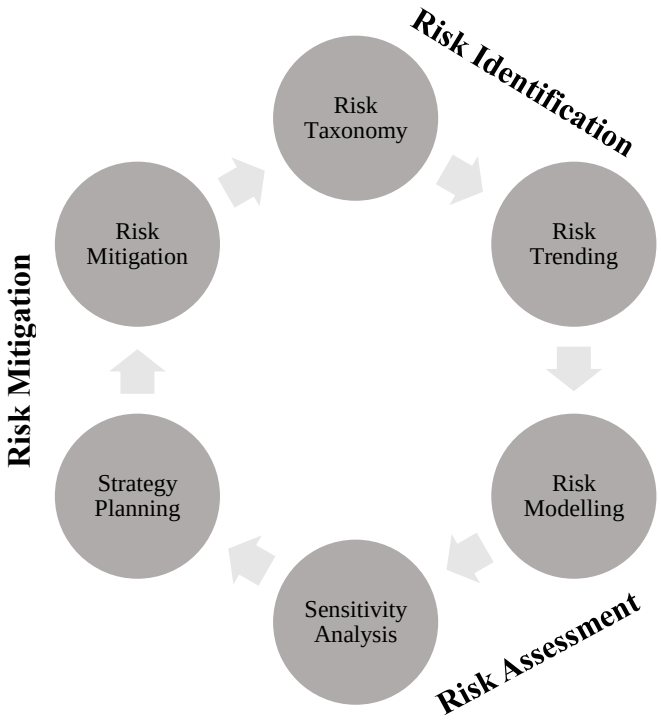

Figure 3.4: A proactive supply chain risk management process as adapted from Ghadge et al. (2013)

Kleindorfer and Saad (2005) present a very similar framework for proactive supply chain risk management as Manuj and Mentzer (2008a), with the exception that the last step is not included. They, however, stress the importance of that the selected mitigation strategies must fit the environment and the needs of the supply chain.

Kleindorfer and Saad (2005) also present an extended proactive supply chain risk management process, designed specifically for disruption risks. The first step of this process is to attain attention and approval from senior management. Secondly, key processes that have a high probability of supply disruptions should be identified and mapped. It then continues with the steps of the process presented by Manuj and Mentzer (2008a) and ends with an auditing and evaluation of the implemented strategies.

Knemeyer et al. (2009) present a process that is adapted for risks that have a low probability but, if they occur, have a high impact on the supply chain. They propose to begin the proactive supply chain risk management process with an identification of key locations and threats. Key locations are facilities with the characteristic that if they were affected with a disruption, the consequences would be that the flow of goods in the supply chain would experience a major disruption. Management has to judge itself what they characterize as a key location, though common examples are facilities that are a single source of some type of raw material or a main distribution center of a major market. Knemeyer et al. (2009) stress the fact that a key location does not have to be owned or operated by the focal organization. The second step is an assessment of the potential risks on each key location. The proposed third step is an evaluation of possible risk mitigation strategies for each key location, before selecting appropriate strategies in the fourth and final step. The last three steps of this process are identical to the first three steps suggested by Manuj and Mentzer (2008a) in figure 3.3.

Swedish Standards Institute (2013) presents a BCM process which involves the five elements seen in figure 3.5. Central to their model is *operational planning and control.* Examples of

actions this step can include are: ensuring the relevance of the business continuity scope, managing costs related to the process, providing training of staff and ensuring that continuity is embedded within the organization.

As stated in section 3.2, BCM starts with understanding possible impact before identifying risks. Hence, a business impact analysis is to be conducted first, and a *Risk Assessment* follows once possible impact is understood. The two processes should identify measures that limit the impact, shorten the disruption and reduce the likelihood of a disruption. Next, risk mitigation strategies should be chosen which meet the business continuity objectives of the organization. Thereafter, business continuity procedures can be formed and implemented. Finally, the procedures need to be exercised and tested. In this part of the process, flaws in the current business continuity plans need be found and improved. (Swedish Standards Institute, 2013) The two last steps will be further discussed in sections 3.2.6 and 3.2.7.

Figure 3.5: Elements of BMC as adapted from Swedish Standards Institute (2013)

Another framework for BCM is presented by Gibb and Buchanan (2006). The framework is supposed to cover the design, implementation and monitoring of BCM and consists of nine steps. As seen in figure 3.6, the steps have similarities with figure 3.3. The third and fourth step correlate well with step number one, two and three in the process by Manuj and Mentzer (2008a) (see figure 3.3), while step six correlates to step four in the process by Manuj and Mentzer (2008a). The first two steps are called *program initiation* and *project initiation*. These steps will be further discussed in section 3.2.2. The third step, *risk analysis*, can be broken down into three parts: risk analysis, risk evaluation and business impact analysis.

Once the risks are identified, the aim is to find options to handling the risks, both proactively and reactively. Next, *monitoring and control* focus on putting in place effective communication,

command and control structures which can ensure the realization of the plan. Thereafter, *testing* should ensure that the plans are complete and relevant. New employees should receive training when starting to work, while the already employed needs re-orientation training at least once a year. In this step, communication is also vital as to spread the knowledge of the business continuity work. Lastly, the *review* is to ensure that the business continuity work does not become dated due to changes in the company's internal and external environment. (Gibb and Buchanan, 2006) The final step will be discussed in section 3.2.7.

Figure 3.6: A framework for BMC as adapted from Gibb and Buchanan (2006).

3.2.1.1 Summary

The suggested proactive supply chain risk management processes, both in traditional supply chain risk management and in BCM, are all considered to be fairly similar. They all share the same basics steps of *Risk Identification*, *Risk Assessment* and choosing risk mitigation strategies and their differences are mainly found in the proceeding and succeeding steps. By examining the goals and purposes of these different steps, the processes can be summarized to the steps presented in figure 3.7.

Figure 3.7: The proactive supply chain risk management process

3.2.2 Initiation

To start the proactive supply chain risk management process, authors suggest several steps to take. As stated in section 3.2.1, Knemeyer et al. (2009) begin their suggested proactive supply chain risk management process for catastrophic risks by identifying key locations. Kleindorfer and Saad (2005), on the other hand, suggest that the process should begin with identifying key processes. To conclude, the unit of analysis should be determined in the *Initiation* step.

Gibb and Buchanan (2006) state that before the risk analysis can begin, a program charter and a program plan should be developed, that will give guidelines and prioritization information for the future supply chain risk management initiatives. Gibb and Buchanan (2006) also state that it is important to define objectives for supply chain risk management projects.

The different actions in the *Initiation* step are summarized in table 3.1.

Table 3.1: Actions in the Initiation step

Initiation	
Part	**Action**
Initiation of the supply chain risk management process	Define unit of analysis
	Create a program charter
	Create a program plan
	Define objectives

3.2.3 Risk Identification

It is possible to use several different methods to identify risks. Kırılmaz and Erol (2016) list five different sources that can be used to recognize potential risks: (1) recorded risks in

literature; (2) historical events within the company; (3) experiences and thoughts from employees; (4) risk experts; and (5) specific webpages with listed risks.

Norrman and Jansson (2004) suggest a method called risk mapping and give two logic diagram techniques to help identify risk sources. The first technique is called a *fault tree analysis*, where all potential events that could lead to a critical event are evaluated. The mapping begins with the critical events and the analysis continues backwards to identify the causes. The second technique is called *event tree analysis*, is used to analyze events that can occur after a critical event.

The methods to identify sources of risk are summarized in table 3.2.

Table 3.2: Methods to identify sources of risks

Risk Identification		
Part	**Method**	
Identify sources of risks	Find recorded risks in literature	
	Evaluate historical events within the company	
	Gather thoughts from employees	
	Use risk experts	
	Use specific webpages	
	Risk mapping	Fault tree analysis
		Event tree analysis

3.2.4 Risk Assessment

Several authors suggest that the *Risk Assessment* should be divided into two different parts; estimate probability of an event and estimate potential loss (Kırılmaz and Erol, 2016; Knemeyer et al., 2009; Norrman and Jansson, 2004).

Kırılmaz and Erol (2016) state that the probability of an event should be determined by finding a probability distribution function based on historical data. Knemeyer et al. (2009) confirm this and suggest using the found probability function in simulation models, which they state is particularly effective for catastrophic events (low probability and high impact), since those risks often are specific for individual buildings. The simulations can therefore offer precise comparisons between different locations. Knemeyer et al. (2009) also state that expert estimates can be used to estimate probabilities.

The potential loss is often estimated in costs or loss of revenue (Kırılmaz and Erol, 2016; Knemeyer et al., 2009), and the assessment should be based on potential sources of loss that easily can be quantified, for example loss of physical assets and products in inventory. The assessment should then be complemented and adjusted with other factors, for example human loss or information loss. (Knemeyer et al., 2009)

The *Risk Assessment* methods are summarized in table 3.3.

Table 3.3: Risk Assessment methods

Risk Assessment	
Part	**Method**
Estimate probability	Find probability distribution function based on historical data
	Simulation models
	Expert estimates
Estimate loss	Quantitative estimation
	Qualitative estimation

3.2.5 Selecting Risk Mitigation Strategies

Theory proposes a range of possible solutions to handle identified risks, however, it has been discussed that all risk mitigation strategies either increase the redundancy or improve the flexibility of the supply chain (Sheffi and Rice, 2005). In this report, only the strategies that have been argued to mitigate supply disruptions are described. These strategies either improve the flexibility of the suppliers and/or the focal company, increases the information flow or increases the redundancies within the supply chain.

3.2.5.1. Collaboration

Collaboration with suppliers has in several studies been found to decrease supply risk. Hallikas and Lintukangas (2016) showed that partners who are setting common goals or cooperating through process improvements have a decreased risk. Tang (2006b) extends this by arguing that collaborative information sharing decreases the risk as the information on inventory and demand becomes visible and planning can be improved. Tang's (2006b) argument is confirmed by Chen et al. (2013), whose study finds that open communications and joint quality improvements decrease the risk.

Ponis and Ntalla (2016) state that creating long-term relationship and trust is a strategy that can generate a helping partner when a disaster occurs.

The collaboration strategy is often found to be used when uncertainties are great or when an organization finds itself highly dependent on a specific supplier (Mishra et al., 2016).

3.2.5.2 Hedging

Manuj and Mentzer (2008a) describe hedging as the strategy to create a dispersed portfolio of suppliers, facilities and customers. This could include having several production facilities and warehouses that are strategically located to minimize the risk of having all production affected by disruptions simultaneously.

Hedging could also include sourcing from different suppliers (Manuj and Mentzer, 2008a). Sourcing from a single supplier generates many benefits including facilitating supplier collaboration and lower costs. However, only sourcing from a single supplier also results in increased risks, as the supply chain becomes vulnerable to supply disruptions. (Yu et al., 2009) Hedging, which is the use of multiple suppliers, is therefore an option to lower the supply risk (Manuj and Mentzer, 2008b).

Christopher and Peck (2004) recommend to always have several suppliers if possible, although, to increase collaboration, one of them could be considered the main suppliers. Yu et al. (2009)

finds that both single and multiple sourcing have their strengths and weaknesses, and suggest an evaluation of trade-offs for each individual case.

3.2.5.3 Buffering

Buffering is used as a protection of supply disruptions. It is a flexible solution since it can be used for all products and their components and, as it does not require any process improvements, it is relatively easy to implement. (Mishra et al., 2016) Though, even without its high investment costs, the strategy could become costly, as the holding costs of the extra inventory are continuous. It is therefore important to compare the holding cost to the cost of a potential disruption. (Chopra and Sodhi, 2004)

Chopra and Sodhi (2004) describe buffering as one of the appropriate strategies to use for supply disruptions, especially if the risk has a relatively high probability. However, they also stress that products with short life cycles are difficult to buffer, as their value quickly decreases and their demand is unpredictable.

Tang (2006a) highlights that buffering does not necessarily need to imply increased safety stocks. Instead, he defines the concept *strategic stock* as a buffer that is held at selected locations and that could be shared by several members of the supply chain.

3.2.5.4 Postponement

Postponement is used when delaying product differentiation in order to increase flexibility (Manuj and Mentzer, 2008b; Tang, 2006a). By designing products in a standardized and modular way, the production can be adapted to meet the actual demand. After a fire at a supplier's facility in 2000, Nokia managed to handle the disruption with relatively small impact on their business, since their modular design only required a small redesign in order to make components from other suppliers fit. (Manuj and Mentzer, 2008b)

Postponement requires an understanding of modular product design, which could inquire high investment costs (Tang, 2006a). However, it has also been argued that postponement is an effective risk mitigation strategy, both in terms of cost and time (Manuj and Mentzer, 2008b).

3.2.5.5 Increase Agility

An organization's agility is determined based on how fast it is able to react to unexpected events. Agility consists of several factors, though there are two aspects that serve the greatest importance; visibility and velocity. (Christopher and Peck, 2004)

Christopher and Lee (2004) state that a lack of visibility within the supply chain is considered to result in chaos and poor decisions. This can be improved with increased supplier collaboration as stated in section 3.2.5.1, but can also be handled through removing intervening inventories or by increasing the visibility internally within the focal organization (Christopher and Peck, 2004).

To increase velocity the main focus should be on decreasing the time it takes for the goods to move throughout the entire supply chain. Therefore, in-bound lead-times and non-value adding activities are important aspects to minimize while streamlining processes. (Christopher and Peck, 2004)

3.2.5.6 Create a Supply Chain Risk Management Culture

By creating a supply chain risk management culture within an organization, an increased awareness is present on all departments and everyone should be responsible for minimizing the

risks within their specific responsibilities. Top management needs to be highly involved and a special cross-functional risk management team should be formed that records and reports on the risk management work. (Christopher and Peck, 2004)

3.2.5.7 Avoidance

The avoidance strategy is used when an organization finds the risks in a product or geographical market to be unacceptable and therefore chooses other options (Manuj and Mentzer, 2008b; Manuj and Mentzer, 2008a; Miller, 1992). The strategy can be used either when the risk is found to be too high (Miller, 1992) or when a specific type of risk is considered too unacceptable exposing the organization to (Manuj and Mentzer, 2008b).

3.2.5.8 Summary

The presented risk mitigation strategies are summarized in table 3.4.

Table 3.4: Risk mitigation strategies

Risk Mitigation Strategies	
Strategy	**Action**
Collaboration	Joint process improvements
	Joint quality improvements
	Open communication
	Long-term relationship and trust
Hedging	Multiple manufacturing locations
	Multiple warehousing locations
	Multiple suppliers
Buffering	Increased safety stocks
	Strategic stocks
Postponement	Modular design
Increase agility	Remove intervening stocks
	Increase internal visibility
	Reduce inbound lead-times
	Reduce non-value adding activities
Create a supply chain risk management culture	Involvement of top management
	A special supply chain risk management team
Avoid risks	Location not selected due to high risks

3.2.6 Implement and Educate

As the selected strategies are implemented, theory suggests several other activities to conduct simultaneously. Manuj and Mentzer (2008a) state that it is important to put relevant performance measures in place in order to be able to follow the results of the implemented strategies.

Both the Swedish Standards Institute (2013) and Gibb and Buchanan (2006) discuss the importance of creating a business continuity plan. The Swedish Standards Institute (2013) also describe the importance of implementing ways to detect disruptions.

Gibb and Buchanan (2006) put an emphasis on training and state that every employee should be educated in the company's supply chain risk management processes every year and that every new employee should receive training when they begin at the company.

The actions of the *Implement and Educate* step are summarized in table 3.5.

Table 3.5: Actions for the Implement and Educate step

Implement and Educate	
Part	**Action**
Implementation	Create performance measures
	Create a business continuity plan
	Implement ways to detect disruptions
Education	Yearly training
	Training of new employees

3.2.7 Monitoring, Testing and Evaluation

Kleindorfer and Saad (2005) present several methods to monitor and evaluate a company's supply chain risk management strategy. First, they state that periodic auditing is important in order to receive ongoing feedback. This can either be conducted internally within the company, by a contracted second party or a third party in form of an external certified examiner. Secondly, benchmarking within the industry gives a continuous understanding of sources of risks. Lastly, legal reviews of implementation plans, and ongoing results should be conducted.

Gibb and Buchanan (2006) state that testing of the implemented strategies should be conducted within three months and thereafter every year.

The actions of the *Monitoring, Testing and Evaluation* step are summarized in table 3.6.

Table 3.6: Actions for the Monitor, Testing and Evaluation step

Monitor, Testing and Evaluation	
Part	**Action**
Monitoring	Periodic auditing
	Reviews of implementation plans
	Reviews of ongoing results
Testing	Testing within three months of implementation
	Yearly testing
Evaluation	Benchmarking

3.2.8 Summarized Framework

The discussed concepts of proactive supply chain risk management are summarized in figure 3.8. The mitigation strategies are the depicted in a higher level compared to the actions in the other steps, since the *Selecting Mitigation Strategy* actions are too many to fit into the figure.

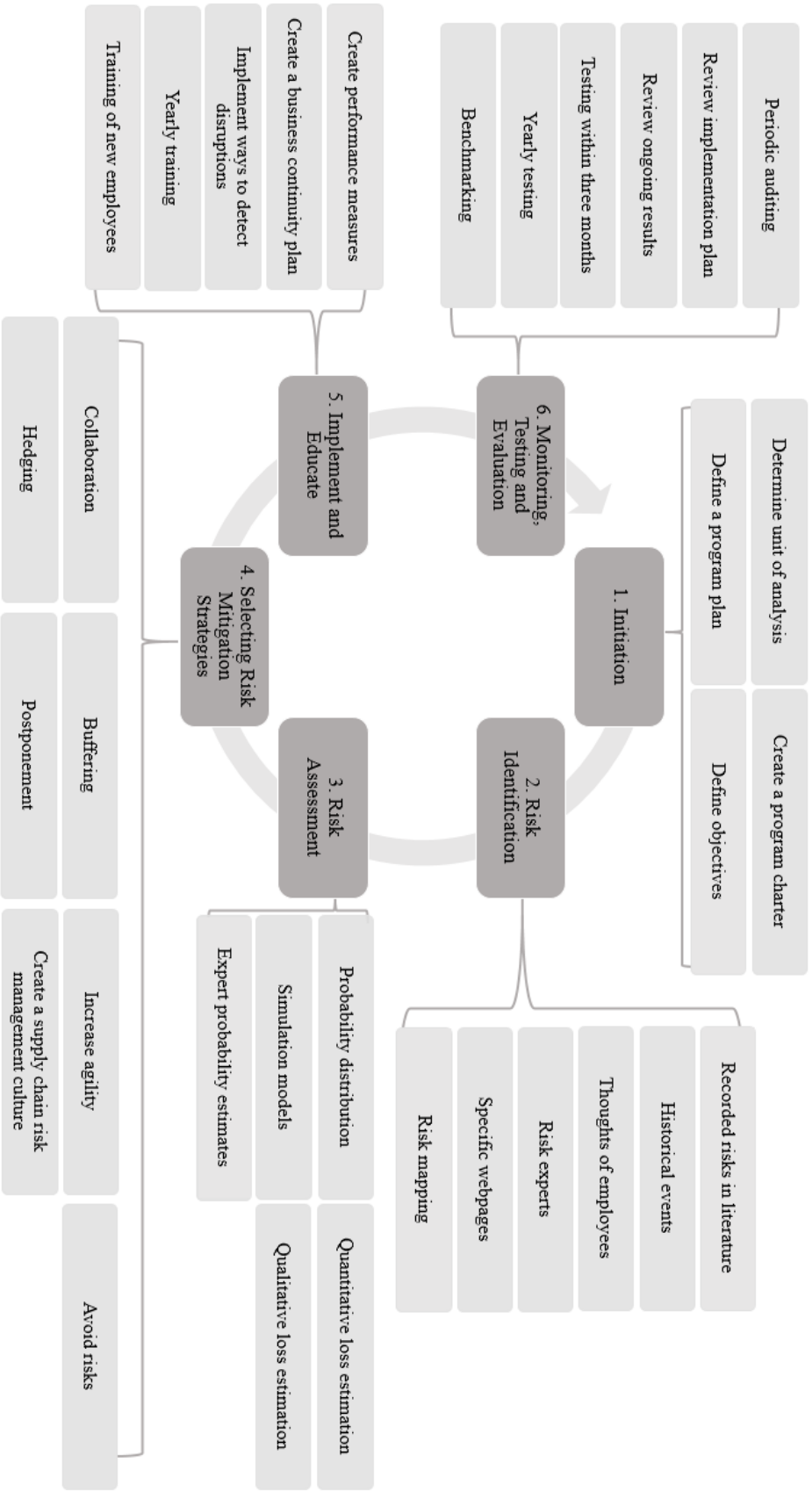

Figure 3.8: A summarized framework of proactive supply chain risk management

3.3 Reactive Supply Chain Risk Management

Reactive supply chain risk management handles the actions which are taken after a risk has occurred (Grötsch et al., 2013)

3.3.1 Reactive Supply Chain Risk Management Process

Regarding processes of actions or steps to take after an incident has occurred, only one by Hopp et al. (2012), has been found. This process entails five steps which have been visualized in figure 3.9. According to this process, once a disruption has occurred, it needs to be recognized and a response initiated. After this is done, a disruption management team is vital to get in place. Once the disruption management team is in place, an initial plan needs to be developed. Since proper response actions only can be made once the plan is created, this step is of essence. When starting to work with the plan, new information will appear. Once this happens, the plan should be reviewed and revised if the information changes the situation. Finally, once the disruption becomes less critical, the reactive work should be evaluated. Based on the evaluation, the organization should learn from the incident to improve for future disruption.

3.3.1.1 Summary

Due to being the only process found on reactive supply chain risk management, it will be considered as the, by theory, suggested process throughout the report and it is summarized in figure 3.9.

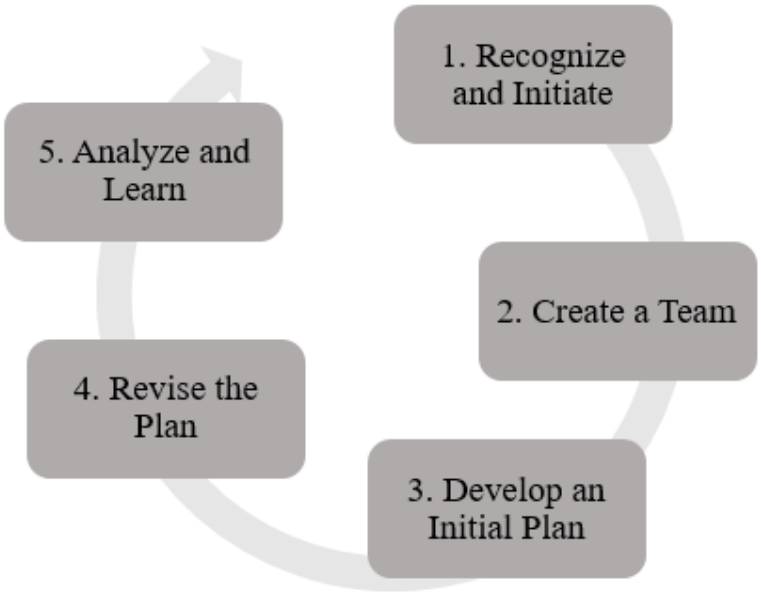

Figure 3.9: The reactive supply chain risk management process

3.3.2 Recognize and Initiate

In order to start the reactive supply chain risk management process, the incident needs to be recognized and a response initiated (Hopp et al., 2012), which is summarized in table 3.7.

Table 3.7: Actions in the Recognize and Initiate step

Recognize and Initiate	
Part	**Action**
Recognize	Identify that a disruption has happened
Initiate	Prepare for the coming steps in the process

3.3.3 Create a Team

Once the incident is recognized, communication with all stakeholders of the disruption, including both suppliers and competitors, should be done. The aim is to put together a crisis management team that can come up with an action plan. (Hopp et al., 2012) A summary of this step is presented in table 3.8.

Table 3.8: Actions in the Create a Team step

Create a Team	
Part	**Action**
Create a Team	Communicate with suppliers
	Communicate with competitors
	Put together a team

3.3.4 Develop an Initial Plan

Developing an initial plan needs to be done quickly in order to ensure that actions to respond to the crisis can be taken. Musson (2001) has presented seven strategies to handle supply chain risks reactively. Although these strategies can be developed proactively, they will need to be decided on and implemented once the incident has happened. Their aim is to maintain partial or complete production volumes. The seven strategies are:

- Use of spare capacity within the organization.
- Shutdown of marginal product lines and transfer of key products to those production facilities.
- Assistance from competition.
- Advice and assistance from trade organizations.
- Outsourcing to subcontractors, job shops, etc.
- Re-labeling of competitors' products (after consideration of legal implications).
- Establishment of temporary facilities when production capabilities can be established with acquired equipment.

In addition to this, Bland (2013) discusses the importance of communication after a disruption. An essential part of the reactive work is protecting the reputation of the company. A tool in this work is communication. The four categories of people or organizations with whom communication is important are those who: (1) are effected by the disruption; (2) are involved within it; (3) need to know; and (4) have the power of effecting others. The key according to Bland (2013) is to show that the company cares.

Ponis and Ntalla (2016) argue how trust is important to savior even during disruptions. Laying off employees to cut costs or reducing product quality caused more problems than benefits for

companies in the long-term, according to a comparison of cases. This also reflects back to the company's reputation, in which Ponis and Ntalla (2016) agree with Bland (2013) on its importance for the company. Collaboration and cooperation within the supply chain should also be sought once a disruption has occurred.

Assortment planning can also be used in the reactive work. If presenting products to customers in a different way, the demand on the relevant products can be effected. This means that products which might not have been affected by the disruption can be used to absorb some of the demand which usually is for a more affected product. Hence, the customers might not to the same degree notice the disruption. (Tang, 2006a)

The presented strategies are summarized in table 3.9.

Table 3.9: Strategies in the Develop an Initial Plan step

Develop an Initial Plan	
Part	**Strategy**
Develop an Initial Plan	Use of spare capacity
	Shutdown of marginal product lines and transfer of key products
	Assistance from competition
	Advice and assistance from trade organizations
	Outsourcing
	Re-labeling of competitors' products
	Establishment of temporary facilities
	Communication in the supply chain
	Retain the company's values
	Collaboration in the supply chain
	Assortment planning

3.3.5 Revise the Plan

When new information becomes available, the initial plan will have to be revised to stay updated. This revision will in most cases need to be done frequently. (Hopp et al., 2012) The suggested actions of this step are presented in table 3.10. When revising the plan, it has been interpreted, by the authors of this study, that the strategies listed in table 3.9 could be duplicated to this step, as the revision could lead to that new strategies are chosen. However, as theory only suggests to list the strategies in the *Develop an Initial Plan* step, the chosen strategies will be listed there throughout the report.

Table 3.10: Actions in the Revise the Plan step

Revise the Plan	
Part	**Action**
Revise the Plan	Identify when new information is available
	Evaluate if planned actions have become obsolete

3.3.6 Analyze and Learn

When the crisis has been managed, the organization should analyze what they did well and not so well in order to be improved to next time (Hopp et al., 2012), which is summarized in table 3.11.

Table 3.11: Actions in the Analyze and Learn step

Analyze and Learn	
Part	**Action**
Analyze	Analyze what went well
	Analyze what could have been done better
Learn	Find ways to incorporate the analysis into future risk management

3.3.7 Summarized Framework

The discussed concepts of reactive supply chain risk management are summarized in figure 3.10.

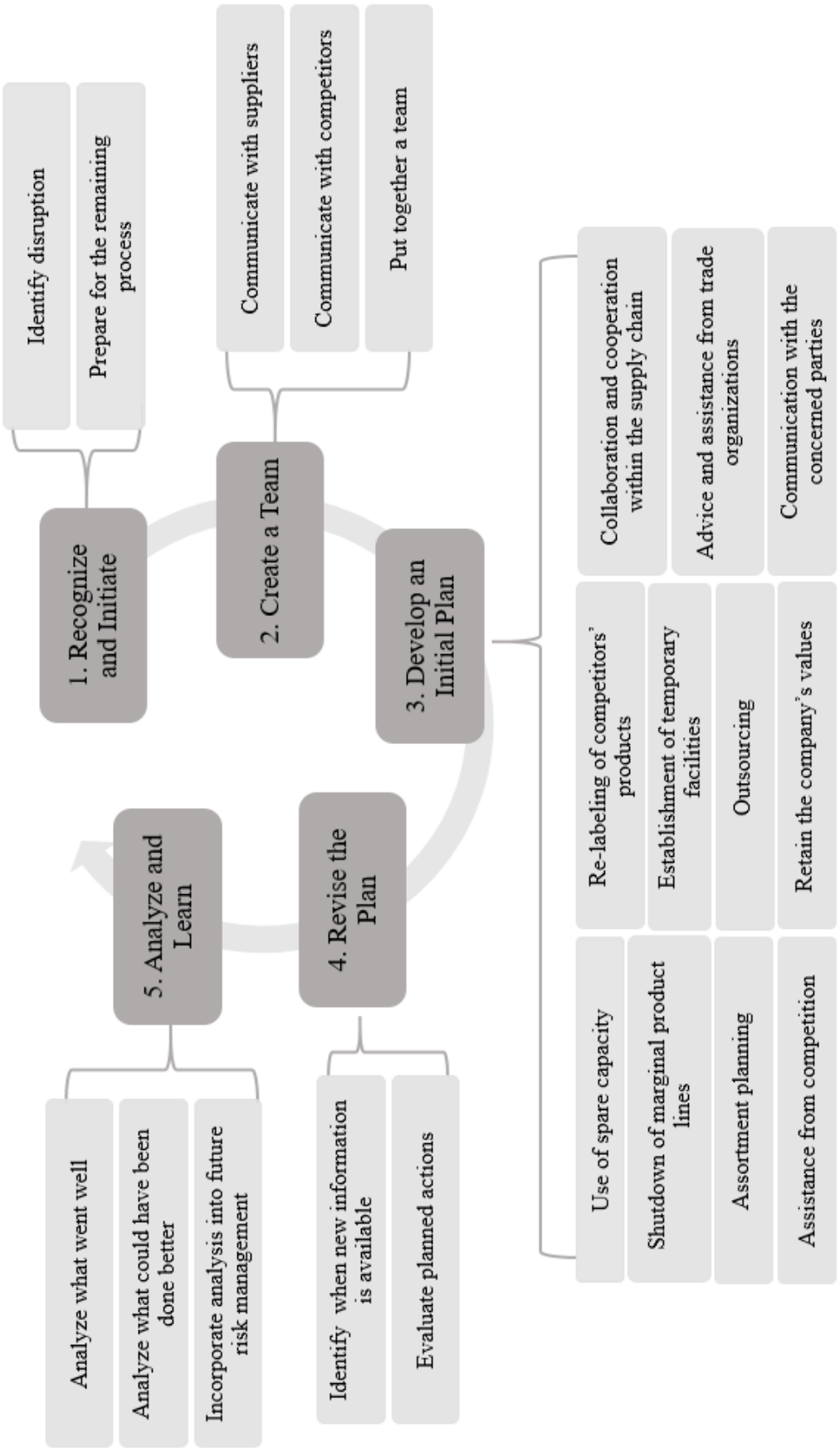

Figure 3.10: A summarized framework of reactive supply chain risk management

3.4 Connections Between Proactive and Reactive Supply Chain Risk Management

Almost no theory discussing the direct connections of how proactive supply chain risk management can enable reactive supply chain risk management has been found by the authors of this study. Hence, these connections are found as fragments in articles discussing other parts of supply chain risk management.

Ponis and Ntalla (2016) have conducted a comparison of disruption cases in which connections between proactive and reactive supply chain risk management can be found. First of all, creating trust and long-term relationships in the supply chain eases the cooperation and collaboration after a disruption has happened. The aspect of relationships is also mentioned by Singhal et al. (2011), in which reactive strategies become more effective if the relationship is good. Furthermore, having a plan for expenses in case of a disruption enables the company to make quick and reasonable decisions once a disruption has happened. Lastly, having developed systems which facilitate a quick detection and response also helps mitigating the impact.

Olson and Anderson (2016) mention the speed with which actions were taken after a disruption, due to the company having created a business continuity team assigned to the task in advance. Communication was enabled by having created a business continuity plan in which for example up-to-date call trees could be found. However, too many details in the business continuity plan confused the reactive work and delayed it. Training and testing had also aided the employees in knowing the actions to take once a disruption emerged. (Hatton et al., 2016)

A summary of the in theory presented connections between proactive and reactive supply chain risk management are presented in table 3.12. The proactive actions are described on a more detailed level as they have a larger focus in the study, since the purpose is to create proactive supply chain risk management guidelines. This means that for the proactive side of the connections, both the step and the concerned action or method will be presented. The step will be written first, followed by the action or method in parentheses.

Table 3.12: Connections between proactive and reactive actions

Connections	
Proactive	**Reactive**
Selecting Risk Mitigation Strategies (long-term relationship and trust)	Develop an Initial Plan
Implement and Educate (create a business continuity plan)	Develop an Initial Plan
Implement and Educate (implement ways to detect disruptions)	Develop an Initial Plan
Selecting Risk Mitigation Strategies (a special supply chain risk management team)	Develop an Initial Plan
Implement and Educate (yearly training)	Recognize and Initiate
Implement and Educate (training of new employees)	Recognize and Initiate

3.5 Research Model

The studied theory is summarized in order to further develop the overall system which can be found in figure 1.4. The result of this conclusion is the research model for the study, as seen in figure 3.11. As can be noticed, figure 3.8 and 3.10 go into even more detail with one more layer of actions, compared to the steps showed in figure 3.11. However, these would have created a too complex figure visually and are hence not showed in figure 3.11. The suggested links in section 3.4 have been illustrated through arrows. If more than one connection is found between a step in the proactive supply chain risk management process and a step in the reactive supply chain risk management process, the thickness of the arrow is increased. Consequently, the thicker the arrow, the more connections between those steps.

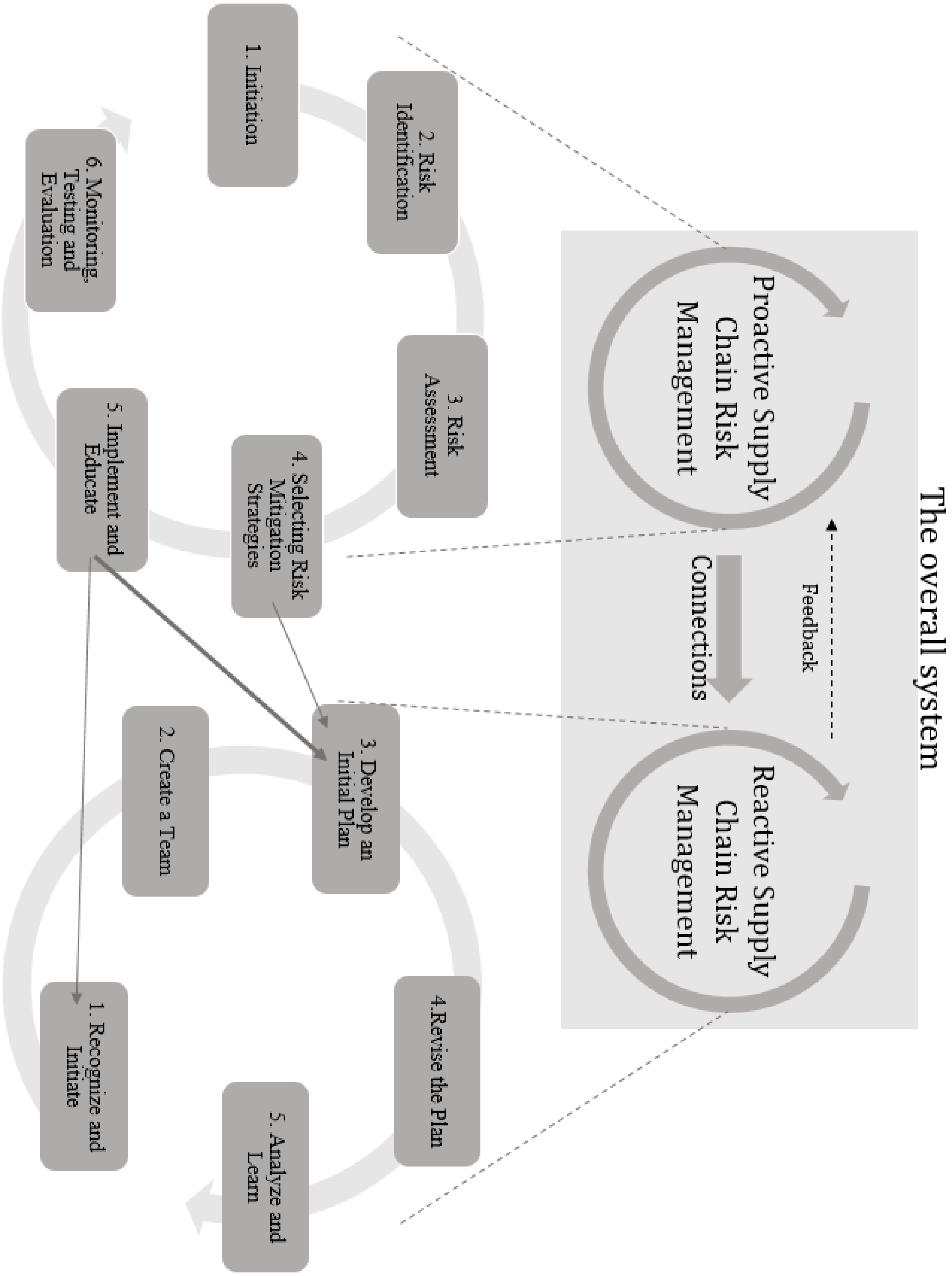

Figure 3.11: A summary of the theoretical framework

4 EMPIRICAL FINDINGS

In this chapter, the empirical findings from the data collection is presented. The chapter is divided into three main sections. Firstly, the proactive supply chain risk management at Axis during the last years is described. Next, the handling of the four studied disruptions is presented. Lastly, the found connections between proactive and reactive supply chain risk management are listed.

4.1 Proactive Supply Chain Risk Management at Axis

The proactive supply chain risk management at Axis during the last few years is described in one section as it is primarily not dependent on the four studied disruptions described in section 4.2.

Axis does not have a set structure for its proactive supply chain risk management process towards suppliers and contract manufacturers. Instead, the employees claim that risk is with them constantly in their everyday work and in every decision that they make. There exists a structured proactive risk management process for R&D-projects, which always begins with a brainstorming session with the members of the project team where possible risks are identified and assessed, and mitigation strategies are chosen. This process is, however, excluded from the study.

Since Axis does not have a proactive supply chain risk management process towards its upstream supply chain, the authors of this report had to put the activities that are conducted into an overall structure to make it easier for the readers to follow the reasoning. The chosen structure follows the process and activities that were identified in the studied theory and presented in chapter 3.2 since it is a familiar structure that runs through the entire report.

4.1.1 Initiation

As Axis does not have a structured proactive supply chain risk management process, no conscious decision on the unit of analysis that is studied has been made. Axis has not created any program charters or objectives with its proactive supply chain risk management.

4.1.2 Risk Identification

The identification of risks in the upstream supply chain is done infrequently as potential risks are observed by the employees themselves in their everyday work. Historical events play an important role as potential risks are observed, as they create a basis for all risk identification.

4.1.3 Risk Assessment

Axis does not use any standardized tools or methods to assess identified risks. The impact on turnover and the length of disruption are sometimes estimated. The probability of a risk is estimated internally within the organization and could, for example, be rated *low*, *high* or *no risk*. However, the type of rating varies depending on the employee that is leading the assessment meeting.

4.1.4 Selecting Risk Mitigation Strategies

Axis has chosen several strategies to mitigate risks of supply disruptions. Some of the main decisions concern activities that fit into the strategy *hedging*. The production is divided between six contract manufacturers that are spread to different geographical locations across the globe. In addition to this, one of Axis' major contract manufacturers, SVI, has another facility nearby

the main factory. Until 2011, each product was only produced at one contract manufacturer. However, employees realized that it put Axis in a vulnerable position and began a project with the aim of producing each product on two separate locations. The flooding at SVI (see 4.2.2) became a catalyst for this project. Today, Axis only divides the production of high-volume products between two contract manufacturers, as it was found too time-consuming to initiate production at two sites for every product. Producing at more than one contract manufacturer is, however, difficult when initiating the production of a new product, so for new, high-volume products the focus is instead on the speed with which a second contract manufacturer can be developed once the first contract manufacturer has proven to be stable in the production of the product. It is also important for Axis that its production does not make up too little of a contract manufacturer's business, in order to receive enough attention, while at the same time not too much, in order to not make the contract manufacturers too dependent on Axis. Axis wants to stay between 10 to 35% of a contract manufacturer's total business. The contract manufacturers should always have 30% extra capacity that could be used if Axis needs to move production from one contract manufacturer to another, or if the demand suddenly increases.

Axis also has warehouses on several geographical locations, for example, there are six CLCs located on three different continents. Axis wishes to own the tools that are used by the suppliers and does so in many cases.

Axis wants to have at least two suppliers for strategic components, and although it is not measured, it is desired not to let a strategic component from a single supplier be in more than 50% of the product volume. Axis had during 2015 noticed that Sony's sensors were used in 80% of Axis' products, and a new supplier, Panasonic Corporation (hereafter referred to as Panasonic) was contacted. Axis had developed its first products with sensors from Panasonic (including redesigning some of the current products) at the end of 2015. Additionally, for strategic components, Axis has created relationships with suppliers that it currently does not purchase components from. The reason for this is mainly to keep up with the development of technology and many of these suppliers' sensors are tested regularly.

As Axis has chosen to outsource many activities, *collaboration* has, ever since the company was founded, been very important. Axis strives to create long-term relationships with its partners and the employees within Axis find the communication towards suppliers and contract manufacturers to be open. Occasionally, Axis works together with suppliers and contract manufacturers to improve processes, for example has Axis recently matched its forecast to be ready when a supplier needs it. Having joint quality improvements is, however, more common. Axis often has discussions on how components can be improved and suppliers are invited at the start of development projects to give input on the design of Axis' products. Neither joint process improvements, nor joint quality improvements are done with regards to risk. The main collaboration with regard to risk is done with audits where Axis points out potential risks to suppliers and contract manufacturers, and requires a BCP to handle the identified risks. Although, there are not always consequences if the suppliers and contract manufacturers choose to not follow Axis' advise. One example of this is that before the fire at the contract manufacturer SVI's facilities in Thailand, 2014, Axis had observed that SVI did not have any sprinklers, however, Axis had not pushed for it when SVI did not comply. The audits are only conducted with the suppliers which have a relatively small total production volume (as other bigger companies audit the large component manufacturers). All collaboration work that Axis

conducts with its upstream partners results in many travels. Hence, the major sites have visits from Axis employees almost every week during a year.

Axis also collaborates downstream in the supply chain and has created a network with its distributors to facilitate communication.

Buffering is another strategy that is important to Axis. In the supply chain, the stocks of finished products correspond to between 40 to 45 days of demand. Most of the finished products are stored at the distributors. Normally, the contract manufacturers themselves handle the ordering of components from selected suppliers (although all other communication between the contract manufacturers and the suppliers should go via Axis). However, to ensure the supply of strategic components, including chips and sensors, Axis orders and stores these itself. Usually, the stock of strategic components covers two to three months of production. Axis also stores production and testing equipment. The testing tools are developed to be flexible and can be used to test several different products.

Axis uses modular design partially, since it has been proven difficult and unpractical to conduct fully. Not all products are built with modules, and those that are, usually only have a few components that are interchangeable. When possible, Axis builds modules with the sensor cards and the camera modules. This is done to make it easier to redesign.

Axis has not worked actively to remove intervening stocks or non-value adding activities. Nevertheless, reducing lead-times receives much attention within the company and it is one of the major KPIs that Axis works with. However, it is not always easy as Axis also wants to reduce air shipping, in favor of slower and more environmentally friendly alternatives, and many of the components have standardized lead-times. Increasing the internal visibility is a part of Axis' core value *Always Open* and employees are urged to post information on the internal network, Galaxis. To facilitate communication between departments, Axis has created commodity teams which are cross-functional and mainly consist of Operations and R&D and which have meetings regularly. A part of their agenda is to discuss potential risks for their respective components.

Top management is continuously involved in discussions about proactive supply chain risk management with other employees within Axis and supports the work when asked to. Axis has not appointed anyone responsible for supply chain risk management. Instead, all employees should take responsibility. Axis wants a company culture which encourages collaboration and absence of prestige, where the employees take own initiatives to solve problems and do not blame them on their coworkers.

Axis has never made the decision to not be present at specific locations due to high risks, as the quality of the components has been more prioritized.

4.1.5 Implement and Educate

Axis has implemented one KPI to track one of the chosen strategies. It evaluates whether Axis stays between 10 to 35% of a contract manufacturer's total business.

Axis has hired a company which helps with tracking the macro environment, to help keep track of occurrences around the world.

Axis does not have a business continuity plan. Neither is any specific training on supply chain risk management conducted.

4.1.6 Monitoring, Testing and Evaluation

Axis conducts audits of the suppliers regularly and has frequent meetings with suppliers regarding the ongoing results. Axis does not test its supply chain risk management, nor is benchmarking conducted.

4.2 Reactive Supply Chain Risk Management at Axis

In this section, the reactive supply chain risk management at Axis is described for the four studied disruptions. In the cases in which Axis did not have a predetermined, structured reactive supply chain risk management process, the handling of the disruption has been labelled disruption management.

4.2.1 Earthquake/Tsunami 2011

On March 11, 2011, an earthquake struck close to the northeastern coast of the Japanese island Honshu. The earthquake had a magnitude of 9.1 on the Richter scale (USGS, 2016a), and its energy triggered a tsunami, which shortly afterwards hit the Japanese coast. (Buerk, 2011; Pletcher and Rafferty, 2016) The National Police Agency of Japan (2016) reported that 15,893 people had been found killed from the disaster and that 2,556 people are still missing.

The tsunami alone destroyed 104,000 buildings, and another 170,000 buildings were partially destroyed or damaged. The earthquake, on the other hand, destroyed 25,000 buildings and 200,000 buildings were either partially destroyed or damaged. (Vervaeck and Daniell, 2012)

4.2.1.1 Impact on Axis' Upstream Supply Chain

Several of Axis' suppliers were affected by the disruption, although not always directly since in many cases the factories of the second-tier suppliers were the facilities which had been damaged. Nine suppliers were identified as being critically affected. In particular, Sony and Hitachi Ltd. Corporation, who produced camera modules, were given the most attention by Axis. The study of this case has, however, focused on the reactive work with all nine critical suppliers and their components, since they all were handled simultaneously.

4.2.1.2 The Reactive Supply Chain Risk Management Process

There was no predetermined reactive supply chain risk management process in place which could be used for this disruption. Axis learned about the earthquake and the tsunami both through media and from employees that were in Japan visiting suppliers. The sourcing department knew which of its suppliers that had production in Japan, however, not the exact location of all the factories. Axis had previously not collected any information regarding their second or third tier suppliers and the locations of their factories. To create an understanding of the situation, the sourcing department began contacting all suppliers that they thought had a potential for being affected.

Some suppliers were very helpful and gave information quickly, whereas some of the suppliers were unwilling to give any information until they themselves had the full picture, which could take several weeks. Since it was too dangerous to travel to Japan, two of Axis' employees travelled to London to visit a conference for the security industry in order to meet face-to-face with representatives of some of these suppliers. There were also suppliers that claimed to be unaffected by the disruption, but then revealed a month later that they had problems, as they had now found out that their suppliers had been affected and were unable to deliver.

When enough information was gathered to paint a rough picture of the situation, which took about two weeks, Axis' head of Operations put together a team to handle the disruption. This team consisted of managers from the departments that were the most affected by the disruption, for example sourcing, supply and logistics. The team began to identify which products were affected and which of those products that were the most critical. The products that generated the most money for Axis and had low stock levels were prioritized in production to use the available components, although no product was taken out of production completely. Simultaneously, the team worked on getting as large of an allocation as possible of components from the suppliers' inventories. They also created a plan for the logistics in terms of to which contract manufacturer the components should be sent. Usually, the contract manufacturers themselves handle the ordering of the components. In this case, however, it was important that a contract manufacturer that produced a prioritized product had available components. Axis therefore stepped in and temporarily overtook some of the ordering.

Axis did not communicate with or ask for assistance from competitors during the disruption management, nor was there any communication with trade organizations. Axis did not consider re-labeling competitors' products and no temporary production facilities were established. The possibility to use other suppliers was, however, considered. It was difficult though, since most of the affected components were single sourced and unique for each supplier. Using other suppliers would therefore require a redesign of Axis' products. Operations had an ongoing discussion with R&D to prepare for eventual redesigns. As more information became available and Axis managed so secure allocations of components, the redesigns became unnecessary and were consequently never realized.

Sales had difficulties planning its work and to bring products that had not been affected forward to customers, since it for a long period of time was uncertain which components that had been affected. Assortment planning was therefore considered an unsuitable strategy for this disruption. Sales instead had a close communication with the distributors to keep them updated.

No formal learning session was conducted after the disruption was managed and no strategies or processes were changed. Instead, the experience increased the individual's knowledge of reactive supply chain risk management. Some employees have learned the importance of thoroughly examining the impact of the entire supply chain once a natural hazard has occurred in order to learn if any second or third tier suppliers are affected. Others learned how the different suppliers reacted in this type of situation, which can be used in future disruptions.

4.2.1.3 Impact on Axis Internally

The handling of the disruption was given a large focus within the organization and resources were allocated to handle the situation. Sales experienced a lower self-esteem in its selling as information on the availability of different products was missing. However, as the disruption was handled, many departments felt confidence in knowing that they could handle this type of incidents well.

4.2.1.4 Impact on Axis' Customers

The disruption caused longer lead-times of some of Axis' products, in particular products that contained a camera component from Sony. Some of the distributors received smaller quantities than they had ordered. Overall, however, the disruption barely affected Axis' end customers.

4.2.2 Flooding 2011

The flooding of 2011 was one of the worst ones in the history of Thailand. 9.1% of the country's area was inundated which in turn affected more than 13 million people, caused 680 deaths and created costs for loss and damage of USD 46.5 billion. One of the major factors for the disaster was the heavy rainfall where the average rainfall of 2011 was 35% higher than the 50-year average. The rainfall was mostly in the north of Thailand from which it made its way to the south where the rivers could not contain all the water and the flooding consequently occurred. (Poapongsakorn, N. and P. Meethom, 2012)

4.2.2.1 Impact on Axis' Upstream Supply Chain

The flooding affected a number of companies in Axis' upstream supply chain including suppliers, one contract manufacturer (SVI) and one CLC. Since flooding of SVI was the main cause of the disruption for Axis, the following sections will only consider the reactive supply chain risk management regarding SVI.

SVI is one of the first contract manufacturers that Axis employed and was at the time responsible for 50% of Axis assembly. The flooding struck SVI's facilities on October 21, 2011, and disrupted manufacturing until January 16, 2012, through damaging equipment, components, products and facilities (SVI Public Company Limited, 2011).

4.2.2.2 The Reactive Supply Chain Risk Management Process

When the disruption happened, no one from Axis was in Thailand. Employees heard of the flooding through the media as well as from suppliers in the area. SVI was quick in contacting Axis and informing about the disruption, although at first it could not give information on the damage since SVI itself did not fully know. Once boats were obtained, something which took some days, SVI could start evaluating the level of damage. At that point, it became clear for SVI that almost everything was destroyed. For Axis, the degree of impact was discovered through continuous communication with SVI.

For Axis, no predetermined reactive supply chain risk management process was in place. Once having heard of SVI's predicament, the sourcing director of Axis flew to Thailand and SVI. This was done in order to obtain more details on the impact, as well as to help SVI recover. Pictures of the flooding was also taken in order to document how well the disruption was dealt with. Simultaneously, the head of Operations at Axis created a team in Sweden which fully focused on the reactive supply chain risk management. This team was similar to the team from the earthquake/tsunami and contained only Axis members although it communicated continuously with SVI. The team started analyzing what type of recourses were affected since SVI held both tools, components and products. They also started calculating the number of components in their supply chain which was difficult since they had no system for tracking this. Throughout the process, although less in the end, the team held frequent meetings. In order to decide on what strategies to choose in order to recover from the disruption, brainstorming sessions were held within the team. Employees were then appointed responsible for the different strategies chosen and the actions associated with them.

During the disruption management, Axis did not ask for assistance from either competitors or trade organizations. It did not do re-labeling of competitors' products or use assortment planning. Since spare capacity within Axis is scarce, none was used in the disruption management. However, spare capacity was used from within the contract manufacturers as assembly was transferred from SVI to other contract manufacturers. In a similar manner,

although Axis itself did not establish temporary facilities where production could be set up, SVI did this in its second facility. Hence, when the flooding occurred, SVI could start the process of initiating production at that facility. Due to being a large customer and having good relationships, Axis was prioritized in this process. As an effect of the crisis, one product was put to end of life (EOL)[3] due to the entire stock of one component (which was no longer produced by the supplier) in the product being destroyed in the flooding. Some products which were due to be introduced at different contract manufacturers were paused in order to first move already existing products. No products were, however, put to EOL in order to increase capacity for prioritized products. Retaining the company's values was important during the disruption management, although this view does not seem to have been predetermined, but rather depending on the employees working in the process. The core value *Act as One* as well as developing long-term relationships with suppliers are values that were mentioned during the interviews.

Besides the communication with SVI in order to fully understand the degree of impact, continuous communication was also conducted in order to help SVI recover. During the process of moving products to other contract manufacturers, communication was key between Axis and those parties as well. It can be mentioned that the other contract manufacturers contacted Axis when hearing of the disruption, asking if they could help Axis with the disruption management. Collaboration was done for example through Axis aiding SVI in the purchasing of components. The sourcing director who flew to the SVI site in Thailand also helped SVI with the prioritization regarding Axis' products.

The initial plan was continuously altered once new information emerged. However, if changing the plans too often it could risk creating confusion amongst the employees, thus the team tried to balance these two aspects.

Once the disruption was considered to be managed by Axis, no formal learning session was held. During the interviews, the individual employees at Axis, however, mentioned aspects which they had learned from the reactive supply chain risk management. These aspects include: having production and assembly at multiple sites; not allocating too much of assembly/production to one supplier; the need for Axis to stock testing system and tools and; that some suppliers are so good at recovering from disruptions that Axis' focus could be on assisting them in their recovery instead of developing workarounds at Axis.

4.2.2.3 Impact on Axis Internally

Overall, the crisis is seen to have had a positive effect on Axis internally – cooperation increased both within and between departments, employees became more focused on the tasks at hand and the company's self-esteem regarding the management of disruptions grew. The work with using multiple contract manufacturers, something which Axis had begun working with proactively, see section 4.1, was also intensified due to the reactive supply chain risk management process. Regarding the learning individual employees had done, no structural changes at Axis were made to incorporate the learnings. The employees, however, believe that the already existing work with using multiple contract manufacturers for the same product became more important as a result of the disruption.

[3] The term at Axis for when a product is seen to be at the end of the life cycle and removed from the product portfolio. Customers are hence no longer able to buy the product.

A negative impact of the disruption was how the development of new products was hampered since the existing products were prioritized, with the possible result of Axis becoming less competitive in the future.

4.2.2.4 Impact on Axis' Customers

The impact on Axis' customers is thought to be low. There were some back logs towards the distributors, but since they keep stock, the end customers' experience of the disruption is believed to have been minor.

4.2.3 Fire 2014

The fire was, as mentioned in section 1.2.3, not a natural disaster, but a technological one. It occurred early in the morning on the November 12, 2014, (Thai PBS Reporters, 2014) and only directly affected the contract manufacturer called SVI. In the investigation of the cause of the fire, it was suspected that it had started on the ceiling of the building due to an electricity short-circuiting. The fire then rapidly spread through the facilities of a combined area of 20,000 square meters. The total cost of damage was expected at 1 billion baht. Although two employees got temporary injuries from having inhaled smoke, no one died from the fire. (NNT, 2014)

4.2.3.1 Impact on Axis' Upstream Supply Chain

The fire affected one of Axis' contract manufacturer, SVI.

4.2.3.2 The Reactive Supply Chain Risk Management Process

Once the fire had happened, Axis received the news from SVI, through the media, from Axis' employees who were there as well as from brokers who called and tried to sell components to Axis. Employees at Axis were visiting the site during the time the fire happened, and could report back. Certain people at Axis headquarters hence received live footages during the night and in the morning key employees from Operations and R&D had a meeting to discuss the disruption. Footages were also obtained from drones through the media, in which Axis could see that the part of the facilities in which Axis' production was centered was heavily damaged. Once top management had recognized the fire, they communicated it to the rest of the organization.

Prior to the fire, no reactive supply chain risk management process was in place. Project leaders for projects within Axis' disruption management were determined within one or two days after the disruption. Three main projects were decided on within the scope of the disruption management. Two of these concerned moving production from SVI to two different contract manufacturers and the third focused on aiding SVI in their recovery. The project leaders were then free from any formal supervision of top management. In the process of forming the team, no suppliers or competitors were contacted. Although the suppliers were continuously communicated with, they were never thought of as being a part of the team. Even though this disruption did not require any design changes of products, the products had at this point in Axis' history become so technically advanced that R&D still had to be involved, although in the moving of the production of products between contract manufacturers rather than redesign. This was the first point in Axis' history in which R&D became involved in the reactive supply chain risk management of this type of disruptions. The main responsibility for the management of the disruption was, however, still amongst Operations.

During the first couple of days after the fire, once the team was created, Axis started investigating the number of components in the supply chain. Once this was done, they started

buying components in order to provide the contract manufacturers to which production was moved with components. Employees were also sent to SVI in order to help with the recovery process.

Axis did not put any products to EOL in order to free capacity for prioritized products. Due to the disruption not necessitating any design changes of products, the development of new products was not delayed. However, the introduction of new products was put on hold in some cases in order to first move existing products between contract manufacturers. While Axis had no spare capacity which could be used for the disruption management, spare capacity was engaged amongst the contract manufacturers in moving the production of certain products from SVI. This reallocation process was easier compared to during the flooding since Axis at this point had more contract manufacturers. However, since not having fully documented how the production worked at SVI, the moving process became more difficult than necessary. In addition to this, SVI could also move production to their second facility in which they already previous to the fire had produced a small number of Axis products. In the process of moving production, new machines for production and testing had to be bought by Axis since the previous ones had been destroyed. SVI had improved since the flooding incident and was faster in communicating to Axis which equipment it needed.

In the reactive supply chain risk management process, Axis did neither ask competitors for help, nor trade organizations. They did not buy competitors' products in order to make them into Axis-labeled products. Although it was thought of and discussed, assortment planning was not used. Regarding company values, they were thought to be of such an importance that an interviewee even expressed it as that it was Axis' values which solved the disruption. The fact that Axis, as during the flooding, once again maintained the business relationship with SVI and in addition to this helped SVI recover was for example due to their principle of developing long-term relationships with suppliers. The core value *Act as One* was also considered especially important in the reactive supply chain management process. Communication was consistently employed for example with the contract manufacturers in the process of moving production between them. It was also communicated to Sales and later the customers that one product family was affected. One example of the collaboration which existed in the supply chain originating from Axis was when SVI asked Axis for help in the purchasing of components in which Axis obliged.

Regarding Sales, if not having the product asked for by the customer, Sales sometimes offered a more expensive product at the same price as the inferior one, hence lowering Axis' margins. This is a strategy commonly employed at Axis when having shortages of certain products. Sales, however, experienced difficulties in knowing which products could replace which.

The information kept changing as SVI itself unraveled new information and forwarded it to Axis. Overall, Axis had expected SVI to be slower in its recovery process than it was. The number of components available was also important information which varied along the process. It took Axis a couple of days in order to get an overview of the number of components in Axis' supply chain, and a week or two before knowing this number in detail. In addition to this, the development of the process to initiate production of products previously produced at SVI at other contract manufacturers was monitored. Depending on how the previously mentioned information changed, the strategies were altered accordingly. One example is how

the allocation of the production of a camera family between SVI and another contract manufacturer was adjusted correspondingly to how well the initiation of production went.

At the end of this disruption management, which in total lasted six months, no formal learning session was held. The individual employees nonetheless learned from it. These learnings include that Axis needed to produce more products at two contract manufacturers. In addition, individuals learned that Axis needs to be harder on demanding sprinkler systems at suppliers' facilities.

4.2.3.3 Impact on Axis Internally

During the reactive supply chain risk management, resources from development projects were allocated to the disruption management which hampered the development of new products. The fact that R&D and Operations had to cooperate was seen as positive since R&D generally focuses on the short term in designing the best products possible, while Operations focuses on the long-term in securing that the company can deliver.

Regarding the employees in Sales, they experienced insecurity in their selling since they did not fully know if the products could be delivered or not.

4.2.3.4 Impact on Axis' Customers

Overall, the impact on Axis' customers does not seem to have been significant. January and February, 2015, offered a lowered availability towards the customers, something which was recovered by March, 2015. The notion that Axis has a great number of sellers and the sellers' good relationships with the customers were also mentioned to have lessened the impact, since they could communicate the situation and try to find new solutions.

4.2.4 Earthquake 2016

The Japanese island Kyushu was in the middle of April, 2016, hit with a series of earthquakes. The main shock occurred on April 15, 2016, and had a magnitude of 7.0. (USGS, 2016b) 65 people were killed by the earthquake and 331 people were severely injured. The earthquake destroyed around 2,100 houses and 94 public buildings, and another 8,000 buildings were damaged. (Vervaeck, 2016) The infrastructure of the region was seriously damaged (Zhao and Liu, 2016).

4.2.4.1 Impact on Axis' Upstream Supply Chain

The earthquake affected Sony's sensor factory in Kumamoto, which was Axis' largest supplier of sensors. The factory in Kumamoto was the only one of Sony's factories that produced the type of sensors that Axis used. The sensors were strategic components in Axis' cameras and they were unique for each supplier, which means that the cameras needed to be redesigned if another sensor should be used. The sensor production was completely disrupted in 6 months, and it was not until December 2016 that Axis received full quantities again. At the time of the disruption, 50% of Axis' cameras contained sensors from Sony.

4.2.4.2 The Reactive Supply Chain Risk Management Process

Axis did not have a predetermined reactive supply chain risk management process in place to handle this disruption.

Three of Axis' employees had travelled to Japan a few days prior to the earthquake. During the Friday of April 15, 2016, they had met with the sensor manufacturer Panasonic to discuss their cooperation and growing business relationship. On the Monday of April 18, 2016, they had

planned a meeting with Sony. Around midnight between the Friday and the Saturday, the earthquake awoke them. When they had evacuated the hotel, they received information on where the epicenter of the quake had been and realized that there was a large possibility that Sony's sensor factory in Kumamoto could have been affected. They contacted their managers back in Lund, Sweden, so that the disruption management could begin immediately when everyone came back to work after the weekend. Axis also received information on that the earthquake had occurred through media.

On the Monday April 18, 2016, there was no information on how badly damaged Sony's factory was, as Sony had not been allowed by authorities to enter and examine the building. However, the Axis' employees visiting Japan had their meeting as planned with Sony, though with a completely altered agenda, as they tried to get information from Sony on the damage. Even though Sony did not have much information to give, all three employees have stated that they realized that it probably was quite serious as they could see the fear and anxiety in the eyes of Sony's employees. Prior to the disruption, the employees at Axis were unaware that the factory in Kumamoto was the only facility in which Axis' sensors were produced. This was information that was discovered at this time.

Axis' sourcing director and core technologies manager both cancelled all their meetings and spent the Monday April 18, 2016, discussing the possible implications of the earthquake. They listed which of Axis' products contained Sony's sensor and what their demand was. This list could not be completed until several days later, as Axis had no knowledge on which sensors that were used in the camera modules that Axis purchased and used in some of its products. Simultaneously, the material supply manager began mapping the number of sensors that already existed in Axis' supply chain, both in Axis' own stock, but also in the contract manufacturers' inventory and in the distributors' stock of finished goods. The information about Axis' own stock levels was quickly gathered, though it took a few weeks to receive the information from all the contract manufacturers and distributors, as well as gathering the information on the status on the incoming orders to Axis' own stock.

With the small amount of information that was gathered on Monday April 18, 2016, the sourcing director and the core technologies manager painted the worst-case scenario that Axis would not receive any new deliveries of sensors from Sony during 2016. From that scenario, they found possible actions, among one was the redesigning of five of Axis' high-volume products which contained sensors from Sony to instead contain sensors from Panasonic. High-volume products were chosen since it would result in a smaller number of redesign projects compared to if low-volume products had been chosen. These actions were presented for management on Friday April 22, 2016 and a mutual vision for the future members of the disruption management team was created, in which the objective was to handle the disruption without any impact for the end customers. A meeting was held with the product managers on the morning of Tuesday April 26, 2016, to discuss the timeframe and receive their approval of the redesigns.

A team was then organized by the sourcing director and the core technologies manager, together with members from top management, to handle the disruption. The team was cross-functional with members from Operations, R&D, Sales and Technologies. Sales was included later in the process. The team worked on handling the disruption until August, 2016, although most main actions were finished in June, 2016. In the beginning of the process, they had daily meetings

each morning to give updates, which was later changed to meetings every second morning. Suppliers and competitors were never contacted with the purpose of creating an inter-company team.

Many ongoing R&D projects were put on hold as the redesign projects were initiated. The redesign projects had a very strict scope, where only the sensors were changed and no new features were to be added, in order to reduce the time frames. To facilitate the redesign of the cameras, Axis purchased large amounts of sensors from Panasonic and Omnivision to ensure that the components were available once the production of the redesigned products was to be initiated. In the end, however, only the sensors from Panasonic were used in the redesigns.

At the same time, Axis had weekly meetings with Sony to receive more information on how serious the disruption was. It took Sony about a month to be able to give a reasonable estimate. Frequent communication with Sony was also held in order to try to have a large allocation of sensors from Sony's finished goods inventory. Canon gave great support regarding the communication as Canon had had a close relationship with Sony for a long time. Many employees at Axis also described how Sony had much more respect for Canon than for Axis, since Canon is, just as Sony, a Japanese company. Although being relatively small, Axis became a prioritized customer and received a large allocation of sensors from Sony.

To increase the stock of sensors from Sony, Axis bought all sensors that it could find on the spot market. Axis did not shut down any product lines during the disruption management. Neither were competition nor trade organizations asked for assistance and none of the competitors' products were purchased and re-labeled. Axis did not establish any temporary production facilities as it would have been too time-consuming and Axis does not have the right competences within the organization to produce sensors. Axis collaborated with the contract manufacturers to make the production initiation of the redesigned products efficient and quick. To have an overall picture of the communication in the supply chain, Axis handled all communication between the suppliers and the contracts manufacturers. Axis tried working with assortment planning during the first two weeks of the disruption management, however, it was difficult as the information was constantly changing and the customers were reluctant to switching products. However, the forecasts of products similar to the affected products were increased, just in case.

All interviewees have stated that Axis' values were very important during the disruption management and that the values were, because of the disruption, strengthened. Everyone within the company was open to cross-functional collaboration and Axis openly shared information with the members of the supply chain. It was also important that the quality of the products was not compromised with as they were redesigned.

The team members changed over time as new information was received. New information also changed some of the planned actions of the initial plan. Axis managed to receive a larger allocation of sensors from Sony than was hoped for. The contract manufacturers also had larger stocks than Axis had estimated. Due to this, Axis could cancel two of the five initiated redesign projects as they became unnecessary.

When the disruption was handled, Axis conducted a formal learning session where positive and negative aspects of the disruption management were discussed. The session concluded that the collaboration had worked well and that everyone had had clear responsibilities and had worked

towards the same goals. It was also concluded that Axis had reacted quickly and that the created worst-case scenario had been helpful. The key issues for the disruption management were described to be difficulties in learning the contract manufacturers' stock levels as well as in distributing allocated sensors to contract manufacturers. However, the learning session has not resulted in any structural changes.

4.2.4.3 Impact on Axis Internally

The disruption management required many resources from within Axis and several R&D projects became six to nine months delayed. The resource allocation was not only costly, but the delay of new products could probably have resulted in decreased revenues. The disruption management did, however, result in increased collaboration and trust between the departments within Axis.

4.2.4.4 Impact on Axis' Customers

Axis customers were barely affected by the disruption. Axis had slightly longer lead-times on one or two products for a limited period of time.

4.3 Connections Between Proactive and Reactive Supply Chain Risk Management

In this section, the connections found between the proactive and reactive supply chain risk management for each disruption will be described. The connections are divided into two categories: experienced connections and imagined connections. The experienced connections are connections which were in fact experienced at Axis. The imagined connections are different in the sense that they derive from proactive actions which were not done previously of the disruption, but if having done those proactive actions, the connections could have existed.

4.3.1 Earthquake/Tsunami 2011

Below, connections experienced at Axis between the proactive supply chain risk management and the reactive supply chain risk management for this disruption will be accounted for in section 4.3.1.1. The employees at Axis have also answered questions regarding whether, in hindsight, possible connections could be thought of which depended on proactive actions not taken by Axis prior to the disruption. These will be described in section 4.3.1.2.

4.3.1.1 Experienced connections

During this disruption, two connections which all facilitated the reactive work of finding components were experienced. First and foremost, the proactive work which had been done regarding dual sourcing meant that Axis had more than one supplier of camera lenses, a component which was affected by the tsunami. This enabled the reactive strategy of finding components. Secondly, having developed long-term relationships and trust in the supply chain lead to Axis being prioritized and hence able to get hold of a larger number of components from affected suppliers once the disaster had occurred.

4.3.1.2 Imagined connections

When analyzing which proactive actions could have facilitated the reactive supply chain management process, two were thought of. Most of these proactive suggestions would have aided the development of the initial plan and the revision of it. First and foremost, if having had tougher discussions with the suppliers regarding the suppliers' reactive supply chain risk management process, the impact of the disruption might have been lowered. In addition, Axis

might have been able to receive information on for example the number of components faster which would have, in turn, enabled Axis in the choosing of reactive actions to take. Secondly, having had mapped the supply chain better, Axis might had known which suppliers to contact asking about the effects of the tsunami.

4.3.2 Flooding 2011

Below, connections experienced at Axis between the proactive supply chain risk management and the reactive supply chain risk management in this disruption will be accounted for in section 4.3.2.1. The employees at Axis have also answered questions regarding whether, in hindsight, possible connections could be thought of which depended on proactive actions not taken by Axis prior to the disruption. These will be described in section 4.3.2.2.

4.3.2.1 Experienced connections

A number of different connections were experienced in this disruption. Having production at numerous locations facilitated the reactive action of finding components, since the contract manufacturers have stocks of components. This also includes that some of the contract manufacturers have production at numerous locations. Ais had multiple contract manufacturers producing the same product. When employing this, not becoming a small customer is important in order to get prioritized in the reactive supply chain risk management process. If being prioritized, collaboration and being allocated components is easier. Regarding collaboration, this existed in this disruption management and can be seen as initiated by the contract manufacturers since they themselves asked if they could aid Axis in any way. The reason for why the collaboration could exist is partly due to Axis having good and long-term relationships with the contract manufacturers. Trust and long-term relationships between the contract manufacturers and Axis aided in the development of an initial plan. Having spare equipment stored in Lund is also a proactive action which enabled a quicker initiation of production at other contract manufacturers. Overall, however, having experienced a disruption management process, for example the handling of the earthquake/tsunami 2011, enabled the creation of a team as well as the creation of the initial plan.

4.3.2.2 Imagined connections

Several proactive actions which were not taken could have become useful in the reactive supply chain risk management. Regarding imagined connections, one thing which Axis could have done which would have enabled them in starting the reactive supply chain management process faster was if having tracked the rain amounts in Thailand. Axis could also have held more conversations with suppliers regarding how the suppliers prepared for and handled risks. Once the flooding happened, Axis discovered they had problems calculating the number of components and products which were intact somewhere, for examples under transportation or in warehouses, in the supply chain. If having developed a system proactively for this, time could have been saved and the creation of the initial plan facilitated. Another aspect which Axis learned that they lacked was documentation on the equipment and documentation on the processes of production at contract manufacturers. This delayed the process since the reactive plan needed to be revised as Axis received this information.

4.3.3 Fire 2014

Below, connections experienced at Axis between the proactive supply chain risk management and the reactive supply chain risk management in this disruption will be accounted for in section 4.3.3.1. The employees at Axis have also answered questions regarding whether, in hindsight,

possible connections could be thought of which depended on proactive actions not taken by Axis prior to the disruption. These will be described in section 4.3.3.2.

4.3.3.1 Experienced connections

The reactive supply chain risk management after the fire revealed several connections. First and foremost, having production at multiple locations was an action which aided the work of finding components and reallocating production from SVI to other contract manufacturers. Secondly, something which also accelerated the reallocation of production was that Axis had created a strategic stock of production equipment in Lund. This enabled production, although at lower quantities than originally desired. This stock contained tools for testing products as well, and that these tools were flexible was also a factor which enabled production. Strategic stock existed for certain components as well, something which aided in creating plans for maintaining production quantities. Thirdly, having developed long-term relationships with especially SVI but also the other contract manufacturers assisted in the communication and collaboration in the supply chain and facilitated the move of production previously done at SVI to other contract manufacturers. Overall, it was also seen as positive to have experienced a disruption of almost the same scope since this aided in the creation of a team, and the development of the initial plan.

4.3.3.2 Imagined connections

When considering possible proactive actions which could have aided reactive actions, a number of different ones were thought of. If having had more tough conversations about SVI's risk management plans, Axis might have received information about for example the state of the production equipment and number of components and products. This would have facilitated the creation of the initial plan. Another connection was that if having had documentation about the production equipment as well as the production process in a system owned by Axis, this would have rendered Axis in a far better position. The reason for this is that when moving the production to another contract manufacturer, Axis would not have had to start all over again if having had documentation from the first producer. When on the topic of documentation, having had documented the number of components and products in the supply chain would have made it easier for Axis in creating the initial plan. Documentation or mapping of which products could replace other ones would have helped Sales in knowing which products to suggest for the customers.

4.3.4 Earthquake 2016

Below, connections experienced at Axis between the proactive supply chain risk management and the reactive supply chain risk management in this disruption will be accounted for in section 4.3.4.1. The employees at Axis have also answered questions regarding whether, in hindsight, possible connections could be thought of which depended on proactive actions not taken by Axis prior to the disruption. These will be described in section 4.3.4.2.

4.3.4.1 Experienced connections

A vast number of connections were thought of for this disruption. Firstly, having started to buy sensors from Panasonic in addition to buying from Sony prior to the earthquake aided in the redesign of products. Secondly, having people geographically close to the affected site in Japan lead to Axis receiving information on the disruption more rapidly, hence enabling the communication. Thirdly, having almost all employees at the same site in Lund facilitated the internal communication, the creation of the team and the creation of the initial plan. Fourthly,

having created a culture based on the chosen core values enabled collaboration within Axis as well as within the supply chain, since Axis strive to *Act as One*. In addition to this, having a culture which does not focus on finding a scapegoat meant that people were fast to act with the reactive supply chain risk management once the disruption was known, instead of focusing energy on finding whom to accuse for the disruption. Axis does also have a culture which promotes taking own initiatives, something which facilitated the creation and realization of the initial plans. Fifthly, the work of finding components was heavily facilitated by Axis having a strategic stock of sensors in Lund. Sixthly, Axis had developed a partial modular design for the cameras which assisted in adapting the cameras for other sensors. Something else which aided in the redesign was that Axis previous of the disruption had conducted redesigns regarding changing sensors in products. They hence knew how to do this. The employees in Operations had also developed a competence in finding components and had throughout the years built a network which facilitates the search on venues like the spot market for finding desired components. This competence was, however, not build consciously but was rather a side effect of having done this before.

In addition to these connections, several ones regarding relationships were thought of as well. In having a long-term relationship with Sony, Axis received more accurate status updates from Sony since Sony trusted Axis. Having good relationships with Sony also facilitated the work of being allocated as many components as possible from Sony and in being prioritized over Sony's other customers in general. In having good relationships with the contract manufacturers, it was easier for Axis to get data on their production. This was something which enabled Axis in the reallocation of production and components between the contract manufacturers. In addition to Panasonic and Sony, Axis had also developed relationships with sensor producing companies from which Axis did not buy any sensors. These relationships turned out to aid in the process of redesigning products and in getting an allocation of components since Axis more rapidly could communicate and be prioritized by those possible suppliers. In some cases, Axis had even tested sensors from those companies which accelerated the redesign. In general, having good relationships with suppliers and contract manufacturers meant that it was easier for Axis to form the initial plans since they knew the companies' delivery precision, level of quality and other important aspects. Finally, not only having good relationships with the suppliers, but also with a partner which has even better relationships and which can support Axis in being prioritized by the suppliers' aids in the reactive action of finding components, the communication and the collaboration. In Axis' case, this partner was Canon.

4.3.4.2 Imagined connections

A number of imagined connections were also thought of. If having had tougher requirements on suppliers' risk management, overall the effects of the disruption might have been smaller and the initial plan facilitated. In addition to this, if having created a business continuity plan, the forming of the team and the making of the initial plans might have been facilitated. Furthermore, if having known for sure that Sony only produced Axis' products at the disrupted site, the creation of the initial plans would have been assisted. Once the disruption happened, Axis discovered that they did not know which camera modules that contained Sony sensors which complicated the process of understanding the degree of impact and hence creating the initial plan. Hence, an information system in which data on what components existed in which product would have facilitated this. An information system for finding the number of components in the supply chain would also have aided in developing the initial plan since the

degree of impact would have been known. Understanding of the contract manufacturers' need of certain components would have been facilitated if having had documentation on or an information system for this.

5 WITHIN-CASE ANALYSIS

The within-case analysis is conducted through pattern matching and explanation building and this chapter is divided into three main parts. First, Axis proactive supply chain risk management is compared to the processes, actions, and strategies that are suggested by theory. Next, the reactive supply chain risk management in each studied disruption is analyzed and compared to theory. Lastly, the found connections for each disruption are analyzed and compared to theory.

5.1 Interpretation Guide

The comparison with theory is presented in tables, were the actions that were found in theory are presented. If an action or strategy was performed by Axis, it is marked with an 'X'. The actions or strategies that Axis have conducted which have not been found in theory are listed as Proposition to theory in the end of the sections. In section 5.4, which analyzes the found connections between proactive and reactive supply chain risk management, '/' has been used to mark that the, by theory, suggested connections could not be found in the studied cases since Axis did not perform the proactive action. If Axis has conducted the proactive action, but not experienced the connection, the box on the far right in the table is left empty. In the same section, explanation building will be done with the proactive supply chain risk management action being presented first followed by an arrow pointing at the succeeding reactive supply chain risk management action. This should visualize how the proactive action aids the reactive action, hence forming a connection.

Axis' supply chain risk management processes, both proactive and reactive, are compared to theory. In the figures that showcase this (5.1, 5.2, 5.3, 5.4 and 5.5), the steps that have been fully conducted by Axis have a dark grey background, steps that have been partly conducted have a light grey background, while the steps that have not been conducted by Axis have a white background.

5.2 Proactive Supply Chain Risk Management

This section compares the proactive supply chain risk management conducted at Axis with theory.

5.2.1 Initiation

Axis does not conduct any of the actions mentioned by theory in the *Initiation* step, as seen in table 5.1.

Table 5.1: Pattern matching of the actions for Initiation taken by Axis for its proactive supply chain risk management

Initiation		
Part	**Action**	
Initiation of the supply chain risk management process	Define unit of analysis	
	Create a program charter	
	Create a program plan	
	Define objectives	

5.2.2 Risk Identification

Axis uses two of the methods mentioned by theory in order to identify potential risks, as seen in table 5.2.

Table 5.2: Pattern matching of the methods for Risk Identification used by Axis for its proactive supply chain risk management

Risk Identification			
Part	**Method**		
Identify sources of risks	Find recorded risks in literature		
	Evaluate historical events within the company		X
	Gather thoughts from employees		X
	Use risk experts		
	Use specific webpages		
	Risk mapping	Fault tree analysis	
		Event tree analysis	

5.2.3 Risk Assessment

Axis does not use any of the methods suggested by theory to estimate the probabilities of identified risks. When potential loss is estimated, only quantitative aspects are considered. A comparison with theory and the methods that Axis conducted are presented in table 5.3.

Table 5.3: Pattern matching of the methods for Risk Assessment used by Axis for its proactive supply chain risk management

Risk Assessment		
Part	**Method**	
Estimate probability	Find probability distribution function based on historical data	
	Simulation models	
	Expert estimates	
Estimate loss	Quantitative estimation	X
	Qualitative estimation	

Axis uses a method to estimate the probabilities of risks that is not mentioned in theory, which is conducting an estimation internally in the organization based on the employees' thoughts and experiences.

Proposition to theory:

- Estimate the probabilities of identified risks using input from employees

5.2.4 Selecting Risk Mitigation Strategies

Axis conducts a majority of the strategies which are suggested by theory, as presented in table 5.4.

Axis performs all actions related to the collaboration strategy, and although joint process improvements are done infrequently, the given examples are considered to be enough to

strengthen the relationships between Axis and its suppliers. Axis also performs all actions related to the hedging strategy, with production, suppliers and warehouses across the globe.

Axis' 30 to 45 days of stock of finished goods is interpreted to include a safety stock to handle potential risks. The two-month stock of strategic components and production and testing equipment are considered to be examples of strategic stock.

Axis' partial use of modular design is interpreted to be very limited and the postponement strategy is therefore not considered to be conducted. The increase-agility strategy is conducted through increasing internal visibility and reducing inbound lead-times. Axis creates a supply chain risk management culture by having a large involvement from top management and no special supply chain risk management team has been created.

Axis has never used the strategy *avoid risks*.

Table 5.4: Pattern matching of the strategies for risk mitigation used by Axis for its proactive supply chain risk management

Risk Mitigation Strategies		
Strategy	**Action**	
Collaboration	Joint process improvements	X
	Joint quality improvements	X
	Open communication	X
	Long-term relationship and trust	X
Hedging	Multiple manufacturing locations	X
	Multiple warehousing locations	X
	Multiple suppliers	X
Buffering	Increased safety stocks	X
	Strategic stocks	X
Postponement	Modular design	
Increase agility	Remove intervening stocks	
	Increase internal visibility	X
	Reduce inbound lead-times	X
	Reduce non-value adding activities	
Create a supply chain risk management culture	Involvement of top management	X
	A special supply chain risk management team	
Avoid risks	Location not selected due to high risks	

Apart from conducting the actions suggested by theory, Axis performs several others. Axis owns the manufacturing tools for several of the components that are purchased. Axis has developed flexible testing tools and has developed relationships with several suppliers that Axis currently is not purchasing from. Axis considers the size of the contract manufacturers' total business important and wishes to stay between 10 to 35% and the contract manufacturers should always have 30% extra capacity. Axis has created a company culture with an absence of prestige and has created a network with its distributors to facilitate communication. Axis also conducts audits to raise its suppliers' awareness of their risks.

Proposition to theory:

- Own tools used to produce components
- Use flexible testing tools
- Create relationships with suppliers that are currently not being used
- Be a large enough customer to your contract manufacturers in order to receive attention
- Do not stand for a majority of a contract manufacturers' business in order to not make it too dependent
- Have extra capacity in production
- Create a company culture with an absence of prestige
- Create a network of partners downstream in the supply chain
- Conduct audits to raise suppliers' awareness of their risks

5.2.5 Implement and Educate

Axis has developed one performance measure and the hired company conducting micro-environmental analyses is considered to be a way to detect disruptions. Apart from that, Axis does not conduct any of the actions suggested by theory for the *Implement and Educate* step, as seen in table 5.5.

Table 5.5: Pattern matching of the actions for Implement and Educate taken by Axis for its proactive supply chain risk management

Implement and Educate		
Part	**Action**	
Implementation	Create performance measures	X
	Create a business continuity plan	
	Implement ways to detect disruptions	X
Education	Yearly training	
	Training of new employees	

5.2.6 Monitoring, Testing and Evaluation

Axis' actions in the *Monitoring, Testing and Evaluation* step are summarized in table 5.6. Axis performs some actions related to the monitoring category, but none related to testing and evaluation. However, none of the actions are performed with a focus on supply chain risk management.

Table 5.6: Pattern matching of the actions for Monitoring, Testing and Evaluation taken by Axis for its proactive supply chain risk management

Monitor, Testing and Evaluation		
Part	**Action**	
Monitoring	Periodic auditing	X
	Reviews of implementation plans	
	Reviews of ongoing results	X
Testing	Testing within three months of implementation	
	Yearly testing	
Evaluation	Benchmarking	

5.2.7 Proactive Supply Chain Risk Management Process

Although not having a structured process for its proactive supply chain risk management, Axis conducts several of the, by theory, suggested steps, as presented in figure 5.1. None of the actions suggested in the *Initiation* step are performed, which consequently results in that the *Initiation* step is not considered to be conducted. Few of the actions related to the *Monitoring, Testing and Evaluation* step are performed, and the ones that are performed are not done with focus on supply disruptions. That step is therefore not considered to be conducted. Not all actions in the *Selecting Risk Mitigation Strategies* step are conducted, however since conducting all strategies is not the purpose and since Axis has implemented several different strategies, this step is considered to be fully conducted. The other steps are done, although, not to a great extent, and are considered to be partly conducted.

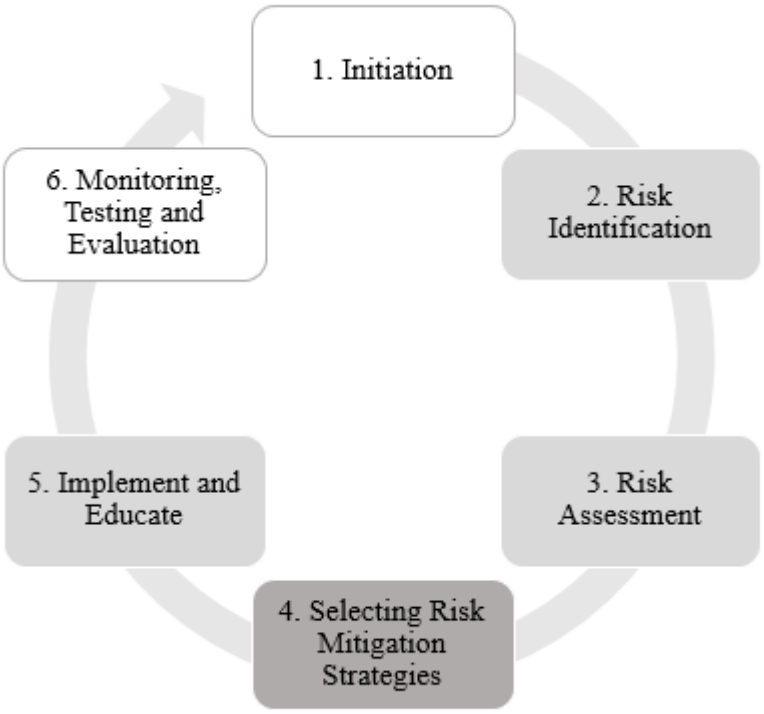

Figure 5.1: Steps conducted by Axis in its proactive supply chain risk management

5.3 Reactive Supply Chain Risk Management

This section compares the reactive supply chain risk management conducted at Axis with theory.

5.3.1 Earthquake/Tsunami 2011

In this section, the actions and strategies conducted in the disruption management for the earthquake/tsunami disruption are analyzed and compared to theory.

5.3.1.1 Recognize and Initiate

Theory does not explicitly state any actions to take to recognize a disruption and to initiate a reactive supply chain risk management process. However, having employees experiencing the earthquake and having others learning about it through media have been interpreted as two actions that fit into the category. The preparation for the disruption management that Axis took was to identify the degree of impact of the disruption by contacting suppliers to receive

information on how they had been affected. The comparison with theory is presented in table 5.7.

Table 5.7: Pattern matching of the actions to Recognize and Initiate taken by Axis for the earthquake/tsunami disruption

Pattern Matching: Recognize and Initiate		
Part	**Action**	
Recognize	Identify that a disruption has happened	X
Initiate	Prepare for the coming steps in the process	X

5.3.1.2 Create a Team

Axis created an internal team, which is presented in table 5.8. Although Axis had frequent contact with its affected suppliers, it was never done with the purpose of receiving help to create a team or to include any suppliers in the team.

Table 5.8: Pattern matching of the actions to Create a Team taken by Axis for the earthquake/tsunami disruption

Pattern Matching: Create a Team		
Part	**Action**	
Create a Team	Communicate with suppliers	
	Communicate with competitors	
	Put together a team	X

5.3.1.3 Develop an Initial Plan

A comparison with theory and the strategies that Axis conducted are presented in table 5.9. Communication in the supply chain was conducted both towards suppliers to receive new information (although it was sometimes difficult) and towards contract manufacturers to help them prioritize production. Axis also communicated downstream with the distributors. Axis' company values were retained as different groups worked together to solve the disruption, and since there was no compromise with quality. Axis collaborated in the supply chain by helping the contract manufacturers with the ordering process. Axis did not use any spare capacity. Instead, different managers and employees had to put aside their regular tasks to handle the disruption.

Table 5.9: Pattern matching of the strategies in the initial plan taken by Axis for the earthquake/tsunami disruption

Pattern Matching: Develop an Initial Plan		
Part	**Strategy**	
Develop an Initial Plan	Use of spare capacity	
	Shutdown of marginal product lines and transfer of key products	
	Assistance from competition	
	Advice and assistance from trade organizations	
	Outsourcing	
	Re-labeling of competitors' products	
	Establishment of temporary facilities	
	Communication in the supply chain	X
	Retain the company's values	X
	Collaboration in the supply chain	X
	Assortment planning	

One strategy that Axis put much focus on, and that is not brought up in the studied theory, is to convince suppliers to give them large allocations of components.

Proposition to theory:

- Get allocations of affected components

5.3.1.4 Revise the Plan

Axis revised the plan continuously, which is summarized in table 5.10. New information was identified by having continuous communication with Axis' suppliers. The plan to redesign some products became obsolete as new information regarding allocations was received.

Table 5.10: Pattern matching of the actions to Revise the Plan taken by Axis for the earthquake/tsunami disruption

Pattern Matching: Revise the Plan		
Part	**Action**	
Revise the Plan	Identify when new information is available	X
	Evaluate if planned actions have become obsolete	X

5.3.1.5 Analyze and Learn

In this disruption, Axis did not conduct any formal learning sessions. No actions related to this step was therefore conducted as summarized in table 5.11.

Table 5.11: Pattern matching of actions to analyze and learn taken by Axis for the earthquake/tsunami disruption

Pattern Matching: Analyze and Learn		
Part	**Action**	
Analyze	Analyze what went well	
	Analyze what could have been done better	
Learn	Find ways to incorporate the analysis into future risk management	

5.3.1.6 The Reactive Supply Chain Risk Management Process

Although Axis did not have a predetermined reactive supply chain risk management process that they could use to handle this disruption, they conducted actions in many of the suggested steps, as seen in figure 5.2. The actions or strategies taken can be seen above in sections 5.3.1.1 - 5.3.1.5. Axis conducted all actions for *Recognize an Initiate* and *Revise the Plan*, but none for *Analyze and Learn*. Axis used quite few of the suggested strategies for the step *Develop an Initial Plan*, however, since they used three of them, and one strategy which was not suggested by theory, the step is considered to be fully conducted.

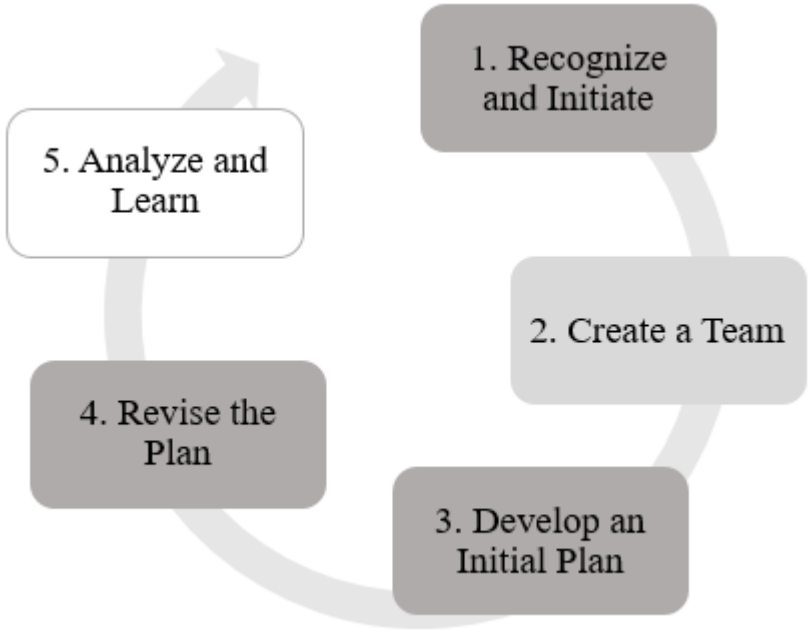

Figure 5.2: Axis' reactive supply chain risk management process for the earthquake/tsunami disruption compared to literature

5.3.2 Flooding 2011

In this section, the actions and strategies taken by Axis in the reactive supply chain risk management process for the flooding disruption are analyzed and compared to theory.

5.3.2.1 Recognize and Initiate

When the flooding occurred, Axis learned about it through communication from suppliers, SVI, and media. As preparation for the coming steps, an Axis employee flew to the SVI site. The comparison with theory is presented in table 5.12.

Table 5.12: Pattern matching of the actions to Recognize and Initiate taken by Axis for the flooding disruption

Pattern Matching: Recognize and Initiate		
Part	**Action**	
Recognize	Identify that a disruption has happened	X
Initiate	Prepare for the coming steps in the process	X

One action which Axis employed and which has not been found in the studied theory was to have an Axis employee at the site who could give insight into the disruption.

Proposition to theory to initiate a reactive supply chain risk management process:

- Send employees to the disrupted site

5.3.2.2 Create a Team

The head of Operations created a team with employees which should be dedicated to handling the disruption. Although communication with SVI was held, the discussion was not about whether to include an employee from the supplier in the created team. The comparison with theory is presented in table 5.13.

Table 5.13: Pattern matching of the actions to Create a Team taken by Axis for the flooding disruption

Pattern Matching: Create a Team		
Part	**Action**	
Create a Team	Communicate with suppliers	
	Communicate with competitors	
	Put together a team	X

5.3.2.3 Develop an Initial Plan

For the initial plan, several strategies were chosen which can be seen in table 5.14. Axis chose to already existing contract manufacturers a larger production allocation, which has been interpreted as a way of outsourcing. Communication was held continuously in the supply chain, with suppliers, contract manufacturers and CLCs. Collaboration also existed, in particular with the contract manufacturers in order to move product lines between them, as well as in helping SVI recover. In this process, company values were maintained, especially *Act as One* and long-term relationships in the supply chain.

Regarding shutting down marginal product lines, Axis did not use that strategy. Despite one product being put to EOL due to the disruption, the reason for this was not to create capacity for prioritized product lines, but rather since components were destroyed.

Table 5.14: Pattern matching of the strategies in the initial plan taken by Axis for the flooding disruption

Pattern Matching: Develop an Initial Plan		
Part	**Strategy**	
Develop an Initial Plan	Use of spare capacity	
	Shutdown of marginal product lines and transfer of key products	
	Assistance from competition	
	Advice and assistance from trade organizations	
	Outsourcing	X
	Re-labeling of competitors' products	
	Establishment of temporary facilities	
	Communication in the supply chain	X
	Retain the company's values	X
	Collaboration in the supply chain	X
	Assortment planning	

In the disruption management, Axis employed one strategy which have not been found in theory which is that they paused the initiation of new products in order to gain capacity for prioritize products.

Proposition to theory:

- Put the initiation of new products on hold

5.3.2.4 Revise the Plan

As seen in in table 5.15, Axis constantly received new information from which they revised the plans.

Table 5.15: Pattern matching of the actions to Revise the Plan taken by Axis for the flooding disruption

Pattern Matching: Revise the Plan		
Part	**Action**	
Revise the Plan	Identify when new information is available	X
	Evaluate if planned actions have become obsolete	X

5.3.2.5 Analyze and Learn

At the end of this disruption management, Axis did not have a formal learning session, hence the furthest right column in table 5.16 is empty. Axis began to produce its products at two contract manufacturers after this disruption, however, since this was not a result of a formal learning session, the learning part of table 5.16 is not considered to be conducted.

Table 5.16: Pattern matching of actions to Analyze and Learn taken by Axis for the flooding disruption

Pattern Matching: Analyze and Learn		
Part	**Action**	
Analyze	Analyze what went well	
	Analyze what could have been done better	
Learn	Find ways to incorporate the analysis into future risk management	

5.3.2.6 The Reactive Supply Chain Risk Management Process

When the flooding occurred, Axis did not have a predetermined reactive supply chain risk management process in place. As seen in sections 5.3.2.1 - 5.3.2.5. Axis did, however, do all steps in the reactive supply chain risk management process except for the final one; *Analyze and Learn*, as seen in figure 5.3. The actions in the other steps were done to various amounts, where all the actions in *Recognize and Initiate* and *Revise the Plan* were conducted, while only one third of the actions in the consecutive step, C*reate a Team*, were employed. Several actions in the *Develop an Initial Plan* step were done, which means that it is considered is fully conducted, following the same logic as described in section 5.3.1.6.

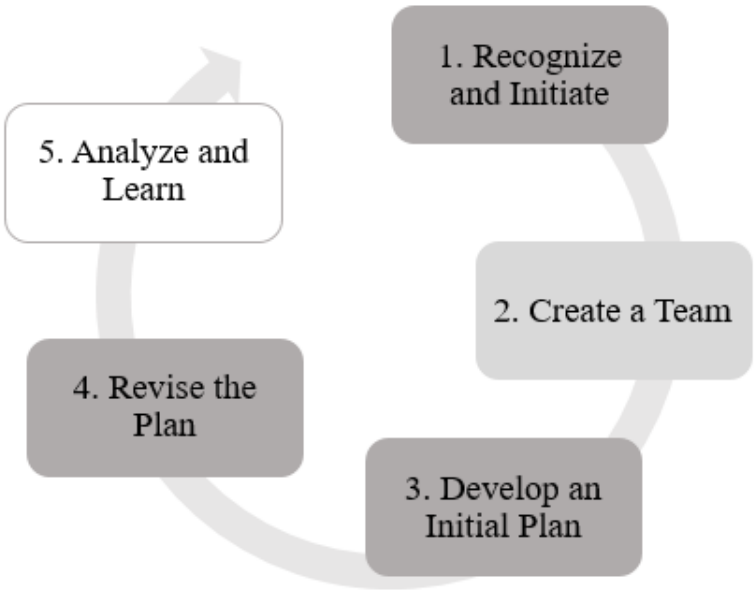

Figure 5.3: Axis' reactive supply chain risk management process for the flooding disruption compared to literature

5.3.3 Fire 2014

In this section, the actions and strategies conducted in the reactive supply chain risk management process for the fire disruption is analyzed and compared to theory.

5.3.3.1 Recognize and Initiate

Axis recognized from Axis' employees at SVI as well as from the media that the fire had happened. The preparation was mainly done through internal communication. This is summarized in table 5.17.

Table 5.17: Pattern matching of the actions to Recognize and Initiate taken by Axis for the fire disruption

Pattern Matching: Recognize and Initiate		
Part	**Action**	
Recognize	Identify that a disruption has happened	X
Initiate	Prepare for the coming steps in the process	X

5.3.3.2 Create a Team

One of the actions to create a team suggested by theory was employed by Axis, as seen in table 5.18. One or two days after the fire, the leaders for the disruption management team were chosen and they then created the rest of the team. Neither suppliers nor competitors were thought of as possible members of this team.

Table 5.18: Pattern matching of the actions to Create a Team taken by Axis for the fire disruption

Pattern Matching: Create a Team		
Part	**Action**	
Create a Team	Communicate with suppliers	
	Communicate with competitors	
	Put together a team	X

5.3.3.3 Develop an Initial Plan

Some of the strategies suggested in table 5.19 were employed. Some of Axis' contract manufacturers got a larger allocation due to SVI not being able to produce. Communication in the supply chain was maintained continuously, especially with the contract manufacturers concerning the reallocation of production amongst them, in which collaboration also played a role. The companies' values were also maintained during the disruption management, and then especially Axis' idea of having long-term relationships with other actors in the supply chain. In addition to this, the core value *Act as One* helped the collaboration both within Axis and between actors in the supply chain.

Table 5.19: Pattern matching of the strategies in the initial plan taken by Axis for the fire disruption

Pattern Matching: Develop an Initial Plan		
Part	**Strategy**	
Develop an Initial Plan	Use of spare capacity	
	Shutdown of marginal product lines and transfer of key products	
	Assistance from competition	
	Advice and assistance from trade organizations	
	Outsourcing	X
	Re-labeling of competitors' products	
	Establishment of temporary facilities	
	Communication in the supply chain	X
	Retain the company's values	X
	Collaboration in the supply chain	X
	Assortment planning	

The strategy of pausing the development of new products as well as buying more components are strategies which has not been found in the studied theory.

Proposition to theory:

- Free resources by putting R&D-projects on hold
- Get allocations of affected components

5.3.3.4 Revise the Plan

The initial plan was revised on a number of occasions, due to for example new information on the number of components available or the degree of success regarding initiation of production at other contract manufacturers than SVI. This is summarized in table 5.20.

Table 5.20: Pattern matching of the actions to Revise the Plan taken by Axis for the fire disruption

Pattern Matching: Revise the Plan		
Part	**Action**	
Revise the Plan	Identify when new information is available	X
	Evaluate if planned actions have become obsolete	X

5.3.3.5 Analyze and Learn

No formal learning session was held, however, individual employees learned from the disruption management. This is not seen as enough to consider the suggestions from theory confirmed. The comparison with theory can be seen in table 5.21.

Table 5.21: Pattern matching of actions to Analyze and Learn taken by Axis for the fire disruption

Pattern Matching: Analyze and Learn		
Part	**Action**	
Analyze	Analyze what went well	
	Analyze what could have been done better	
Learn	Find ways to incorporate the analysis into future risk management	

5.3.3.6 The Reactive Supply Chain Risk Management Process

No predetermined reactive supply chain risk management process was in place at Axis when the fire occurred. Axis, however, did actions or strategies from all steps except from the final one; *Analyze and Learn*, as seen in figure 5.4. The actions or strategies taken can be seen above in sections 5.3.3.1 - 5.3.3.5. Not all actions or strategies suggested during each step of figure 5.4 were, however, employed. In *Create a Team*, for example, only one out of three suggested actions were conducted. The *Develop an Initial Plan* step is considered fully conducted following the same logic as presented in section 5.3.1.6. The actions in *Recognize and Initiate* as well as *Revise the Plan* are all employed.

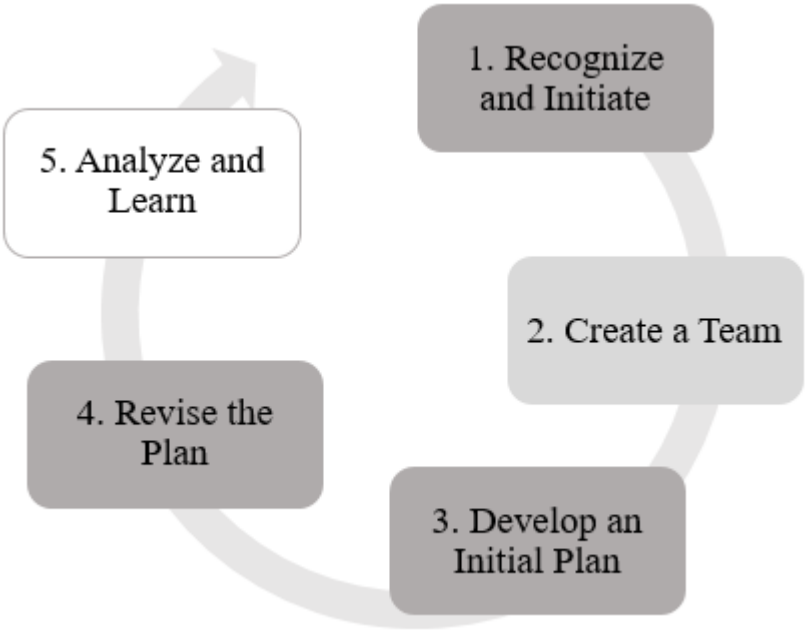

Figure 5.4: Axis' reactive supply chain risk management process for the fire disruption compared to literature

5.3.4 Earthquake 2016

In this section, the actions and strategies conducted in the reactive supply chain risk management process for the earthquake disruption are analyzed and compared to theory.

5.3.4.1 Recognize and Initiate

Axis' employees identified the earthquake immediately as three of them were in Japan and experienced it. It is also stated that some of Axis' employees learned about it through media. These two actions have in previous sections been interpreted as possible actions to recognize a disruption. To prepare for the coming steps, the souring director and the core technologies manager analyzed the possible impacts of the disruption. The comparison with theory of this step in the reactive supply chain risk management process is presented in table 5.22.

Table 5.22: Pattern matching of the actions to Recognize and Initiate taken by Axis for the earthquake disruption

Pattern Matching: Recognize and Initiate		
Part	**Action**	
Recognize	Identify that a disruption has happened	X
Initiate	Prepare for the coming steps in the process	X

There are four actions that were performed in this disruption management that helped Axis prepare for the handling of the disruption which have not been mentioned in theory. Firstly, having a face-to-face meeting with the affected supplier helped Axis understand the level of impact of the earthquake, without being given any specific information. Secondly, Axis tried to find information on available sensors in its supply chain. Thirdly, a common goal for the disruption management was created and communicated. Lastly, a worst-case scenario was created that formed a framework for Axis initial reactive disruption handling

Proposition to theory to recognize a disruption:

- Early face-to-face meeting with the affected supplier

Proposition to theory to initiate a reactive supply chain risk management process:

- Find information on available components/products in the supply chain
- Create a common vision for the reactive supply chain risk management
- Create a worst-case scenario

5.3.4.2 Create a Team

For this disruption, Axis created a cross-functional team, however, no communication was made with the suppliers or competitors with the purpose of including them in the team. This is summarized in table 5.23.

Table 5.23: Pattern matching of the actions to Create a Team taken by Axis for the earthquake disruption

Pattern Matching: Create a Team		
Part	**Action**	
Create a Team	Communicate with suppliers	
	Communicate with competitors	
	Put together a team	X

5.3.4.3 Develop an Initial Plan

Axis used several of the by theory suggested strategies when the initial plan was created, as seen in table 5.24. Components were purchased from other suppliers, which has been interpreted as a part of the outsourcing strategy. Axis communicated frequently in its supply chain, though mainly with Sony. The company's values were retained as many of them, including *Act as One*, were used to handle the disruption. Axis collaborated in the supply chain in the sense that both Axis and contract manufacturers worked together to start up the production of the redesigned products.

Table 5.24: Pattern matching of the strategies in the initial plan taken by Axis for the earthquake disruption

Pattern Matching: Develop an Initial Plan		
Part	**Strategy**	
Develop an Initial Plan	Use of spare capacity	
	Shutdown of marginal product lines and transfer of key products	
	Assistance from competition	
	Advice and assistance from trade organizations	
	Outsourcing	X
	Re-labeling of competitors' products	
	Establishment of temporary facilities	
	Communication in the supply chain	X
	Retain the company's values	X
	Collaboration in the supply chain	X
	Assortment planning	

Axis used several strategies that have not been mentioned in the studied theory. Canon, which is the main owner of Axis, gave assistance. Axis also changed its forecasts of the products, to prepare for higher sales of the unaffected products. To help reduce the risk of stock-out of components, Axis purchased sensors on the spot market and worked to get a large allocation of Sony's finished goods inventory. The two main strategies that were used to handle this disruption was, however, to put R&D-projects on hold to use the resources to redesign affected products.

Proposition to theory:

- Assistance from partner/owners
- Adjust forecasts
- Purchase components on the spot market
- Get allocations of affected components
- Free resources by putting R&D-projects on hold
- Redesign affected products

5.3.4.4 Revise the Plan

Axis continuously identified new information, and the new information changed both the team members and some of the strategies, for example, two redesign projects were cancelled as they became unnecessary. The comparison with theory is summarized in table 5.25.

Table 5.25: Pattern matching of the actions to Revise the Plan taken by Axis for the earthquake disruption

Pattern Matching: Revise the Plan		
Part	**Action**	
Revise the Plan	Identify when new information is available	X
	Evaluate if planned actions have become obsolete	X

5.3.4.5 Analyze and Learn

Axis had a formal learning session, were employees that had been involved in the disruption management discussed both what they had done well and what they had struggled with. However, no outcome of this meeting has changed Axis risk management yet. The comparison with theory is summarized in table 5.26.

Table 5.26: Pattern matching of actions to Analyze and Learn taken by Axis for the earthquake disruption

Pattern Matching: Analyze and Learn		
Part	**Action**	
Analyze	Analyze what went well	X
	Analyze what could have been done better	X
Learn	Find ways to incorporate the analysis into future risk management	

5.3.4.6 The Reactive Supply Chain Risk Management Process

Axis did not have a predetermined reactive supply chain risk management process in place to handle this disruption. However, all steps in the suggested reactive supply chain risk

management process have been either partly or fully conducted, as described in sections 5.3.4.1, 5.3.4.2, 5.3.4.3, 5.3.4.4, and 5.3.4.5. and as summarized in figure 5.5. Axis has done all actions in the *Recognize and Initiate* and *Revise the Plan* steps. The *Develop an Initial Plan* is considered fully conducted following the same logic as presented in section 5.3.1.6. The steps *Create a Team* and *Analyze and Learn* are partly conducted as not all actions have been employed by Axis.

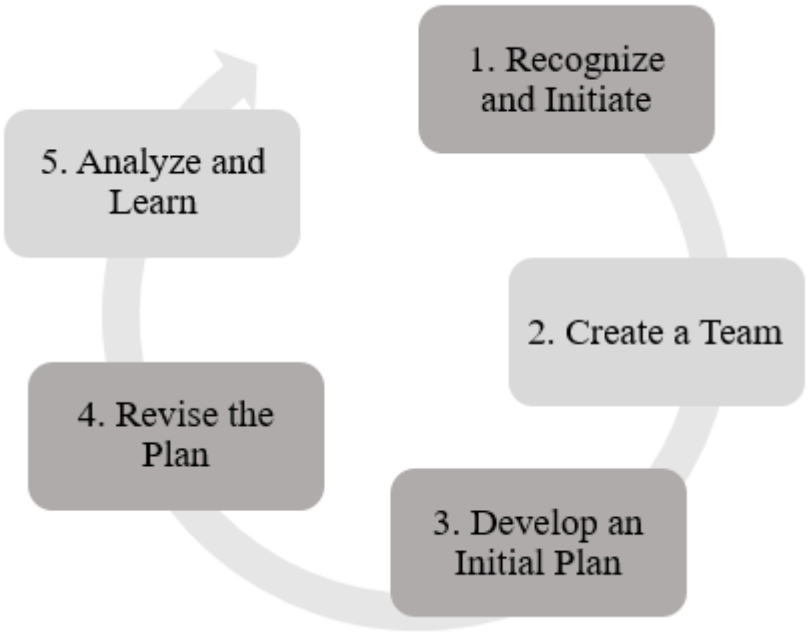

Figure 5.5: Axis' reactive supply chain risk management process for the earthquake disruption compared to literature

5.4 Connections Between Proactive and Reactive Supply Chain Risk Management

This section compares the connections between proactive and reactive supply chain risk management experienced at Axis with theory. The proactive actions are described on a more detailed level as they have a larger focus in the study, since the purpose is to create proactive supply chain risk management guidelines. This means that for the proactive side of the connections, both the step and the concerned action or method will be presented. The step will be written first, followed by the action or method in parentheses. For the reactive steps, strategies are sometimes, but not always, specified. If they are specified, this was done to make it easier for the reader to understand from where in the empirical findings the information was derived.

In this section, 'X' marks a connection which has been experienced by Axis. '/' has been used to mark that the, by theory, suggested connections could not be found in the studied cases since Axis did not perform the proactive action. If Axis has conducted the proactive action, but not experienced the connection, the box on the far right in the table is left empty. Explanation building will be done with the proactive supply chain risk management action being presented first followed by an arrow pointing at the succeeding reactive supply chain risk management

action. This should visualize how the proactive action aids the reactive action, hence forming a connection.

5.4.1 Earthquake/Tsunami 2011

In this section the connections between the proactive and reactive supply chain risk management at Axis are compared with theory.

5.4.1.1 Connections Between Proactive and Reactive Actions

Prior to the earthquake/tsunami, Axis had done a number of proactive supply chain risk management actions as seen in section 4.1, although there are also many actions which Axis had not conducted. Compared with table 5.27, only one of the proactive actions found in theory regarding connections was conducted. Hence, this one was the only one from which connections could exist, while the others could not be tested.

As seen in section 4.3.1.1, having trust and long-term relationships enabled collaboration and the development of an initial plan. The reason for this is that Axis in the process of buying certain components became prioritized and therefore had an easier time getting the amounts that were needed. This connection is seen in table 5.27.

Table 5.27: Pattern matching for the connections between proactive and reactive supply chain risk management actions seen at Axis for the earthquake/tsunami disruption

Pattern Matching: Connections		
Proactive	**Reactive**	
Selecting Risk Mitigation Strategies (long-term relationship and trust)	Develop an Initial Plan	X
Implement and Educate (create a business continuity plan)	Develop an Initial Plan	/
Implement and Educate (implement ways to detect disruptions)	Develop an Initial Plan	/
Selecting Risk Mitigation Strategies (a special supply chain risk management team)	Develop an Initial Plan	/
Implement and Educate (yearly training)	Recognize and Initiate	/
Implement and Educate (training of new employees)	Recognize and Initiate	/

Several connections which Axis experienced were not found in the studied theory, and hence discovered. These can be seen in the lists below. Certain connections which Axis did not experience, but imagined could have existed if having done additional proactive supply chain risk management actions, were also suggested. If a proactive or reactive action, method or strategy has not been suggested by theory, the reasons for why specific steps are chosen for the actions, methods or strategies follows once the lists are presented.

Proposition to theory of connections which were experienced by Axis:

1. Selecting Risk Mitigation Strategies (multiple suppliers, called dual sourcing by Axis) → Develop an Initial Plan (finding components)

Proposition to theory of connections which were imagined by Axis:

1. Selecting Risk Mitigation Strategies (cooperation of risk management with suppliers) ⟶ Develop an Initial Plan
2. Selecting Risk Mitigation Strategies (having mapped the supply chain)⟶ Develop an Initial Plan (communication since knowing which suppliers to contact asking about the effects of the tsunami)

Using multiple suppliers has been suggested by theory as an action for *Selecting Risk Mitigation Strategies*. Finding components on the other hand is new and is seen to be most appropriate as a strategy in *Develop an Initial Plan*.

For the imagined connections, cooperation of risk management with suppliers is considered to be an action in *Selecting Risk Mitigation Strategies*. Having mapped the supply chain is argued to be a way of increasing agility. The first connection is considered to aid the step *Develop an Initial Plan* in general while the second one, in addition to this, specifically aids with communication.

5.4.1.2 Connections Between the Proactive and the Reactive Supply Chain Risk Management Processes

Due to only having conducted one proactive action out of the ones suggested by theory in table 5.27, several connections could not exist. However, new connections were experienced in addition to the ones found in theory. Since the imagined connections did not in fact occur, figure 5.6 will only visualize the experienced connections. If having shown the imagined connections, these would have been drawn between Selecting Risk Mitigation Strategies and Develop an Initial Plan

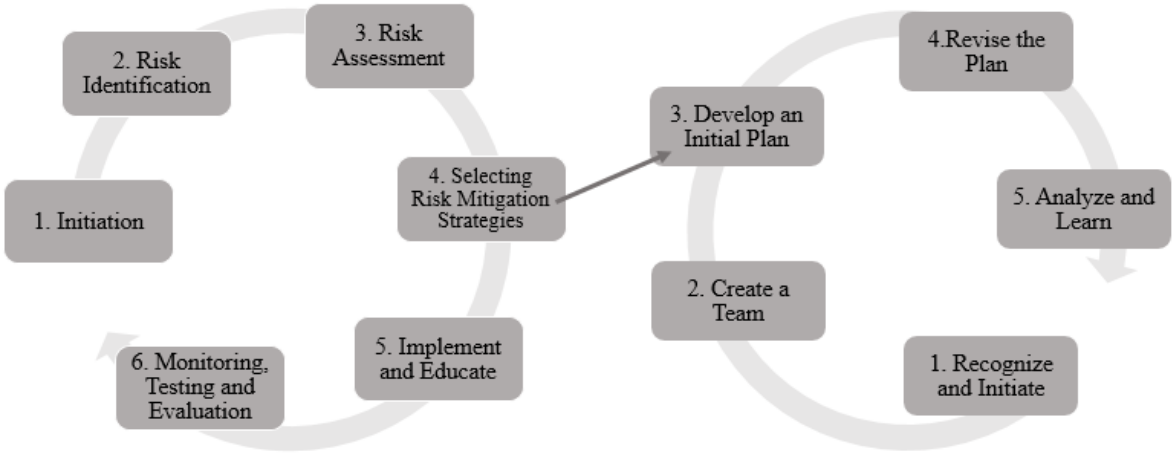

Figure 5.6: A visualization of the found connections between proactive and reactive supply chain risk management in the earthquake/tsunami disruption

5.4.2 Flooding 2011

In this section the connections between the proactive and reactive supply chain risk management at Axis are compared with theory.

5.4.2.1 Connections Between Proactive and Reactive Actions

Although Axis did a number of proactive supply chain risk management actions as seen in section 4.1, only one connection found in the studied theory was conducted. Regarding creating

trust and long-term relationships, the connection found in theory existed in the supply chain risk management of the flooding. The comparison with theory can be seen in table 5.28.

Table 5.28: Pattern matching for the connections between proactive and reactive supply chain risk management actions seen at Axis for the flooding disruption

Pattern Matching: Connections		
Proactive	**Reactive**	
Selecting Risk Mitigation Strategies (long-term relationship and trust)	Develop an Initial Plan	X
Implement and Educate (create a business continuity plan)	Develop an Initial Plan	/
Implement and Educate (implement ways to detect disruptions)	Develop an Initial Plan	/
Selecting Risk Mitigation Strategies (a special supply chain risk management team)	Develop an Initial Plan	/
Implement and Educate (yearly training)	Recognize and Initiate	/
Implement and Educate (training of new employees)	Recognize and Initiate	/

Connections not found in theory were experienced at Axis during the supply chain risk management of the flooding. These can be seen in the lists below. Certain connections which were not experienced but could have been if Axis had done the correlated proactive supply chain risk management actions were also imagined by the interviewees. If a proactive or reactive action, method or strategy has not been suggested by theory, the reasons for why specific steps are chosen for the actions, methods or strategies follows once the lists are presented.

Proposition to theory of connections which were experienced by Axis:

1. Selecting Risk Mitigation Strategies (multiple manufacturing locations) → Develop an Initial Plan (finding components, reallocating production)
2. Selecting Risk Mitigation Strategies (not becoming an insignificant customer) → Develop an Initial Plan (finding components and collaboration)
3. Selecting Risk Mitigation Strategies (strategic stock of equipment in Lund) → Develop an Initial Plan (quicker initiation of production at other contract manufacturers)
4. Implement and Educate (having experience of a disruption) → Create a Team and Develop an Initial Plan

Proposition to theory of connections which were imagined by Axis:

1. Implement and Educate (tracking indicators of for example natural disasters) → Recognize and Initiate
2. Selecting Risk Mitigation Strategies (cooperation of risk management with suppliers) → Develop an Initial Plan
3. Selecting Risk Mitigation Strategies (an information system for tracking components in the supply chain) → Develop an Initial Plan
4. Selecting Risk Mitigation Strategies (documentation on the equipment at each contract manufacturer) → Develop an Initial Plan

5. Selecting Risk Mitigation Strategies (documentation on the production process at each contract manufacturer) → Develop an Initial Plan (initiation of production at another contract manufacturer)

In the experienced connections, having multiple manufacturing locations as well as strategic stock are strategies already suggested by theory. The proactive action found in connection two is also positioned in *Selecting Risk Mitigation Strategies* since not becoming an insignificant customer for the supplier is seen as a way of collaboration. Having experience of a disruption is on the other hand seen as education, and is hence placed in *Implement and Educate*. Since strategies to handle disruptions once they have occurred are placed under the reactive step *Develop an Initial Plan*, all proactive actions facilitate this step. Having experience of a disruption was however also seen to have facilitated the step *Create a Team*.

In the imagined connections, four of them are placed as strategies in *Selecting Risk Mitigation Strategies*. Cooperation of risk management with suppliers is seen as a way of collaborating while a system for tracking components, documentation on the equipment and documentation on the production process are seen as increasing agility. Tracking indicators of disruptions is placed in *Implement and Educate* since it is a way of detecting disruptions. Connections two, three, four and five are all seen to facilitate *Develop an Initial Plan* since that is the step to which strategies used for managing the disruption belongs. The first connection is however seen to facilitate the recognition of disasters, and is hence seen as belonging to *Recognize and Initiate.*

5.4.2.2 Connections Between the Proactive and the Reactive Supply Chain Risk Management Processes

From the flooding disruption, several new connections were experienced in addition to the ones from theory. Since only one proactive action was conducted prior to this disruption, the other possible connections could not be evaluated. Figure 5.7 will only picture the experienced connections due to the imagined ones not having happened. If having shown the imagined connections, these would have been drawn between Selecting Risk Mitigation Strategies and Develop an Initial Plan, as well as one between Implement and Educate and Recognize and Initiate.

Figure 5.7: A visualization of the found connections between proactive and reactive supply chain risk management in the flooding disruption

5.4.3 Fire 2014

In this section, the connections between the proactive and reactive supply chain risk management at Axis are compared with theory.

5.4.3.1 Connections Between Proactive and Reactive Actions

Out of the proactive actions seen in table 5.29, only one had been conducted by Axis prior to the fire. Creating trust and long-term relationships facilitated the development of the initial plan. Collaboration in the supply chain was enabled, for example as Axis helped to move the production from SVI to other contract manufacturers. Axis also had an easier time in being allocated components and products by SVI.

Table 5.29: Pattern matching for the connections between proactive and reactive supply chain risk management actions seen at Axis for the fire disruption

Pattern Matching: Connections		
Proactive	**Reactive**	
Selecting Risk Mitigation Strategies (long-term relationship and trust)	Develop an Initial Plan	X
Implement and Educate (create a business continuity plan)	Develop an Initial Plan	/
Implement and Educate (implement ways to detect disruptions)	Develop an Initial Plan	/
Selecting Risk Mitigation Strategies (a special supply chain risk management team)	Develop an Initial Plan	/
Implement and Educate (yearly training)	Recognize and Initiate	/
Implement and Educate (training of new employees)	Recognize and Initiate	/

Although only one of the proactive supply chain risk management actions in table 5.29 was conducted, numerous other ones were done by Axis prior to the fire, as seen in section 4.1. From these ones, several connections with the reactive supply chain risk management actions could be seen. These can be seen in the lists below. In addition to these ones, several imagined connections were also found when envisioning proactive actions which could have been conducted. If a proactive or reactive action, method or strategy has not been suggested by theory, the reasons for why specific steps are chosen for the actions, methods or strategies follows once the lists are presented.

Proposition to theory of connections which were experienced by Axis:

1. Selecting Risk Mitigation Strategies (multiple manufacturing locations) → Develop an Initial Plan (finding components, reallocating production)
2. Selecting Risk Mitigation Strategies (strategic stock of equipment in Lund) → Develop an Initial Plan (quicker initiation of production at other contract manufacturers)
3. Selecting Risk Mitigation Strategies (flexible tools) → Develop an Initial Plan (quicker initiation of production at other contract manufacturers)
4. Selecting Risk Mitigation Strategies (strategic stock of components in Lund) → Develop an Initial Plan (maintaining production)

5. Implement and Educate (having experience of a disruption) → Create a Team and Develop an Initial Plan

Proposition to theory of connections which were imagined by Axis:

1. Selecting Risk Mitigation Strategies (cooperation of risk management with suppliers) → Develop an Initial Plan
2. Selecting Risk Mitigation Strategies (documentation on the equipment at each contract manufacturer) → Develop an Initial Plan
3. Selecting Risk Mitigation Strategies (documentation on the production process at each contract manufacturer) → Develop an Initial Plan (initiation of production at another contract manufacturer)
4. Selecting Risk Mitigation Strategies (an information system for tracking components in the supply chain) → Develop an Initial Plan
5. Strategic Risk Mitigation Strategies (documentation on which products can replace which) → Develop an Initial Plan (Sales would know which products to sell)

For the experienced connections, the proactive actions in connections one, two and four are suggested by theory. For connection three, flexible tools is seen as a way of hedging and is hence positioned in *Selecting Risk Mitigation Strategies*. Connection five belongs to *Implement and Educate* since having experience of a disruption is seen as a type of education. All connections facilitate *Develop an Initial Plan* since this is the step in which strategies to take once a disruption has happened belong. The last connection is also seen to have aided *Create a Team* since the team was similar to the one from the flooding in section 5.3.2.

All the imagined connections spring from actions which are argued to belong in *Selecting Risk Mitigation Actions*. Cooperation of risk mitigation with suppliers fits into the collaboration category. Documentation on equipment, production process as well as which products can replace which are reasoned to be ways of increasing agility through visibility. All proactive actions are seen to facilitate *Develop an Initial Plan*, since that is the step to which strategies to mitigate the impact of disruptions once they have happened belong.

5.4.3.2 Connections Between the Proactive and the Reactive Supply Chain Risk Management Processes

In figure 5.8, the experienced connections are visualized between the proactive and the reactive supply chain risk management processes for the fire disruption. Since the imagined connections were not experienced, they will not be found in the figure. If having shown the imagined connections, these would have been drawn between Selecting Risk Mitigation Strategies and Develop an Initial Plan.

Figure 5.8: A visualization of the found connections between proactive and reactive supply chain risk management in the fire disruption

5.4.4 Earthquake 2016

In this section, the connections between the proactive and reactive supply chain risk management at Axis are compared with theory.

5.4.4.1 Connections Between Proactive and Reactive Actions

As seen in section 4.1, only one of the proactive actions in table 5.30 was conducted prior to the earthquake. Due to this, only the connection related to this strategy was possible and as seen in table 5.30 it was in fact experienced at Axis. In spite of not having conducted the proactive action regarding creating a business continuity plan, the connection was imagined. If having had a business continuity plan it was seen as possible that Axis would have had an easier time creating a team and developing the initial plan. Since this is an imagined connection, this will, however, not be shown in table 5.30.

Table 5.30: Pattern matching for the connections between proactive and reactive supply chain risk management actions seen at Axis for the earthquake disruption

Pattern Matching: Connections		
Proactive	**Reactive**	
Selecting Risk Mitigation Strategies (long-term relationship and trust)	Develop an Initial Plan	X
Implement and Educate (create a business continuity plan)	Develop an Initial Plan	/
Implement and Educate (implement ways to detect disruptions)	Develop an Initial Plan	/
Selecting Risk Mitigation Strategies (a special supply chain risk management team)	Develop an Initial Plan	/
Implement and Educate (yearly training)	Recognize and Initiate	/
Implement and Educate (training of new employees)	Recognize and Initiate	/

In addition to the connections seen in theory, several others have been found for this disruption. These can be seen in the lists below. Imagined connections were also thought of when picturing potential proactive actions which Axis could have benefitted from. If a proactive or reactive action, method or strategy has not been suggested by theory, the reasons for why specific steps are chosen for the actions, methods or strategies follows once the lists are presented.

Proposition to theory of connections which were experienced by Axis:

1. Selecting Risk Mitigation Strategies (multiple suppliers, called dual sourcing by Axis) → Develop an Initial Plan (redesign of products)
2. Selecting Risk Mitigation Strategies (having people at/close to the disrupted site) → Develop an Initial Plan (communication)
3. Selecting Risk Mitigation Strategies (most employees at the same site) → Create a Team and Develop an Initial Plan (internal communication)
4. Selecting Risk Mitigation Strategies (core values, for example *Act as One*) → Develop an Initial Plan (collaboration)
5. Selecting Risk Mitigation Strategies (culture which does not focus on finding someone to blame) → Create a Team and Develop an Initial Plan
6. Selecting Risk Mitigation Strategies (culture which promotes taking own initiatives) → Develop an Initial Plan
7. Selecting Risk Mitigation Strategies (strategic stock of components in Lund) → Develop an Initial Plan (maintaining production)
8. Selecting Risk Mitigation Strategies (modular design)→ Develop an Initial Plan (redesign of products)
9. Implement and Educate (previous experience of redesigning products regarding sensors) → Develop an Initial Plan (redesign of products)
10. Implement and Educate (having developed a competence in finding components) → Develop an Initial Plan (finding components)
11. Selecting Risk Mitigation Strategies (having good relationships with a partner which has even better relationships with suppliers) → Develop an Initial Plan (finding components and being prioritized in general)
12. Selecting Risk Mitigation Strategies (having relationships with suppliers that are currently not bought from)→ Develop an Initial Plan (finding replacing components)

Proposition to theory of connections which were imagined by Axis:

1. Selecting Risk Mitigation Strategies (cooperation of risk management with suppliers → Develop an Initial Plan
2. Selecting Risk Mitigation Strategies (having mapped the supply chain) → Develop an Initial Plan
3. Strategic Risk Mitigation Strategies (documentation of which components are in which products) → Develop an Initial Plan
4. Selecting Risk Mitigation Strategies (an information system for tracking components in the supply chain) → Develop an Initial Plan
5. Strategic Risk Mitigation Strategies (documentation on the contract manufacturers' need of components) → Develop an Initial Plan

Of the experienced connections, the proactive actions in connections one, seven and eight are suggested by theory. The proactive actions in connections two, three, four, five, six, eleven and

twelve have been reasoned to belong to *Selecting Risk Mitigation Strategies*. Connections two, three, eleven and twelve are seen to be part of collaborating, while connections four, five and six are seen to contribute to a supply chain risk management culture. Connections nine and ten concern having experience and are hence positioned in *Implement and Educate*. For the reactive actions, all proactive strategies are seen to facilitate *Develop an Initial Plan*. The reason for this is that this is the step in which strategies to mitigate the impact of occurred disruptions belong. Having most employees at the same site is seen to facilitate *Create a Team* since it is easier to get in contact with people. Having a culture which does not focus on finding someone to blame is seen to make the disruption management faster, and hence facilitates both *Create a Team* and *Develop an Initial Plan*.

All the imagined connections have been imagined in the previous disruptions. Hence, the reasoning for why the steps have been chosen for the proactive and reactive actions, methods or strategies can be found in sections 5.4.1.1, 5.4.2.1 and 5.4.3.1.

5.4.4.2 Connections Between the Proactive and the Reactive Supply Chain Risk Management Processes

From this disruption, several connections were experienced which were not found in the studied theory. Of the connections found in theory, only two were experienced due to Axis not having conducted the other proactive actions necessary for the other connections. These ones could hence not be investigated. The experienced connections will be visualized in figure 5.9. If having shown the imagined connections, these would have been drawn between Selecting Risk Mitigation Strategies and Develop an Initial Plan.

Figure 5.9: A visualization of the found connections between proactive and reactive supply chain risk management in the flooding disruption

6 CROSS-CASE ANALYSIS

This chapter presents the cross-case analysis. First, the reactive supply chain risk management of each studied disruption is compared both to each other and to theory. Next, the found connections between proactive and reactive supply chain risk management are compared to both each other and to theory.

In this chapter, the studied disruptions have been given a shorter label in order to make the tables more easily comprehensible. The labels are presented below.

D1: Earthquake/Tsunami 2011
D2: Flooding 2011
D3: Fire 2014
D4: Earthquake 2016

6.1 Reactive Supply Chain Risk Management

In this section, the reactive disruption management of the studied disruptions are compared with each other and to theory.

6.1.1 Recognize and Initiate

In all studied cases, Axis has begun the disruption management with identifying the disruption and with preparing for the coming steps, as seen in table 6.1.

Table 6.1: Cross-case pattern matching of the actions to Recognize and Initiate taken by Axis

Pattern Matching: Recognize and Initiate					
Part	**Action**	**D1**	**D2**	**D3**	**D4**
Recognize	Identify that a disruption has happened	X	X	X	X
Initiate	Prepare for the coming steps in the process	X	X	X	X

The studied cases have extended the studied theory by giving suggestions on ways to *Recognize and Initiate* a reactive supply chain risk management process, as seen in table 6.2.

Table 6.2: Cross-case explanation building of the actions to Recognize and Initiate taken by Axis

Explanation building: Recognize and Initiate					
Part	**Action**	**D1**	**D2**	**D3**	**D4**
Recognize	Send employees to the disrupted site		X		
	Early face-to-face meeting with the affected suppliers				X
Initiate	Create a worst-case scenario				X
	Find information on available components/products in the supply chain				X
	Create a common vision for the reactive supply chain risk management				X

Only in the flooding disruption did Axis send employees to the disrupted site to receive more information. The main reason that this was not repeated in the fire and earthquake disruptions is probably that Axis coincidentally already had employees at the disrupted sites, and therefore

did not need to send them there. The reason that Axis did not send employees to Japan after the earthquake/tsunami disruption could be because this action had not crossed the minds of the Axis' employees yet, or because it was too dangerous to travel to Japan at the time.

One could argue that if Axis sent employees to the flooded site, then there probably was an early face-to-face meeting with the contract manufacturer. However, since this has not been mentioned by the interviewees, it has not been marked to have been conducted.

Overall, it could be argued that the analysis of *Recognize and Initiate* describes a small trend that Axis has become more refined in its disruption management, as more actions were conducted in the last disruption.

6.1.2 Create a Team

In all four studied disruptions, Axis has put together a disruption management team. The team has always been created internally within the organization, as seen in table 6.3.

Table 6.3: Cross-case pattern matching of the actions to Create a Team taken by Axis

Pattern Matching: Create a Team					
Part	**Action**	**D1**	**D2**	**D3**	**D4**
Create a Team	Communicate with suppliers				
	Communicate with competitors				
	Put together a team	X	X	X	X

The reason for not including suppliers in the team is unknown, but it might indicate a distrust towards them. Not communicating with competitors could be a result of a competitive atmosphere. The reason that these two actions were not done could also simply be that the idea had not crossed the minds of Axis' employees.

6.1.3 Develop an Initial Plan

Axis has been very consistent on which, by theory, suggested strategies that it has used for its initial plan in the four studied disruptions. This is summarized in table 6.4.

Table 6.4: Cross-case pattern matching of the actions to Develop an Initial Plan taken by Axis

Pattern Matching: Develop an Initial Plan					
Part	**Strategy**	**D1**	**D2**	**D3**	**D4**
Develop an Initial Plan	Use of spare capacity				
	Shutdown of marginal product lines and transfer of key products				
	Assistance from competition				
	Advice and assistance from trade organizations				
	Outsourcing		X	X	X
	Re-labeling of competitors' products				
	Establishment of temporary facilities				
	Communication in the supply chain	X	X	X	X
	Retain the company's values	X	X	X	X
	Collaboration in the supply chain	X	X	X	X
	Assortment planning				

The consistency of the chosen strategies has some explanations. As Axis has been described to not have any spare capacity, using spare capacity has been impossible. Assortment planning has been tried in several of the studied disruptions, but has been difficult to implement. Re-labeling of competitors' products has not been considered by any of Axis' employees that have been interviewed for this study.

The outsourcing strategy has been used in three disruptions. It is, however, important to note that in this study, outsourcing has been interpreted to include increasing the volumes at already existing suppliers and contract manufacturers.

Strategies which Axis used and which were not suggested by theory vary more, and are presented in table 6.5.

Table 6.5: Cross-case explanation building of the actions to Develop an Initial Plan taken by Axis

Explanation Building: Develop an Initial Plan					
Part	**Strategy**	**D1**	**D2**	**D3**	**D4**
Develop an Initial Plan	Get allocations of affected components	X	X	X	X
	Free resources by putting development projects on hold		X	X	X
	Put the initiation of new products on hold		X		
	Assistance from partners/owners				X
	Adjust forecasts				X
	Purchase components on the spot market				X
	Redesign affected products				X

The comparison shows that getting allocations of affected components has been one on Axis' main strategies during the studied disruptions. Once again, a tendency towards a more refined disruption management can be seen, as more strategies have been conducted in the last disruption management.

Freeing resources by putting development projects on hold was done in three of the disruptions. The reason why this was not done in the earthquake/tsunami disruption was that R&D was not included in the disruption management of that disruption.

The redesign of affected products was only conducted in the earthquake disruption, as it was not needed in the earthquake/tsunami disruption and it was an impractical solution for the flooding and the fire disruptions.

6.1.4 Revise the Plan

In all four studied disruptions, Axis managed to identify new information and revise the initial plan, as seen in table 6.6.

Table 6.6: Cross-case pattern matching of the actions to Revise the Plan taken by Axis

Pattern Matching: Revise the Plan					
Part	**Action**	**D1**	**D2**	**D3**	**D4**
Revise the Plan	Identify when new information is available	X	X	X	X
	Evaluate if planned actions have become obsolete	X	X	X	X

6.1.5 Analyze and Learn

Only in the last disruption, the earthquake in 2016, did Axis conduct a formal learning session where employees analyzed how well Axis had handled the disruption, as seen in table 6.7. This analysis has, however, not resulted in any changes of Axis' supply chain risk management.

Table 6.7: Cross-case pattern matching of the actions to Analyze and Learn taken by Axis

Pattern Matching: Analyze and Learn					
Part	**Action**	**D1**	**D2**	**D3**	**D4**
Analyze	Analyze what went well				X
	Analyze what could have been done better				X
Learn	Find ways to incorporate the analysis into future risk management				

The analysis shows that over time, Axis has become closer to the theoretical suggested process, as this step was partly conducted in the last disruption.

6.1.6 Reactive Supply Chain Risk Management Process

A summary of the conducted steps in Axis' disruption management is presented in figure 6.1. Steps colored in a darker grey indicate that the steps were fully conducted in all studied disruptions, as seen in sections 5.3.1.6, 5.3.2.6, 5.3.3.6. and 5.3.4.6. The middle-shaded grey indicates that the steps were partly conducted in all studied disruptions. The lightest shade of grey indicates that the steps were partly conducted in only one studied disruption, and not conducted in the other disruptions.

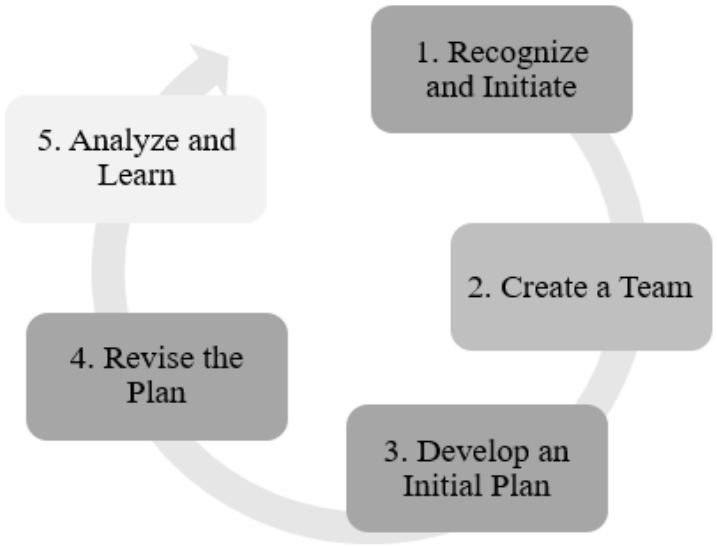

Figure 6.1: A summary of reactive supply chain risk management process steps conducted in the studied disruptions

Figure 6.1 shows that Axis has conducted a majority of the steps fully. The *Create a Team* step has a middle-shaded grey as Axis has used internal teams only. The figure also clearly shows that Axis has been weak in evaluating the management of the disruptions.

6.2 Connections Between Proactive and Reactive Supply Chain Risk Management

In this section, the connections between the proactive and the reactive supply chain risk management of the studied disruptions are compared with each other and to theory.

In this section, 'X' marks a connection which has been experienced by Axis. '/' has been used to mark that the, by theory, suggested connections could not be found in the studied cases since Axis did not perform the proactive action. If Axis has conducted the proactive action, but not experienced the connection, the box on the far right in the table is left empty.

6.2.1 Connections Between Proactive and Reactive Actions

Regarding the proactive actions in the connections found in theory, Axis consistently throughout the four disruptions only conducted one of them. Hence, only one connection was possible. This connection was found to have existed at Axis in each disruption, as seen in table 6.8. For all of the other connections the proactive actions were not conducted, and as a consequent, these connections have not been possible to confirm.

Table 6.8: Cross-case pattern matching for the connections between proactive and reactive supply chain risk management actions seen at Axis for the disruptions

Pattern Matching: Connections					
Proactive	**Reactive**	**D1**	**D2**	**D3**	**D4**
Selecting Risk Mitigation Strategies (long-term relationship and trust)	Develop an Initial Plan	X	X	X	X
Implement and Educate (create a business continuity plan)	Develop an Initial Plan	/	/	/	/
Implement and Educate (implement ways to detect disruptions)	Develop an Initial Plan	/	/	/	/
Selecting Risk Mitigation Strategies (a special supply chain risk management team)	Develop an Initial Plan	/	/	/	/
Implement and Educate (yearly training)	Recognize and Initiate	/	/	/	/
Implement and Educate (training of new employees)	Recognize and Initiate	/	/	/	/

Axis did a number of proactive actions not mentioned in table 6.8. For some of these actions, connections were also experienced. These connections are not found in theory, and are hence presented in this report as suggestions to theory. The concerned connections are seen in table 6.9. As seen in this table, some of the connections were experienced in more than one disruption. No connection is, however, experienced in more than two disruptions. Something which can be seen in both the proactive side and the reactive side of the connections is that a number of the connections spring from the steps of the processes containing the most actions, methods and/or strategies – *Selecting Risk Mitigation Strategies* and *Develop an Initial Plan* respectively. The reason for this could be statistical since these steps are the ones entailing the highest number of actions, methods or strategies. Hence, there is a higher probability for connections to spring from these steps. However, the reason could also be due to the strategic content of the steps. Since decisions regarding which strategies to implement, proactively and

reactively respectively, are taken here, the steps could be said to contain a strategic importance which might be better suited to form connections.

As can be seen in table 6.9, the flooding and the fire disruptions have experienced similar connections between proactive and reactive supply chain risk management. All the connections experienced in the flooding were also experienced in the fire, except for one. The reason for this is argued to be that the disruptions affected the same contract manufacturer and therefore had similar consequences for Axis.

The earthquake disruption has experienced the most connections between proactive and reactive supply chain risk management, according to table 6.9. The reason for this is probably that more people were interviewed about this disruption, as seen in Appendix IV, as well as that it is more recent in people's memories.

Table 6.9: Cross-case explanation building for the connections between proactive and reactive supply chain risk management actions seen at Axis for the disruptions

Explanation Building: Experienced Connections					
Proactive	**Reactive**	**D1**	**D2**	**D3**	**D4**
Selecting Risk Mitigation Strategies (multiple suppliers, called dual sourcing by Axis)	Develop an Initial Plan	X			X
Implement and Educate (having developed a competence in finding components)	Develop an Initial Plan				X
Selecting Risk Mitigation Strategies (multiple manufacturing locations)	Develop an Initial Plan		X	X	
Selecting Risk Mitigation Strategies (not becoming an insignificant customer)	Develop an Initial Plan		X		
Selecting Risk Mitigation Strategies (strategic stock of equipment in Lund)	Develop an Initial Plan		X	X	
Implement and Educate (having experience of a disruption)	Create a Team		X	X	
	Develop an Initial Plan		X	X	
Selecting Risk Mitigation Strategies (strategic stock of components in Lund)	Develop an Initial Plan			X	X
Selecting Risk Mitigation Strategies (having people at/close to the disrupted site)	Develop an Initial Plan				X
Selecting Risk Mitigation Strategies (most employees at the same site)	Create a Team				X
	Develop an Initial Plan				X
Selecting Risk Mitigation Strategies (core values)	Develop an Initial Plan				X
Selecting Risk Mitigation Strategies (culture which does not focus on finding someone to blame)	Create a Team				X
	Develop an Initial Plan				X
Selecting Risk Mitigation Strategies (culture which promotes taking own initiatives)	Develop an Initial Plan				X
Selecting Risk Mitigation Strategies (modular design)	Develop an Initial Plan				X
Implement and Educate (previous experience of redesigning products regarding sensors)	Develop an Initial Plan				X
Selecting Risk Mitigation Strategies (flexible tools)	Develop an Initial Plan			X	
Selecting Risk Mitigation Strategies (having good relationships with a partner which has even better relationships with suppliers)	Develop an Initial Plan				X
Selecting Risk Mitigation Strategies (having relationships with suppliers which are currently not bought from)	Develop an Initial Plan				X

Imagined connections were also derived from the interviews. These were never experienced since the proactive actions were not conducted prior to the disruptions. However, if having done them, certain connections were expected to have existed. Since these connections were never actually experienced, they are, nevertheless, not suggested to theory, but merely noted. The imagined connections can be seen in table 6.10. A noticeable difference from the connections in table 6.9 is that one imagined connection was thought of for every individual disruption out of the four investigated.

Documentation on the equipment as well as the production process at each contract manufacturer are two proactive actions only relevant for the flooding and the fire. In the same way, the benefits of having mapped the supply chain was imagined only for the earthquake/tsunami and the earthquake since these were the disruptions in which more suppliers than just one possibly could have been affected. Having had more cooperation of risk management with suppliers was sought after for all the disruptions, since Axis in hindsight wished that the suppliers and contract manufacturers would have taken more proactive actions in order to mitigate and/or avoid the disruptions. Regarding an information system for tracking components in the supply chain, this was thought to have been needed for the flooding and the fire since new components needed to be bought to initiate production at other contract manufacturers. Since, Axis did not know how many components that already were in their supply chain, this delayed the process of figuring out how many new components to buy. For the earthquake/tsunami and the earthquake disruptions, it would be possible that a system for tracking components in the supply chain would have aided the disruption management. One reason for this is that components as well as the suppliers producing the components were damaged, and an increased knowledge on the availability of components was consequently needed. The reason this was not mentioned for the earthquake/tsunami might be that the interviewees happened to have forgotten it, or that simply finding out which suppliers were affected proved to be an ever-larger problem, hence overshadowing it.

Table 6.10: Cross case summary of the imagined connections between proactive and reactive supply chain risk management actions thought of at Axis regarding the disruptions

Explanation Building: Imagined Connections					
Proactive	**Reactive**	**D1**	**D2**	**D3**	**D4**
Selecting Risk Mitigation Strategies (cooperation of risk management with suppliers)	Develop an Initial Plan	X	X	X	X
Selecting Risk Mitigation Strategies (having mapped the supply chain)	Develop an Initial Plan	X			X
Selecting Risk Mitigation Strategies (documentation on the equipment at each contract manufacturer)	Develop an Initial Plan		X	X	
Implement and Educate (tracking indicators of for example natural disasters)	Recognize and Initiate		X		
Selecting Risk Mitigation Strategies (an information system for tracking components in the supply chain)	Develop an Initial Plan		X	X	X
Selecting Risk Mitigation Strategies (documentation on the production process at each contract manufacturer)	Develop an Initial Plan		X	X	
Strategic Risk Mitigation Strategies (documentation on which products can replace which)	Develop an Initial Plan			X	
Strategic Risk Mitigation Strategies (documentation of which components are in which products)	Develop an Initial Plan				X
Strategic Risk Mitigation Strategies (documentation on the contract manufacturers' need of components)	Develop an Initial Plan				X

6.2.2 Connections Between the Proactive and the Reactive Supply Chain Risk Management Processes

When aggregating the connections found for the four different disruptions, several ones were found. When compared to the suggested connections from theory, only one of the connections was, however, confirmed. It should be clarified though, that this is mainly due to that all proactive actions correlating with the connections have not been conducted, with the exception of one. The other connections have therefore not been rejected, but merely not tested. Figure 6.2 visualizes these experienced connections and those found in theory. The imagined connections are not shown since they were not actually experienced. However, all of them would have been drawn between *Selecting Risk Mitigation Strategies* and *Develop an Initial Plan*, except for one which would have been between *Implement and Educate* and *Recognize and Initiate.*

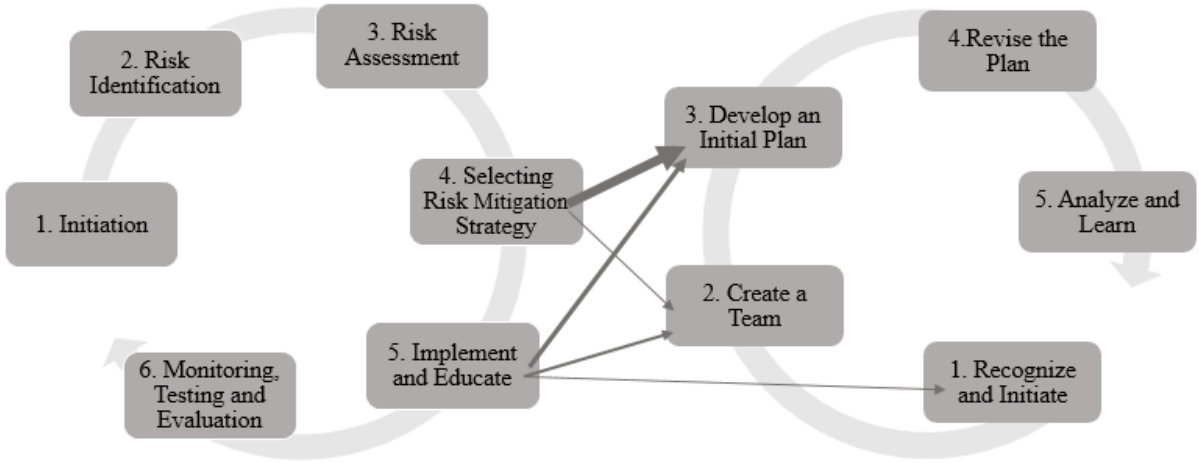

Figure 6.2: A summary of all found connections found in literature and in the studied disruptions

7 MODIFIED FRAMEWORK FOR PROACTIVE AND REACTIVE SUPPLY CHAIN RISK MANAGEMENT

This chapter presents a revised version of the research model, based on the empirical findings.

7.1 Proactive Supply Chain Risk Management

Most of the actions, methods and strategies of Axis' proactive supply chain risk management are discussed in the studied theory. However, the case study discovered some activities new to theory. Axis uses a method to estimate the probabilities of the risks which was not presented in theory. Axis has also chosen several actions to mitigate risks which are not mentioned in the studied theory, although they can all be fitted into the suggested strategies. Owning the tools which are used to produce components could be places in the *increase agility* category. Using flexible testing tools and creating relationships with suppliers which are currently not employed by Axis are actions which belong in the *hedging* category. Being a large enough customer to the contract manufactures in order to receive attention, though still not standing for a majority of a contract manufacturer's business, are two actions which could be placed in the *collaboration* category, similarly to creating a network of partners in the downstream supply chain and conducting audits to raise Axis' suppliers' awareness of their risks. Having extra capacity in production is placed in the *buffering* category. Creating a company culture with an absence of prestige fits into the *create a supply chain risk management culture* category.

Two of the tables from section 3.2 can be modified, and the modified tables are presented below (the tables cannot be modified are not presented in this chapter). Table 3.3 (*Risk Assessment* methods) can be changed into table 7.1 and table 3.4 (*Selecting Risk Mitigation Strategies*) can be changed into table 7.2.

Table 7.1: A summary of methods for Risk Assessment found in the studied theory and the empirical findings. Methods which are presented in italics were found in the empirical findings

Risk Assessment	
Part	**Method**
Estimate probability	Find probability distribution function based on historical data
	Simulation models
	Expert estimates
	Estimate the probabilities of identified risks using input from employees
Estimate loss	Quantitative estimation
	Qualitative estimation

Table 7.2: A summary of actions for Selecting Risk Mitigation Strategies found in the studied theory and the empirical findings. Actions which are presented in italics were found in the empirical findings

Risk Mitigation Strategies	
Strategy	**Action**
Collaboration	Joint process improvements
	Joint quality improvements
	Open communication
	Long-term relationship and trust
	Be a large enough customer to your contract manufacturers in order to receive attention
	Do not stand for a majority of a contract manufacturers' business in order to not make it too dependent
	Create a network of partners downstream in the supply chain
	Conduct audits to raise suppliers' awareness of their risks
Hedging	Multiple manufacturing locations
	Multiple warehousing locations
	Multiple suppliers
	Use flexible testing tools
	Create relationships with suppliers that are currently not being used
Buffering	Increased safety stocks
	Strategic stocks
	Have extra capacity in production
Postponement	Modular design
Increase agility	Remove intervening stocks
	Increase internal visibility
	Reduce inbound lead-times
	Reduce non-value adding activities
	Own tools used to produce components
Create a supply chain risk management culture	Involvement of top management
	A special supply chain risk management team
	Create a company culture with an absence of prestige
Avoid risks	Location not selected due to high risks

The summarized framework of reactive supply chain management, figure 3.8, is updated in figure 7.1 with the new process and the new actions and strategies.

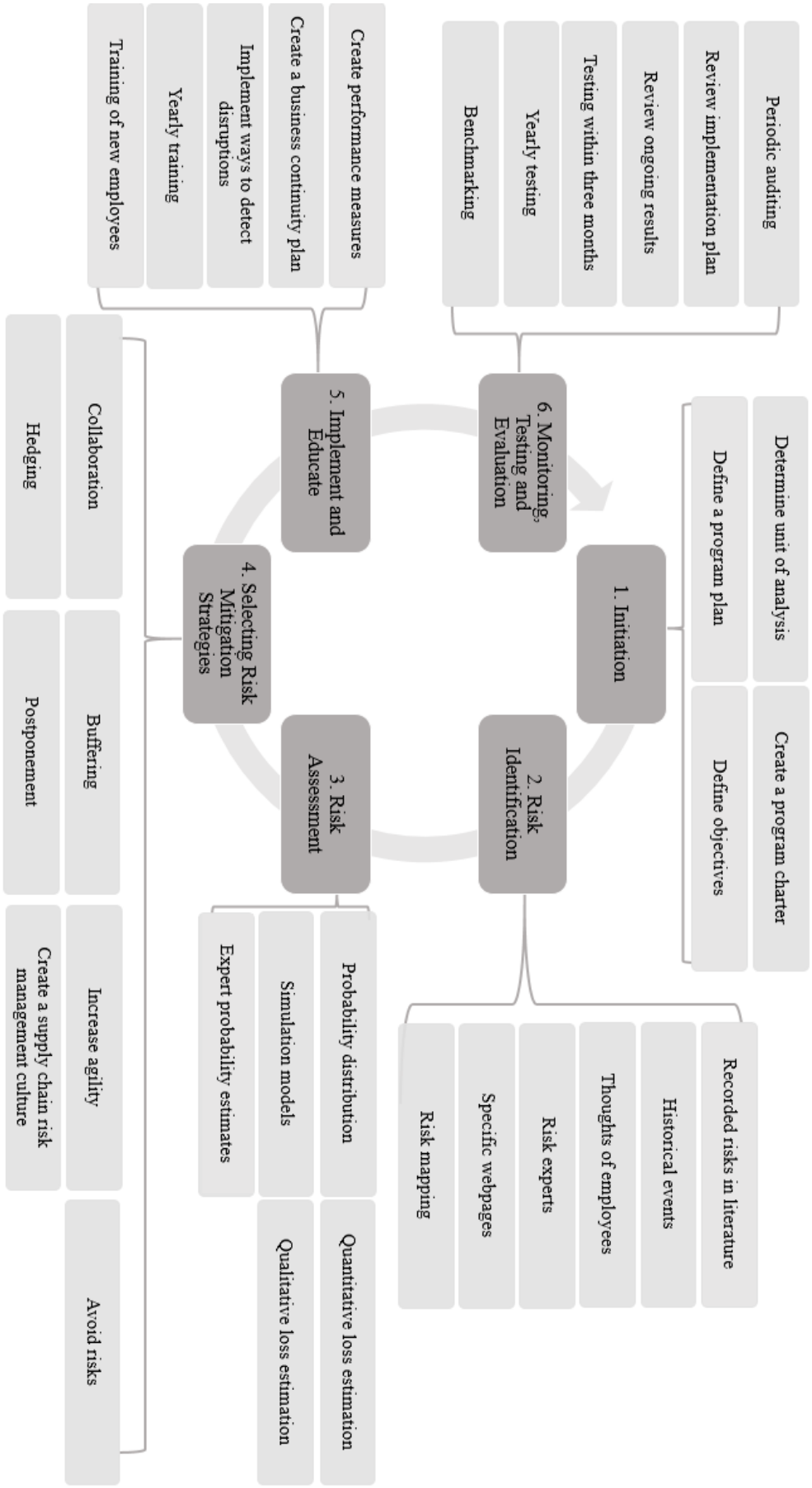

Figure 7.3: The updated summarized framework of proactive supply chain risk management

7.2 Reactive Supply Chain Risk Management

The suggested process for the reactive supply chain risk management does not fit Axis' disruption management completely and some actions are missing. To better reflect reality, it is suggested by the authors of this study that *Develop an Initial Plan* should be changed to *Develop a Plan* and that *Revise the Plan* loops back to *Develop a Plan*. The process presented by theory has also not included any implementation of the chosen strategies, so the authors of this study suggest that an *Implementation of the Plan* step should be added between *Develop a Plan* and *Revise the Plan*. The new reactive supply chain risk management process is presented in figure 7.2.

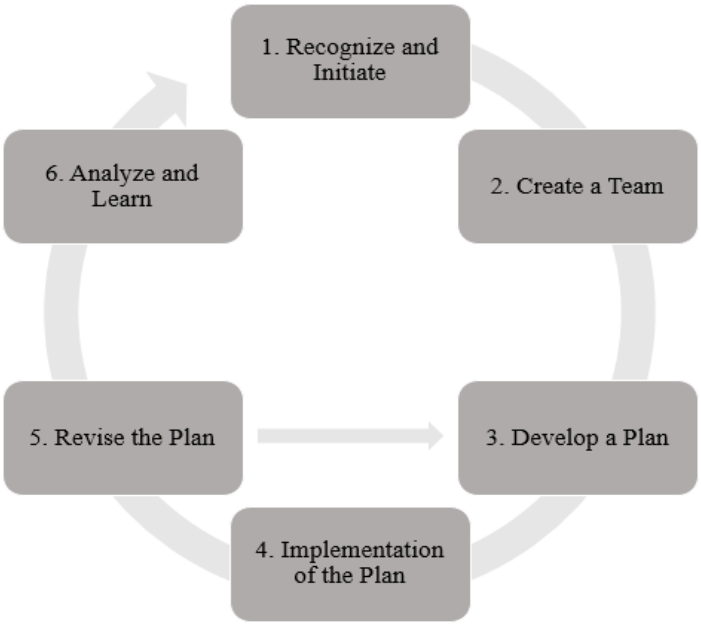

Figure 7.2: The revised reactive supply chain risk

The study of reactive supply chain risk management at Axis contributes to the list of actions which could be considered once a disruption has occurred. Table 3.7, which is a summary of the *Recognize and Initiate* actions found in theory, could therefore be altered to table 7.3. The study at Axis also contributes to a new list of strategies to consider when developing the plan, which alters table 3.9 (a summary of strategies found in theory) to table 7.4. The tables which cannot be modified are not presented in this chapter.

Table 7.3: A summary of actions for Recognize and Initiate found in the studied theory and the empirical findings. Actions which are presented in italics were found in the empirical findings

Recognize and Initiate	
Part	**Action**
Recognize	Identify that a disruption has happened
	Send employees to the disrupted site
	Early face-to-face meeting with the affected suppliers
Initiate	Prepare for the coming steps in the process
	Create a worst-case scenario
	Find information on available components/products in the supply chain
	Create a common vision for the reactive supply chain risk management

Table 7.4: A summary of strategies for Develop a Plan found in the studied theory and the empirical findings. Strategies which are presented in italics were found in the empirical findings

Develop a Plan	
Part	**Strategy**
Develop a Plan	Use of spare capacity
	Shutdown of marginal product lines and transfer of key products
	Assistance from competition
	Advice and assistance from trade organizations
	Outsourcing
	Re-labeling of competitors' products
	Establishment of temporary facilities
	Communication in the supply chain
	Retain the company's values
	Collaboration in the supply chain
	Assortment planning
	Get allocations of affected components
	Free resources by putting development projects on hold
	Put the initiation of new products on hold
	Assistance from partners/owners
	Adjust forecasts
	Purchase components on the spot market
	Redesign affected products

The summarized framework of reactive supply chain management, figure 3.10, is updated in figure 7.3 with the new process and the new actions and strategies.

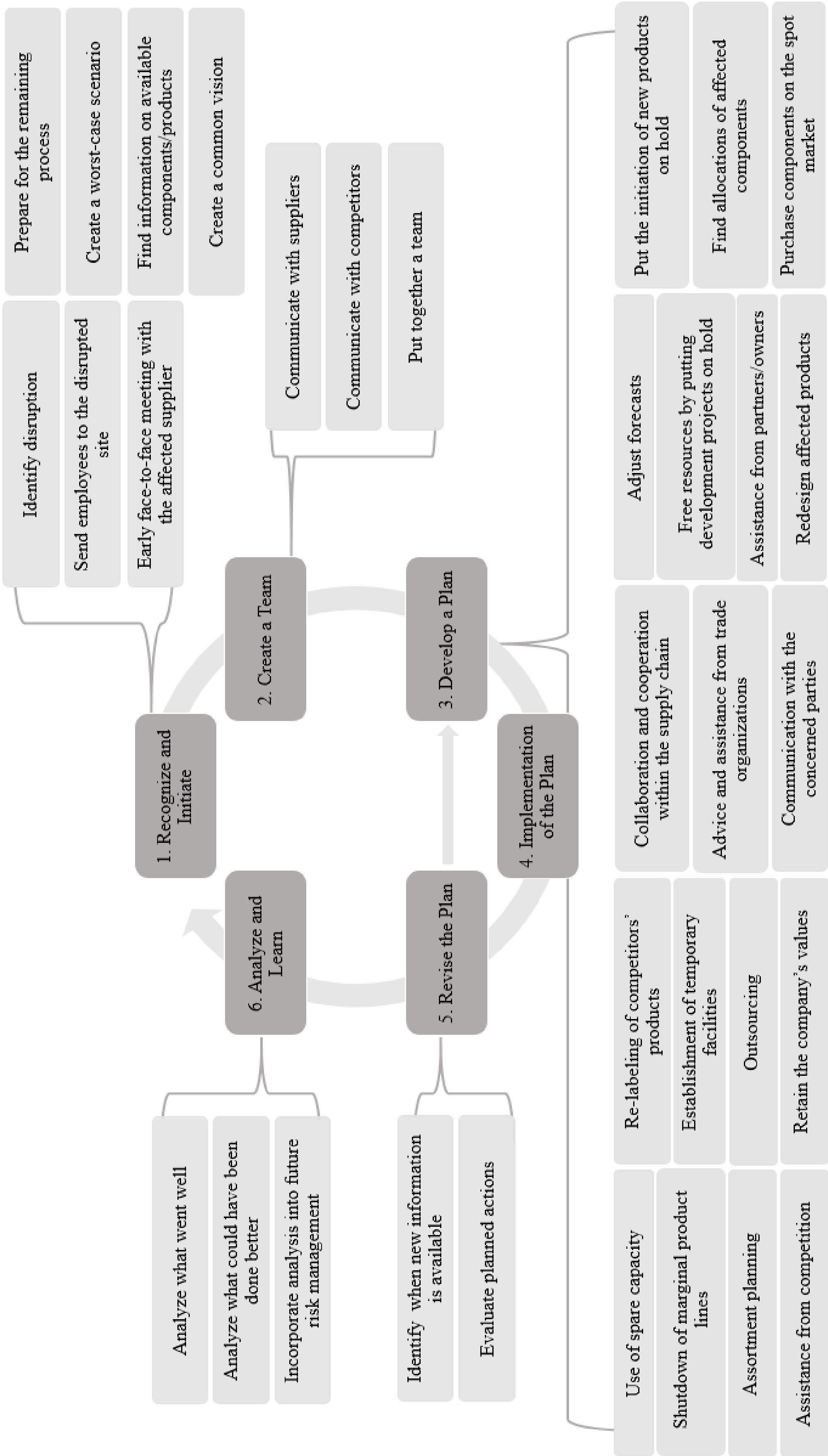

Figure 7.3: The updated summarized framework of reactive supply chain risk management

7.3 Connections Between Proactive and Reactive Supply Chain Risk Management

The study at Axis has resulted in an extended list of connections between proactive and reactive supply chain risk management. Table 3.14, with the connections found in theory, has been updated in table 7.5 with the experienced connections at Axis. Worth noticing is that, as stated in section 2.5, this study has not had the aim to refute connections suggested by theory, but merely to confirm and to augment theory if found necessary. Proactive actions which previously have been stated to facilitate *Develop an Initial Plan* will now be considered to facilitate *Develop a Plan*, since it seen as the most similar to *Develop an Initial Plan*.

Table 7.5: A summary of connections between proactive and reactive supply chain risk management found in the studied theory and the empirical findings. Connections which are presented in italics were found in the empirical findings

Connections	
Proactive	**Reactive**
Selecting Risk Mitigation Strategies (long-term relationship and trust)	Develop a Plan
Implement and Educate (create a business continuity plan)	Develop a Plan
Implement and Educate (implement ways to detect disruptions)	Develop a Plan
Selecting Risk Mitigation Strategies (a special supply chain risk management team)	Develop a Plan
Implement and Educate (yearly training)	Recognize and Initiate
Implement and Educate (training of new employees)	Recognize and Initiate
Selecting Risk Mitigation Strategies (multiple suppliers, called dual sourcing by Axis)	*Develop a Plan*
Implement and Educate (having developed a competence in finding components)	*Develop a Plan*
Selecting Risk Mitigation Strategies (multiple manufacturing locations)	*Develop a Plan*
Selecting Risk Mitigation Strategies (not becoming an insignificant customer)	*Develop a Plan*
Selecting Risk Mitigation Strategies (strategic stock of equipment)	*Develop a Plan*
Selecting Risk Mitigation Strategies (culture which promotes taking own initiatives)	*Develop a Plan*
Selecting Risk Mitigation Strategies (modular design)	*Develop a Plan*
Implement and Educate (previous experience of redesigning products regarding sensors)	*Develop a Plan*
Selecting Risk Mitigation Strategies (flexible tools)	*Develop a Plan*
Selecting Risk Mitigation Strategies (having good relationships with a partner which has even better relationships with suppliers)	*Develop a Plan*
Selecting Risk Mitigation Strategies (strategic stock of components)	*Develop a Plan*
Selecting Risk Mitigation Strategies (core values)	*Develop a Plan*
Selecting Risk Mitigation Strategies (having people at/close to the disrupted site)	*Develop a Plan*
Implement and Educate (having experience of a disruption)	*Create a Team*
	Develop a Plan
Selecting Risk Mitigation Strategies (most employees at the same site)	*Create a Team*
	Develop a Plan
Selecting Risk Mitigation Strategies (culture which does not focus on finding someone to blame)	*Create a Team*
	Develop a Plan
Selecting Risk Mitigation Strategies (having relationships with suppliers which are currently not bought from)	*Develop a Plan*

7.4 Research Model

With the above mentioned modifications, the research model (figure 3.11) has been revised to figure 7.4.

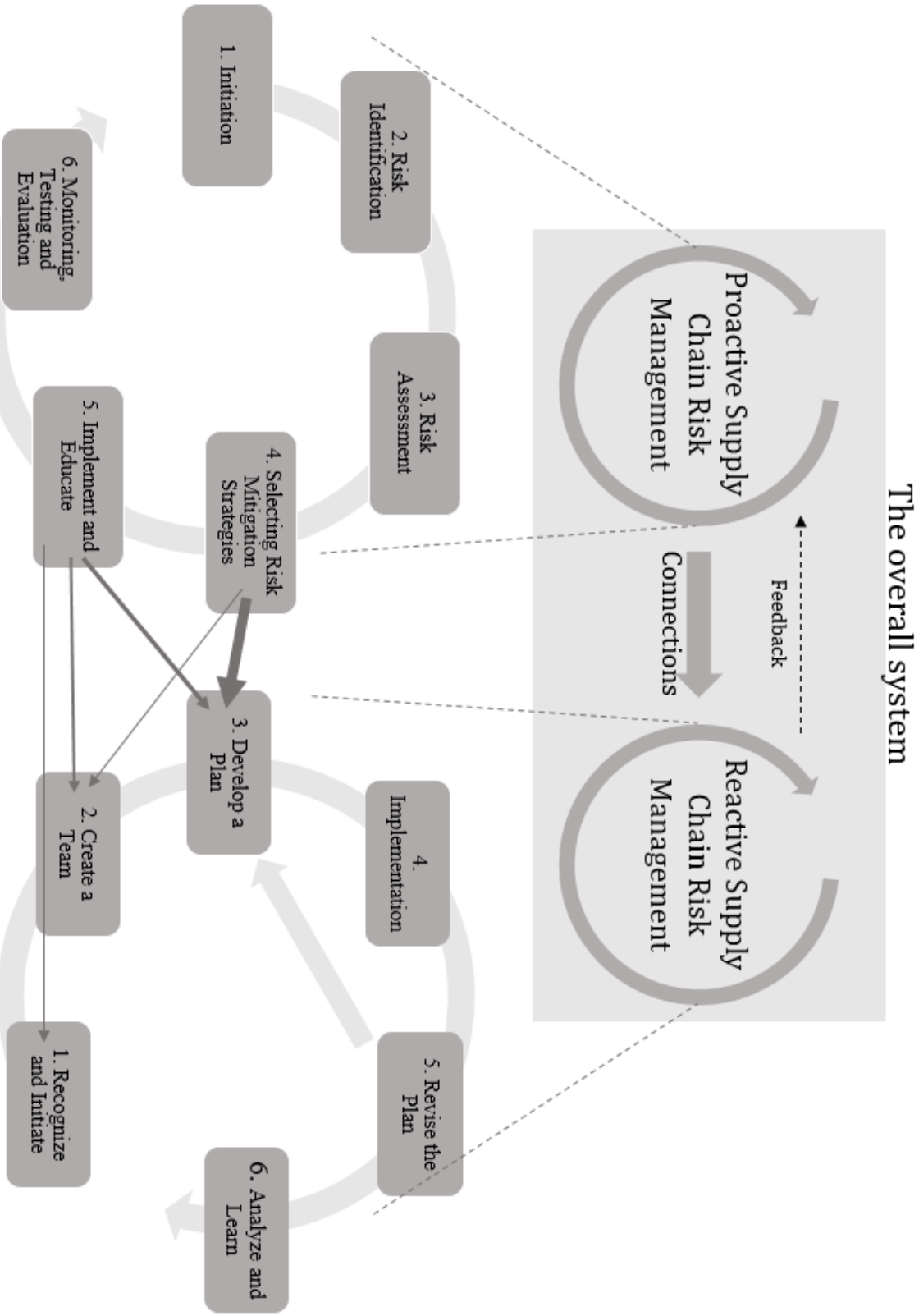

Figure 7.4: The updated research model

8 DESIGNING THE CONSTRUCTS

In this chapter, the development of the suggested guidelines for Axis' proactive supply risk management is described. The validation process is presented, as well as the process of evaluating the applicability of the guidelines.

8.1 Creation of the First Version of the Guidelines

The aim when creating the first version of the guidelines was to find as many guidelines regarding proactive supply chain risk management as possible. This process was broken down into three main processes. Firstly, the suggested proactive supply chain risk management actions mentioned in theory were listed. Secondly, the proactive supply chain risk management actions found from the interviews at Axis were added. These ones were found in different ways. One search concerned the proactive section of the interviews, another the reactive section of the interviews and thirdly certain proactive supply chain risk management actions were derived from the connections parts of the interviews. In addition to this, possible proactive supply chain risk management actions not found through these two processes but thought of by the authors were also added.

When having conducted this work, several proactive supply chain risk management actions were listed as can be seen in Appendix V.

8.2 Creation of the Second Version of the Guidelines

The aim when creating the second version of the guidelines was to limit the list of guidelines as not to overwhelm Axis with too many suggestions, while at the same time providing the guidelines necessary from a supply chain risk management perspective. It was hence a balancing act. In this process, certain criteria were used for reducing the number of proactive supply chain risk management actions:

1. If aspects were interrelated, they were merged into one
2. If supply chain risk management was seen as a minor reason for why or why not to conduct the actions, they were removed. The argument for this was that the suggestion to do them from a supply chain risk management perspective was expected to be overruled by the superior reason why or why not to do them.

When having reduced the list using the two aspects above, a different approach was employed. The list was divided into two parts; aspects Axis were already doing, and aspects that were new to them. The new aspects were seen as the ones which could risk overwhelming Axis, possibly resulting in Axis not actually implementing any of them. These ones were therefore sought to be reduced even more. This was done through comparing them according to two criteria:

1. How effective would they be from a supply chain risk management perspective?
2. How difficult would they be to implement as Axis?

Based on this ranking, the guidelines which had low scores on the first criteria and had high scores on the second criteria were removed. Once this was done, the second version of the guidelines, which can be found in Appendix VI, was completed. A list of the removed guidelines from the first version, and motivations to why they were removed, can be found in Appendix VII.

8.3 Creation of the Final Version of the Guidelines

The final version of the guidelines was created in two steps. Firstly, through validating the second version with selected Axis employees, and, secondly, through investigating further into the applicability of the suggested guidelines.

8.3.1 Demonstrating the Solution's Feasibility

The second version of the guidelines was presented to the employees at Axis who had previously been interviewed for this study as well as the company supervisors. The guidelines were validated through two steps; a workshop and a survey, and these will be further discussed in the sections below.

8.3.1.1 Workshop

In this section, the workshop and the result of the workshop will be further described.

8.3.1.1.1 Purpose, Participants and Design

The purpose of the workshop was twofold. Firstly, the applicability of the guidelines which Axis at the time did not conduct was discussed through different questions. Secondly, the survey (see section 8.3.1.2) was introduced. Regarding who was invited, all interviewees and company supervisors of this study were invited to the workshop, which sum up to 21 persons. Seven of these were able to attend the workshop and they are listed in table 8.1.

Table 8.1: Participants in the workshop

Position
Senior Expert Engineer
Production Preparation Manager
R&D Director
Vice President, Operations
Demand Manager
Commodity Manager, Electronics
Manager Material Supply

The workshop was conducted during one hour. After a short introduction, the participants discussed selected guidelines during 45 minutes, before the survey was briefly introduced. All participants had been sent background information and the questions on the guidelines prior to the workshop.

Five guidelines were selected to be discussed in the workshop, which are presented in table 8.2. These were selected among the guidelines in the second version that Axis did not conduct and were chosen due to being thought to have the highest need of input from different departments since they had a cross-functional nature. In table 8.2, the corresponding questions to each guideline are also presented. The questions were designed so that the authors of the study could receive a better understanding on how these guidelines could be implemented at Axis, to be able to construct a more detailed implementation plan to Axis. In addition to this, it was important that the questions were open as to encourage a discussion.

Table 8.2: The discussed guidelines and their corresponding questions

Guideline	Question(s)
Have defined objectives for the supply chain risk management	What could be appropriate objectives for Axis?
	Who should be responsible for the final creation of the objectives?
Have defined KPIs for the proactive supply chain risk management process	What could be appropriate measures on how well the chosen strategies and objectives are accomplished?
	Who should be responsible for the final creation of KPIs?
Have a proactive supply chain risk management process with five steps: (1) Risk Identification; (2) Risk Assessment; (3) Selecting Risk Mitigation Strategies; (4) Implementation; and (5) Monitoring and Evaluation	Which (cross-functional) groups, departments or functions within Axis could benefit from conducting this process?
	How frequently should the process be repeated?
	Should a structure for *Risk Identification* and *Risk Assessment* be proposed?
Prepare a reactive supply chain risk management process	What should the plan for the reactive supply chain risk management process include?
Increase cooperation of risk management with suppliers	For new suppliers/EMSs/CLCs: Which person/groups/departments/ functions should be responsible for this?
	For current suppliers/EMSs/CLCs: Which person/groups/departments/ functions should be responsible for this?

8.3.1.1.2 Results

The results of the workshop are shown in the tables below. In order to create a comprehensible structure, each of the guidelines in table 8.2 has been given a separate table ranging from table 8.3 to 8.7. The questions are shown in the left column and the results from the workshop in the right one.

Table 8.3: The results for defined objectives for the proactive supply chain risk management

Defined objectives for the proactive supply chain risk management	
Question	**Results**
What could be appropriate objectives for Axis?	Not losing sales or reducing quality due to natural disasters were the objectives focusing on reactive supply chain risk management. More general objectives were: being aware of a number of different tiers in the supply chain, finding the risk areas and/or components, maintaining good supplier relationships. Developing specific commodity strategies was mentioned as a way of doing this.

Who should be responsible for the final creation of the objectives?	A risk management council (which does not exist at Axis at the time of this study)

Table 8.4: The results for defined KPIs for the proactive supply chain risk management process

Defined KPIs for the proactive supply chain risk management process	
Questions	**Results**
What could be appropriate measures on how well the chosen strategies and objectives are accomplished?	These ones were somewhat based on the objectives mentioned above. Lost opportunities sales-wise, sales, market shares, product returns, the Axis' brand value, customer partner satisfaction, the allocation between contract manufacturers, and the allocation between different components were the ones mentioned during the workshop.
Who should be responsible for the final creation of KPIs?	A risk management council (which does not exist at Axis at the time of this study)

Table 8.5: The results for a proactive supply chain risk management process

A proactive supply chain risk management process	
Questions	**Results**
Which (cross-functional) groups, departments or functions within Axis could benefit from conducting this process?	Suggestions included the existing commodity teams that are a mixture of Operations and R&D
How frequently should the process be repeated?	Once a year
Should a structure for *risk identification* and *risk assessment* be proposed?	A semi-structured approach was preferred. A decided structure was thought to facilitate the transition to conducting the process as well as providing results from the two steps in the process which are comparable to each other.

Table 8.6: The results for preparing a reactive supply chain risk management process

Preparing a reactive supply chain risk management process	
Questions	**Results**
What should the plan for the reactive supply chain risk management process include?	The opinions from the members of the workshop varied in this question. While some advocated for the importance to preserve Axis' culture of individuality and hence not have a reactive supply chain risk management process at all, others saw the benefits of one. From these ones, suggestions were primarily based on lessons from the earthquake and included: deciding on the type of project leader (for example from operations, product development and/or technologies); finding out the degree of impact; developing at least one worst-case scenario; evaluating the consequences of actions before taking them; developing an internal communication plan; promoting cross-functional work.

Table 8.7: The results for increased cooperation of risk management with suppliers

Increased cooperation of risk management with suppliers	
Questions	**Results**
For new suppliers/EMSs/CLCs: Which person/groups/departments/ functions should be responsible for this?	Finding someone responsible for this proved troublesome. Today, there is a process where new suppliers are audited before being approved, however, this is not the case for electronics. Hence, the quality department which does the auditing was one suggestion. Supplier evaluation was also suggested to handle this.
For current suppliers/EMSs/CLCs: Which person/groups/departments/ functions should be responsible for this?	The quality department was mentioned to handle this as well. In addition to this, Business Review teams were mentioned?

8.3.1.2 Survey

In this section, the survey and the result of the survey will be further described.

8.3.1.2.1 Purpose, Participants and Design

The purpose of the survey was to collect input on the desirability of all the created guidelines in the second version. Regarding the participants of it, the survey was sent to all interviewees and company supervisors, in total 21 people. Eleven people answered the survey. Five of the participants belonged to R&D, five of the participants belonged to Operations and one participant was a product manager. Six of the participants had attended the workshop.

The survey had two introductory questions, where the participants stated in which function at Axis they worked and whether they had participated in the workshop. They were then asked to rate the suggested guidelines according to four aspects; use of resources, user-friendliness, comprehensiveness and communication, as are described in section 2.6. Each guideline was first rated according to its use of resources and the participants could rate it on a seven-step scale where 1 represented *very little resources* and 7 represented *very large resources*, see figure 8.1. The ratings of the user-friendliness and comprehensiveness aspects followed and they were constructed in the same way. The rating of the communication aspect was also done on a seven-step scale, where 1 represented a *large decrease of communication*, 4 represented an *unchanged situation* and 7 represented a *large increase of communication*. The participants were then asked to answered yes or no on whether they wanted Axis to work with each suggested guideline. The option to choose *do not know* was available for all questions except the first two introductory questions.

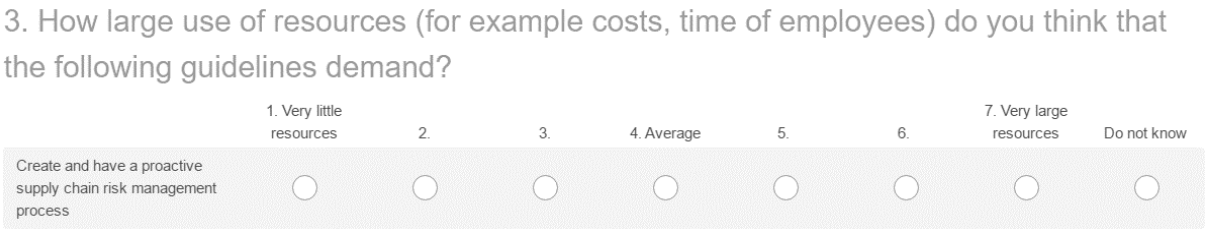

Figure 8.1: An example of the design of the survey

8.3.1.2.2 Results

To find the results of the survey, the average of each aspect was calculated. For the aspects use of resources, user-friendliness and comprehensiveness the averages were calculated by adding their ratings and dividing with the number of people that had answered the question, for each guideline and each aspect individually. The averages in the communication aspect were calculated differently, since it had a different scale. Ratings which indicated a decrease in communication were given negative points and the ratings which indicated an increase in communication were given positive points. The scores were then normalized to force them to stay between -7 and 7. The score for each guideline and aspect was multiplied with a rating that reflected how important the interviewees had found the aspect to be (see section 2.6). This gave each guideline a score on how much value they provided in a supply chain risk management perspective. These averages are seen in the column named Value in table 8.8.

The averages for the question on whether the participants wanted Axis to work according to the guidelines was calculated by giving 1 point to the answer *yes* and -1 point the answer *no*, and then dividing the sum with the number of answers. These averages are seen in the column named Desirability in table 8.8.

The scores are presented in table 8.8 and in figure 8.2. In table 8.8, the guidelines are sorted according to which quadrant they belong to in figure 8.2. Figure 8.2 is further discussed in section 8.3.2.

Table 8.8: The second version of the guidelines and their scores

Guideline	Value	Desirability
Appoint a person at the supplier's responsible for communicating the occurrence to Axis once a disruption has happened	4.4	1.0
Work actively on increasing internal transparency	4.3	1.0
Have a proactive supply chain risk management process	4.3	0.75
Have dual sourcing of strategic components	4.3	0.33
Have defined objectives for the supply chain risk management	4.2	0.71
Prepare a reactive supply chain risk management process	4.0	1.0
Not using a unique component in a disproportionate amount (more than 50%) of the product volume	3.8	0.60
Jointly develop quality with suppliers	3.8	1.0
Have a company culture that encourages cooperation and lack of prestige	3.8	1.0
Appoint one Axis' employee responsible for aiding suppliers in their risk management	3.7	0.14
Develop cross-functional teams	3.7	1.0
Increase cooperation of risk management with suppliers	3.7	1.0
Jointly develop processes with suppliers, contract manufacturers and CLCs	3.6	0.80
Involve top management in supply chain risk management	3.6	0.25
Documentation on the availability of components in the supply chain	3.6	1.0
Have decided that Axis takes control of the communication and collaboration in the supply chain in the occurrence of a disruption	3.6	1.0
Have relationships with suppliers not currently employed by Axis	3.5	1.0
Have stock at more than one geographical location	3.4	0.80
Have open communication with suppliers, contract manufacturers and CLCs	3.4	1.0
Have production at contract manufacturers at multiple geographical locations	3.4	1.0
Have production of high volume products at more than one contract manufacturer	3.1	1.0
Documentation of the equipment at contract manufacturers	3.3	1.0
Documentation of how products are produced at the contract manufacturers	3.2	1.0
Create long-term relationships with suppliers	3.2	1.0
Have good relationships with suppliers, contract manufacturers and CLCs currently employed by Axis	3.0	1.0
Have stock of equipment in Lund, Sweden	2.7	0.43
Have defined KPIs for the objectives regarding proactive supply chain risk management	3.7	0.0
Have stock of finished products in the supply chain (at least one month of demand)	2.8	0.0
Have stock of strategic components (at least two months of demand)	2.6	0.0
Refrain from designing in unique components	3.8	-0.11

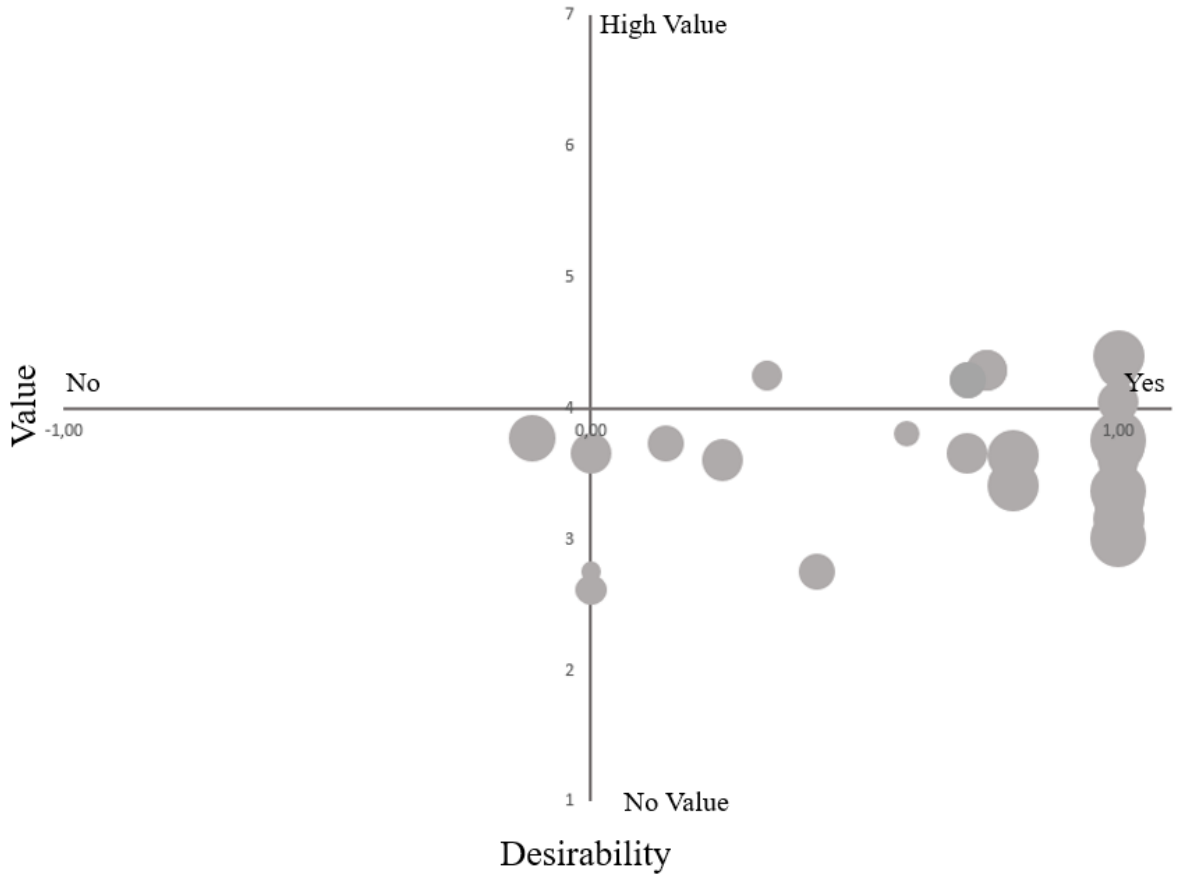

Figure 8.2: The results of the survey. The y-axis represents the results in the column Value in table 8.8, while the x-axis represents the column Desirability in the same table. The size of the circles indicates how many people that answered the question; a large circle means that many people answered the question

8.3.2 Designing the Applicability of the Final Version of the Guidelines

Once having analyzed the results from the workshop and the survey, the second version of the guidelines was altered. Since the workshop only focused on the applicability of the guidelines which Axis did not conduct, it did not provoke the removal of any guidelines. The survey however did this.

As can be seen in figure 8.2, a matrix was formed containing the results from the survey ranking and this formed the base for changes to the second version. The y-axis ranks from 1 to 7 where 7 is seen as the guideline providing the best value possible from a supply chain risk management perspective and 1 as providing no value. This shows the scores in column *Value* in table 8.8. The x-axis ranked from -1 to 1, where 1 shows that the Axis' employees wants to have the guideline, while -1 means that they do not wish to have the guideline. This shows the scores in column Desirability in table 8.8. The matrix' four quadrants were formed based on the center of the axes, which means the position (0,4). When having conducted this division, one guideline was removed from the second version. The guideline which was in the third quadrant, that is below 4 on the y-axes and below 0 on the x-axis, was not considered suitable to suggest for Axis. The reason for this is that Axis was slightly negative towards implementing it, while it at the same time not expected it to provide much value regarding supply chain risk management.

Due to this, the guideline regarding *refraining from designing in unique components* was removed. as seen in table 8.9.

When having created the matrix and positioned the guidelines on the scale accordingly to their scores on *Desirability* and *Value*, two things can be seen. First, all guidelines fall between score 2 and 5 on the y-axis and, more specifically, three out of 30 fall between 3 and 4.5. It would seem as if most guidelines are expected to provide value, based on the four aspects forming the evaluation. However, while not expecting any guidelines to provide low value, no guidelines are expected to provide high value either. Second, when analyzing the scores on the x-axis it can be seen that 26 out of 30 guidelines are to some extent desired, while only one guideline in fact has a to some extent negative desire. 22 out of 30 guidelines score above 0.5 and 17 out of 30 guidelines in fact score 1, that is the highest score. The desirability for most of the proposed guidelines are therefore argued to be high. For the guidelines scoring above 4 on the y-axis, a small trend can be seen that they score well on desirability as well. Overall, however, this trend has not been possible to identify.

With some of the guidelines removed based on the scores on *Desirability* and *Value*, the process of designing the applicability of the remaining guidelines was continued. This process entailed asking employees for advice on specific details of the applicability. When doing this, new information was discovered and two more guidelines removed from the second version of guidelines. The removed guidelines are presented in table 8.9 as well as the reason for their removal.

Table 8.9: The removed guidelines and the motivation for their removal

Guideline	**Reason for removal**
Refraining from designing in unique components	Not being desired to implement while not being expected to provide much value regarding supply chain risk management
Appoint a person at the supplier's responsible for communicating the occurrence to Axis once a disruption has happened	It seemed difficult to decide on the specifics of the guideline. In addition to this, the view was that a supplier often wishes to itself understand the impact before communicating any details to customers, which meant that it could prove difficult for Axis to require this from them.
Appoint one Axis' employee responsible for aiding suppliers in their risk management	Discussions with employees at Axis revealed that the Quality department already works with this and the effect of keeping the guideline would be low
Increase cooperation of risk management with suppliers, contract manufacturers and CLCs	Axis are currently having this cooperation with a number of their suppliers, contract manufacturers and CLCs. The reason for why Axis are not doing it with even more of them is two-fold: (1) if being a standard component, Axis rely on other companies having examined the supplier, contract manufacturer or CLC already; and (2) if being a small buyer, Axis do not expect to be able to influence the company if having done any findings.

In addition to this, two guidelines were added. During the workshop, a supply chain risk management council was repeatedly mentioned. The participants of the workshop were unified in that this council could provide value to Axis. Due to this, the decision to add the supply chain risk management council to the guidelines was made. Also, during conversations with employees at Axis, a need for mapping the supply chain to get a better understanding of potential risks was discussed. In addition to this, if having mapped second tier and third tier, it would be easier for Axis to know which companies which would be relevant to contact in the case of a disruption. The added guidelines can be seen in table 8.10.

Table 8.10: The added guideline and the motivation for its existence

Guideline	**Reason for existence**
Have a supply chain risk management council	Being seen as providing value from the participants of the workshop
Map the supply chain	Get a better understanding of potential risks

With this process done, the third and final version of the guidelines was creating, containing 28 guidelines. These ones will be presented in chapter 9.

9 DESCRIPTION OF THE GUIDELINES

This chapter describes the suggested guidelines for Axis' proactive supply chain risk management. The chapter is divided into two parts; firstly, the guidelines which are new to Axis are presented, and secondly, the guidelines which describe actions that Axis already is conducting are defined.

9.1 Guidelines which are New to Axis

The main purpose of the guidelines which are new to Axis is to create a structure for the proactive supply chain risk management. As can be seen, the new guidelines focus on creating processes, objectives, measures for the objectives and documentation on the supply chain. They should ensure that everyone is working in the same direction, and that the proactive decisions regarding the handling of supply disruptions are made consciously and continuously. It is suggested that Axis assigns an owner to each of the activities proposed by the guidelines, in order to make certain that they are conducted.

Have a supply chain risk management council
If having a council with the purpose of supply chain risk management, the chances are that the subject does not lose importance, does not become forgotten and that it is updated to the extent needed. The people in the council should be experienced employees at Axis, which is the case in the other councils at Axis. The reason for this is since they have to be able to know the company well in order to give good suggestions. The council's purpose is to be the center of suggestions and decisions regarding supply chain risk management. It should not implement the decisions, but merely act on a strategic level. The implementation should be delegated to others within the company. The council should also contain members from different functions as to become cross-functional. The recommended size is around 5-7 people since that makes it more manageable to schedule meetings and to make decisions.

Have a proactive supply chain risk management process
Axis is advised to implement a proactive supply chain risk management process. The suggested process is divided into five steps; (1) Risk Identification; (2) Risk Assessment; (3) Selecting Risk Mitigation Strategies; (4) Implementation; and (5) Monitoring and Evaluation, see figure 9.1. The first three steps were chosen as they are present in all proactive supply chain risk management processes found in theory. The fourth step was chosen to be a part of the process in order to highlight the importance of implementing the chosen strategies. The last step was included in the process to ensure that Axis tracks the progress of its supply chain risk management. The process should be repeated once every year.

Figure 9.1: The suggested process for Axis' proactive supply chain risk

The *Risk Identification* should be conducted using four methods. Axis should continue to look at historical events within the company as well as to gather input from the members of the identification process. However, to widen the perspective, risks listed in literature should be used as inspiration to brainstorm other potential risks. In addition to this, the risk mapping suggested as a guideline could help facilitate the risk identification since it is possible to see critical paths of components.

The *Risk Assessment* should be conducted using the risk matrix (figure 3.1) and both the probabilities and the impacts of the identified risks should be estimated. However, the main purpose of the *Risk Assessment* is to create a priority among the identified risks and the assessment methods do therefore not need to be more sophisticated than an internal estimation within the group.

The proactive supply chain risk management process should first be conducted in cross-functional teams. The commodity teams are good teams to begin with as they already exist, and new teams could be included in the process if needed. The supply chain risk management council should be included in the process once the supply chain risk management council is set up, and should bear the responsibility of the process.

Documentation on the availability of components in the supply chain

As this report is written, Axis is conducting a project where the possibility to map the availability of components is investigated. Axis is therefore advised to await the results of the project before further investigating how to document the components in its supply chain.

Have decided that Axis takes control of the communication and collaboration in the supply chain in the occurrence of a disruption

Once disruptions happen, the reactive actions taken in Axis' supply chain can be simplified if Axis takes responsibility for them. The easiest way for this collaboration to happen is if Axis consciously takes the decision to be responsible for the collaboration, instead of waiting for other actors in the supply chain to contact them. Axis is therefore recommended to take control of the communication and collaboration in their supply chain in the case of a disruption. The

decision to do this should be taken prior to possible disruptions. In addition to this, actions should be taken by Axis to ensure that this can be implemented once a disruption has occurred. The core value *Act as One* that Axis have can be seen as enabling this, since it encourages Axis to facilitate that the supply chain acts as one.

Have defined objectives for the supply chain risk management
Axis is advised to create overall objectives to ensure that the supply chain risk management is based on conscious decisions and to ensure that everyone is working in the same direction. To encourage employees to truly consider the direction of its supply chain risk management, Axis is advised to put together a group with the responsibility to create the objectives or ask the supply chain council to create them once it is set up. If being set up, the supply chain risk management council is responsible for the objectives. If not, the head of Operations is.

Have defined KPIs for the objectives regarding proactive supply chain risk management
Having KPIs for the objectives can help evaluate whether they are being reached as well as help put focus on the importance of the objectives. As with the objectives, Axis is recommended to put together a group, preferably the supply chain risk management council, with the responsibility to develop the KPIs. If the supply chain risk management council is created, it should be responsible for the objectives. This does not mean that the council should perform the measures since it is a strategic group, but merely that it is responsible for that the measures are made by someone else. If the council is not created, the head of Operations is responsible. The creation of the KPIs will have to wait until the objectives are decided on, since the KPIs are to measure the objectives.

Map the supply chain
Axis should increase its knowledge on its supply chain, for example on its second and third tier suppliers, in order to have a better understanding of potential risks as mentioned under *risk identification* in the guideline *have a proactive supply chain risk management process*. However, this is not the entire purpose of the guideline. It also aims to facilitate the reactive supply chain risk management. The reason for this is that it gives Axis an understanding of which components could be disrupted since Axis would have more information on the second and third tier suppliers.

Prepare a reactive supply chain risk management process
Axis is recommended to develop a reactive supply chain risk management process in case of a new disruption. Due to Axis' culture of individuality as well as concerns being raised about the process risking to hamper Axis way of working if being too specific, the process will not be very detailed. A suggestion to the content of the reactive supply chain risk management process is seen in figure 9.2 and a more specified version will be provided to Axis. The suggested process is based on input from the case interviews in order to fit Axis' way of working. Important to note is that the reactive supply chain risk management process should serve as advice and not rules to follow once a disruption has happened. The reason for this is partly to not hamper Axis way of working, as mentioned above, and partly since predicting scenarios beforehand is difficult, and the suggested process therefore is not expected to be completely adjusted to fit future disruptions.

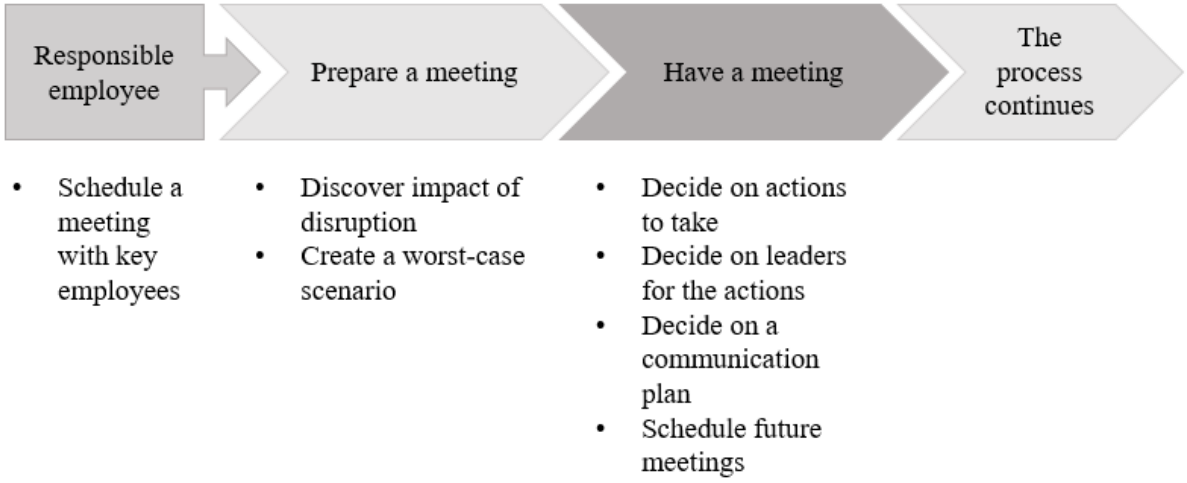

Figure 9.2: A suggestion to the content of the reactive supply chain risk management process

As can be seen in figure 9.2, someone responsible for initiating the reactive supply chain risk management could be identified. This person could schedule a meeting with key employees, preferably the same day or the day after. Before the meeting, the employee could try to discover the impact of the disruption, for example products affected, as well as create a worst-case scenario and get top management's approval for it. At the meeting this could be presented, and decisions on actions to take could be made. All actions suggested by theory or found in the interviews at Axis should serve as an aid in the decision process. Leaders for the chosen actions could be appointed, and a communication plan for Axis internally as well as for external parties could be created. In addition to this, future disruption meetings could be scheduled with key employees. Once this is done, the reactive supply chain risk management continues. At this point the first steps of the reactive supply chain risk management process (*Recognize and Initiate*, *Create a Team* and *Develop a Plan*) have been taken, and the created team should continue on with implementing the strategies in the plan.

9.2 Guidelines which are Already Implemented at Axis

Axis is already doing many things to handle risks, although not all of them have been implemented with the sole purpose of handling risks. In this section, the guidelines which are already implemented at Axis are briefly described. It is important to note that no investigation regarding, for example, if the current stock levels are optimized, has been done for this study.

The guidelines have been organized into five categories, to create a better overview of them. These categories are: collaboration, production, components, buffering and company culture.

9.2.1 Collaboration

This category of guidelines tries to ensure that Axis becomes a prioritized customer once a disruption has happened. If being prioritized, it facilitates the receiving of information, being allocated components and/or products as well as the process of starting up production.

Create long-term relationships with suppliers, contract manufacturers and CLCs
For Axis is it important to have long-term relationships. Axis' employees are quick to communicate this to new suppliers, contract manufacturers and CLCs. These companies are also constantly reminded of this since Axis tries to open up meetings and similar venues with them by stating this. Creating long-term relationships with suppliers, contract manufacturers and CLCs is suggested for Axis to continue working on.

Jointly develop processes with suppliers, contract manufacturers and CLCs
Axis has historically developed processes with its suppliers when it has been thought to be necessary, for example Axis has matched its forecast to be ready when a supplier needs it. Axis is advised to continue this approach.

Jointly develop quality with suppliers, contract manufacturers and CLCs
When developing quality together with suppliers, contract manufacturers and CLCs, a closer relationship can be developed. Due to this, Axis is encouraged to continue with this effort.

Have good relationships with suppliers, contract manufacturers and CLCs currently employed by Axis
Axis considers it important to have long-term relationships with other actors in the supply chain, and having good relationships entailing trust is seen to facilitate this. Axis is encouraged to continue with the endeavor of creating good relationships with suppliers, contract manufacturers and CLCs.

Have open communication with suppliers, contract manufacturers and CLCs
Axis' core value *Always Open* can be seen to enable having open communication with suppliers, contract manufacturers and CLCs. Axis puts emphasis on providing open communication and also desiring this from actors upstream when communicating with them. Axis is recommended to continue having open communication with suppliers, contract manufacturers and CLCs.

Have relationships with suppliers not currently employed by Axis[4]
Having relationships with suppliers which are not currently employed is currently pursued by Axis, however, not due to supply chain risk management. The reason for doing this is mainly to stay aware of technological developments. However, by doing this, it is also easier for Axis to contact these suppliers once a disruption has occurred since Axis has their contact information as well as a relationship with them. Being able to contact suppliers not currently employed by Axis can become helpful when seeking components or when having to redesign products. Axis is hence urged to continue its work with this.

9.2.2 Production
This category of guidelines aims to facilitate the speed with which production can be continued once a disruption has happened.

Have production at contract manufacturers at multiple geographical locations
The wide geographical spread of Axis' contract manufacturers (located on three different continents) has ensured back-up production in situations when one of them has been disrupted. Axis should continue to have the facilities of its contract manufacturers in different geographical regions.

[4] This guideline is also placed under the category *Components* since it serves the purposes of both categories.

Have production of high volume products at more than one contract manufacturer
If having production at multiple contract manufacturers, the chances are that the reallocation of production will be facilitated in the case of a disruption to one contract manufacturer. Production could therefore be partially of fully maintained. Axis is currently conducting this, and is advised in continue doing so.

Documentation of the equipment at contract manufacturers

If a disruption happens, Axis can save time in the process of resuming production at another contract manufacturer if knowing what equipment is needed. It can namely take some time if having to wait for the contract manufacturer to communicate this. As of today, Axis has a process in which it should be documented what equipment is sent to a contract manufacturer. It is however not always followed, especially not if only one equipment part is concerned. Axis is recommended to continue on documenting the equipment at contract manufacturers, and to ensure that all equipment is documented.

Documentation of how products are produced at the contract manufacturers
Axis has begun the work of documenting how products are produced at the contract manufacturers. This means that for old products, this documentation does not exist. However, the old products are gradually put to EOL which means that in a couple of years, all products will hopefully have a documented production process. The benefit of having the documentation is that if a disruption occurs, it is easier for Axis to resume the production at another contract manufacturer since the specifics of production does not need to be figured out once again. Axis is consequently encouraged to continue on with this.

9.2.3 Components
This category of guidelines aims partly at ensuring that components can be supplied by another supplier, and partly at lowering the impact on Axis if one supplier is disrupted.

Have dual sourcing of strategic components
Currently, Axis strives to have dual sourcing of strategic components. Since it is often difficult with these types of components to find suppliers which produce exchangeable products, the recommendation for Axis concerns having duals sourcing of components as a group. Unique products can therefore exist, but as a type of component, dual sourcing should be employed. This reason for this guideline is that if one component becomes disrupted, redesigning products becomes easier.

Not using a unique component in a disproportionate amount of the product volume
Axis is urged to continue its work with not letting a unique product, that is a product which is only produced by one supplier, be designed into an unbalanced number of products. If the supplier of such a component is disrupted, Axis would namely have problems with a large number of products. Redesigning the affected products would also require more resources from Axis. This guideline concerns something which Axis is already doing, for example when it started buying from Panasonic since it realized Sony existed in almost all its cameras, see section 4.1.4. It is suggested that Axis aims the usage of one component to stay below 50% of the product volume, however the percentage number should be further investigated.

Have relationships with suppliers not currently employed by Axis
This guideline has been presented in section 9.2.1, under the category *Collaboration* as it serves the purposes of both categories.

9.2.4 Buffering
This category of guidelines aims to secure the availability of components for Axis once a disruption has happened. This gives Axis a chance to take actions to mitigate the impact for end customers, for example through redesigning products, while still being able to provide the affected products for some time.

Have stock at more than one geographical location
Axis is as of today, working on having stock at more than one geographical location. If having stock at multiple geographical locations, the insufficiency of components and/or products can be lessened since stock at the other location(s) still exist, in the case of a disruption to one location. Axis is therefore recommended to persist with this work.

Have stock of equipment in Lund, Sweden
As of today, Axis owns most of the equipment for its production at the contract manufacturers. The equipment that is not too expensive, mostly fixtures, Axis has stocked in Lund. This is advocated that Axis continue on with. The reason for this is that if the equipment is damaged at one site, Axis does not have to wait for new equipment to arrive before starting up the production at another site.

Have stock of finished products in the supply chain
Axis' business model entails having distributors. These distributors are expected, and in many cases required, by Axis to keep stock of the finished products. In the case of a disruption this means that end customers hopefully will not be affected to the same extent in the case of Axis having trouble producing certain products. It is therefore recommended for Axis to continue to keep its stock levels of finished goods and to require distributors to keep stock.

Have stock of strategic components
If Axis keeps stock of strategic components, the effect of a supplier of those types of components being affected is lessened, since it gives Axis access to the components for a longer time once the disruption is known. This renders Axis the possibility to conduct reactive supply chain risk management actions to mitigate the impact for end customers, for example through redesigning products, while still being able to provide the affected products for some time.

9.2.5 Company Culture
The company culture has been a key success factor for Axis reactive supply chain risk management since it has enabled the rapidness of the process. Decisions have been taken and implemented quickly.

Involve top management in supply chain risk management
Axis' top management is today described to be present and supporting in Axis' proactive supply chain risk management, which it is advised to continue to be.

Work actively on increasing internal transparency
Currently, Axis is working cross-functionally through a number of different forums as for example commodity teams and project development teams. Employees are also encouraged to post information on Galaxis, to enable other employees to take part of the information. Having

internal transparency is seen as important at Axis and can be found in a core value, namely *Always Open*. Axis should continue with the active work on increasing transparency. Alongside this, Axis is suggested that the quality department should take part in the documentations of audits performed by insurance companies. These are documents which today are handled by the CFO. This information could help the quality department in its work regarding to increase supply chain risk management at the suppliers, contract manufacturers and CLCs.

Develop cross-functional teams

Axis should continue to work with proactive supply chain risk management in cross-functional teams, which is done today in the commodity teams and projects.

Have a company culture that encourages cooperation and lack of prestige

Among Axis' core values can be found *Act as One* and *Always Open*. These core values help shape the company culture and are seen to enable and stress the importance of collaboration both internally in Axis and in the supply chain. *Act as One* can also be seen to encourage a lack of prestige since Axis is seen as an entity and the employees should work to help Axis in favor of themselves. Axis is recommended to continue having a company culture which encourages cooperation and lack of prestige.

10 CONCLUSIONS AND CONTRIBUTIONS

This chapter summarizes the findings of the study. First, the fulfillment of the purpose is discussed and the research questions are answered. Next, the theoretical contributions of the study and its limitations are described. Lastly, examples of future research, both within Axis, and for the academic literature, are presented.

10.1 Fulfillment of Purpose and Research Questions

The research has been designed to answer the purpose of the study:

The purpose of the study is to create guidelines for how Axis could work efficiently with its proactive supply chain risk management of major supply disruptions to be effective in its reactive supply chain risk management.

The purpose is considered to be fulfilled as 28 guidelines have been generated to direct Axis' proactive supply chain risk management. Axis did already conduct several actions to manage risks of supply disruptions and a majority of the suggested guidelines do not imply any changes in the way Axis works, but rather serve as a confirmation that the efforts are made in the right direction.

Some of the guidelines are new to Axis and they mainly serve the purpose of structuring the proactive supply chain risk management. They ensure that everyone is working in the same direction, and that the proactive decisions regarding the handling of supply disruptions are made consciously and continuously.

The answers to the research questions have been answered throughout the report and are summarized below. RQ_1 will be summarized last, as its answer is based on the other questions.

10.1.1 RQ_2: How Should Companies Work with Supply Chain Risk Management According to Theory?

Theory divides supply chain risk management into two parts; proactive and reactive. For proactive supply chain risk management, theory strongly suggests a structured process which, at least, includes the three steps *Risk Identification*, *Risk Assessment*, and *Selecting Risk Mitigation Strategies*, although many authors also suggest *Monitoring* and *Evaluation* to be included. Many articles have also been written within the area of business continuity management, which put a larger focus on the impact of the risks. Authors describing business continuity management also strongly advocate creating a business continuity plan, to prepare actions and strategies to conduct once a disruption has occurred.

Reactive supply chain risk management is more infrequently covered in theory, although a five-step process is described: (1) Recognize and Initiate; (2) Create a Team; (3) Develop an Initial Plan; (4) Revise the Plan; and (5) Analyze and Learn.

10.1.2 RQ_3: How has Axis Worked Proactively with Supply Chain Risk Management of Supply Disruptions?

Axis has not yet worked according to a proactive supply chain risk management process. This has resulted in that overall actions, for example creating overall objectives, have been missed, and *Risk Identification* and *Risk Assessment* have been conducted irregularly and without any refined methods. Axis has, on the other hand, implemented a large range of risk mitigation strategies. Some of them have been implemented after a disruption has occurred, to minimize

the impact if a similar disruption were to happen again, while others are implemented after an employee has identified a potential risk. Due to the lack of structure and overall objectives with the proactive supply chain risk management, Axis has not worked to evaluate or test its chosen strategies, nor have the employees been educated in supply chain risk management.

10.1.3 RQ_4: How has Axis Worked Reactively with Supply Chain Risk Management of Supply Disruptions?

Axis has been able to handle supply disruptions well, in the perspective that very few end customers have been affected. Axis has identified and reacted quickly to the news of a disruption and followed the, by theory, suggested process quite closely. A small trend can be found that the organization, quite unconsciously, has learned by its disruption management, as they have been able to react more quickly for each disruption. Also, more departments have been included in the reactive supply chain risk management process for each disruption. The disruption management of the latest studied disruption, the earthquake 2016, was the first in which a formal learning session was conducted in the end of the disruption management.

10.1.4 RQ_5: Which Proactive Factors Facilitated the Reactive Work at Axis?

Several connections between proactive and reactive supply chain risk management have been found in the study. Some of the proactive actions had intentionally been implemented by Axis to reduce the risk of supply disruptions, for example, having dual sourcing, having production at multiple sites, creating long-term relationships and having strategic stocks of components and equipment.

Other proactive actions had been implemented for other reasons, for example the company culture which promotes collaboration and a lack of prestige was not created with the purpose of handling supply disruption. Nevertheless, the company culture did ease the reactive supply chain risk management.

Some proactive factors, which facilitated the reactive supply chain risk management, were based on coincidences. Having experienced disruptions before was nothing that Axis had planned to do to become better at disruption management. Neither was Axis' employees deliberately located at the suppliers' facilities when several of the disruptions occurred in order to quicker find information. These factors were, nonetheless, very helpful.

10.1.5 RQ_1: How can Proactive Supply Chain Risk Management Aid Reactive Supply Chain Risk Management?

Only one connection between proactive and reactive supply chain risk management is confirmed by both theory and the studied disruptions at Axis; creating trust and long-term relationships with suppliers helps developing a plan, as collaboration is easier. All connections which were found in the study, both in theory and in the studied disruptions are listed in table 10.1. In the table, the column named *proactive* lists actions which are taken before a disruption has occurred as well as in which step in the proactive supply chain risk management process that they are performed. The column *reactive* lists the step in the reactive supply chain risk management process which the corresponding proactive action facilitates. The proactive actions are described on a more detailed level as they are in the focus of this study. In figure 10.1, the updated research model of this study is presented, which showcases the proactive and reactive supply chain risk management processes and the found connections.

Table 10.1: The found connections between proactive and reactive supply chain risk management

Connections	
Proactive	**Reactive**
Selecting Risk Mitigation Strategies (long-term relationship and trust)	Develop a Plan
Implement and Educate (create a business continuity plan)	Develop a Plan
Implement and Educate (implement ways to detect disruptions)	Develop a Plan
Selecting Risk Mitigation Strategies (a special supply chain risk management team)	Develop a Plan
Implement and Educate (yearly training)	Recognize and Initiate
Implement and Educate (training of new employees)	Recognize and Initiate
Selecting Risk Mitigation Strategies (multiple suppliers, called dual sourcing by Axis)	Develop a Plan
Implement and Educate (having developed a competence in finding components)	Develop a Plan
Selecting Risk Mitigation Strategies (multiple manufacturing locations)	Develop a Plan
Selecting Risk Mitigation Strategies (not becoming an insignificant customer)	Develop a Plan
Selecting Risk Mitigation Strategies (strategic stock of equipment)	Develop a Plan
Selecting Risk Mitigation Strategies (culture which promotes taking own initiatives)	Develop a Plan
Selecting Risk Mitigation Strategies (modular design)	Develop a Plan
Implement and Educate (previous experience of redesigning products regarding sensors)	Develop a Plan
Selecting Risk Mitigation Strategies (flexible tools)	Develop a Plan
Selecting Risk Mitigation Strategies (having good relationships with a partner which has even better relationships with suppliers)	Develop a Plan
Selecting Risk Mitigation Strategies (strategic stock of components)	Develop a Plan
Selecting Risk Mitigation Strategies (core values)	Develop a Plan
Selecting Risk Mitigation Strategies (having people at/close to the disrupted site)	Develop a Plan
Implement and Educate (having experience of a disruption)	Create a Team
	Develop a Plan
Selecting Risk Mitigation Strategies (most employees at the same site)	Create a Team
	Develop a Plan
Selecting Risk Mitigation Strategies (culture which does not focus on finding someone to blame)	Create a Team
	Develop a Plan
Selecting Risk Mitigation Strategies (having relationships with suppliers which are currently not bought from)	Develop a Plan

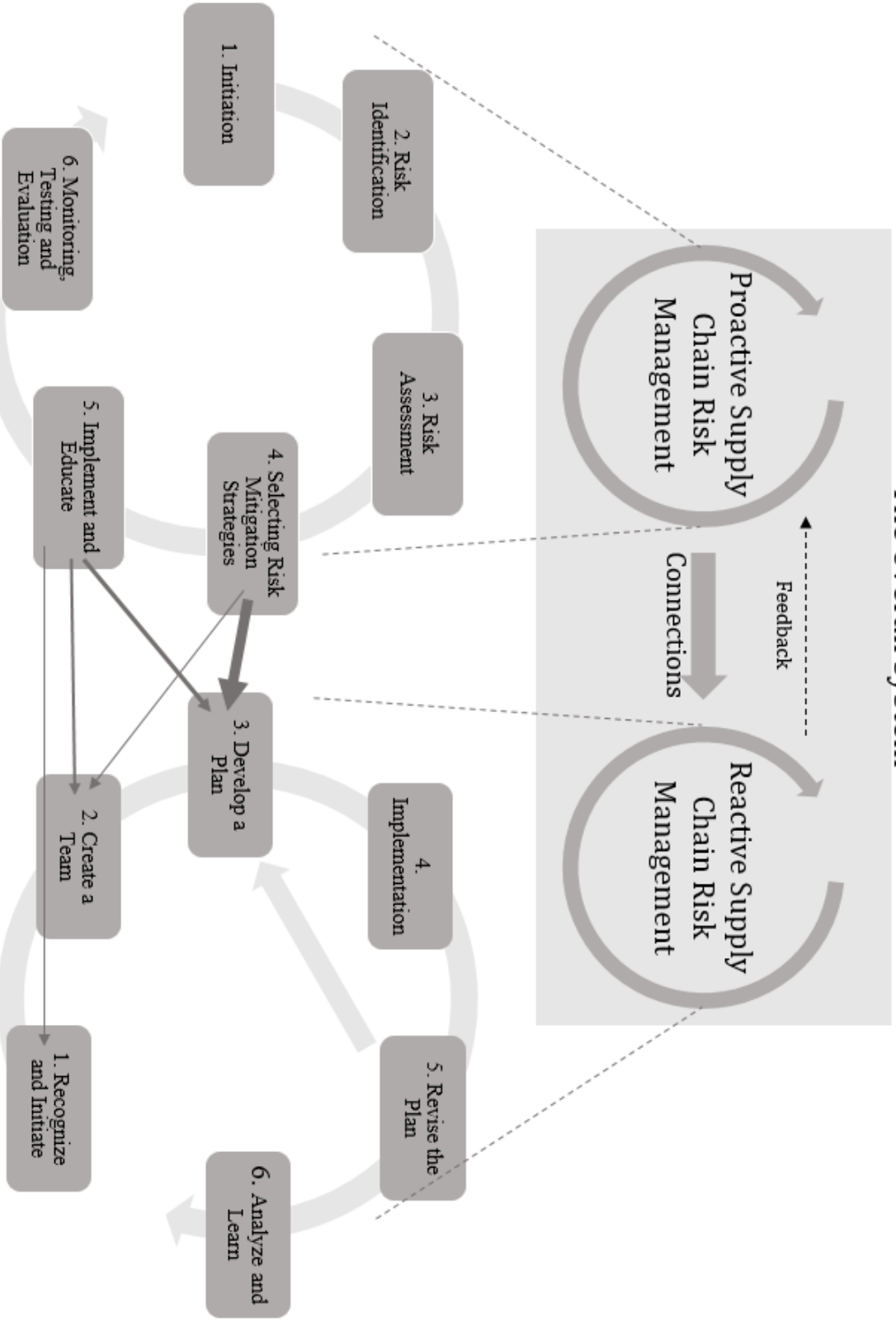

Figure 10.1: The research model of this study

10.2 Research Contribution

This study's main contribution lies in the analysis of the connections of proactive and reactive supply chain risk management. This is an area which had little prior research and this study contributes by confirming one of the previously studied connections and by listing several new connections.

This study has also examined and revised the, by theory, suggested reactive supply chain risk management process (Hopp et al., 2012). The studied cases have provided, to the suggestions by theory (Hopp et al., 2012; Musson, 2001; Bland 2013), several new possible actions to recognize a disruption and to initiate the reactive supply chain risk management process, as well as strategies to consider as the reactive plan is developed.

The contribution to proactive supply chain risk management is not as considerable, as this has been widely studied, for example by Manuj and Mentzer (2008a), Norrman and Jansson (2004), Knemeyer et al. (2009) and Christopher and Peck (2004). However, the study has described one method to assess risk which was not, to knowledge of the authors of this study, mentioned in theory, namely to use input from employees, and some actions to consider when choosing the risk mitigation strategies.

10.3 Limitations

As stated in section 1.6, certain limitations were made regarding the study. It focused on the upstream supply chain. The type of risks it investigated were natural and technological hazards. The type of crisis was desired to be of great impact for the focal company, hence the timeframe for the disruption was set to more than a month and the type of supply to strategic supply. It has also only investigated disruptions involving Axis. Since disruptions previous of 2010 were considered to be difficult to collect proper data on, this limited the number of cases to four since that was the number of disruptions Axis had experienced during the timeframe.

Regarding the findings, experienced connections were limited to the proactive actions taken by Axis. Partly, this resulted in that a number of the connections found in theory could not be tested or confirmed since Axis had not conducted the proactive actions. In addition to this, the suggestions to theory were also limited to the proactive actions taken by Axis since all connections are dependent on both the proactive and the reactive action. If noting the imagined connections, several new connections were thought of. These are seen as interesting by the authors, but as remarked before, has not been considered valid enough to suggest to theory.

The findings of the cases are also limited to the found data. Interviewees might not have remembered certain aspects or remembered them wrongly. As stated in section 2.8, other sources were used in trying to validate and complement the data. However, the risk still exists that certain aspects were not captured by the report.

10.4 Future Research

When conducting this study, research which could complement the findings was thought of. This is divided into future research for Axis and future research for academic literature.

10.4.1 For Axis

This study has investigated how Axis should work with proactive supply chain risk management of supply disruptions. This was however limited to natural and technological

hazards, and hence, Axis could benefit from doing the same type of investigation for different types of risks. Another aspect for Axis to examine is how changes within Axis and Axis' supply chain could alter their supply chain risk management. The report was namely based on historical events and has not taken the future into account. For example, if changing product type from products to services, the guidelines presented by this report are not necessarily the right ones.

Regarding the guidelines presented for Axis, calculations of their profitability regarding supply chain risk management was not made. This is also something which Axis could further examine.

10.4.2 For Academic Literature

Since connections regarding proactive and reactive supply chain risk management in theory was found to be scarce, more studies than this one on the subject need to be done. Since this report had its limitations, studies complementing it are especially recommended. This entails investigating:

- Connections regarding supply chain risk management of disruptions due to different types of hazards other than natural and technological ones.
- Connections regarding supply chain risk management in different industries other than network surveillance.
- Connections regarding supply chain risk management of risks with an estimated impact different from the one investigated in this study.

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APPENDIX I – ARTICLES IN LITERATURE REVIEW

The used articles and their content are summarized in the tables below. The content of the articles has been classified with either '*' or '**'. If the article mentions and briefly describes the stated content area, it has been given a '*'. If the article discusses the concept in detail, it has been given a '**'.

General Concepts

Article	Definition of Risk Management	Definition of Risk	Definition of Supply Chain Risk Management	Definition of Supply Chain	Definition of Supply Chain Management	Definition of Proactive Supply Chain Risk Management	Definition of Reactive Supply Chain Risk Management	Risk Classifications
Christopher and Peck (2004)					**			**
Christopher (2011)					**			
Ghadge et al. (2013)			**					
Grötsch et al. (2013)						*	*	
Hiles (2011)	*							
Hutchins and Gould (2004)	**							
Jüttner (2005)			**					**
Kleindorfer and Saad (2005)								*
Lambert and Cooper (2000)					**			
Lavastre et al. (2013)			**					
March and Shapira (1987)		**						
Manuj and Mentzer (2008b)		**						
Manuj and Mentzer (2008a)								**
Mason-Jones and Towill (1998)								*
Mentzer et al. (2001)				**				
Miller (1992)		*						
Norrman and Lindroth (2002)			**					
Norrman and Jansson (2004)			**					
Singhal et al. (2011)	**							
Tang (2006b)			**		**			
Wagner and Bode (2008)								**
Yu et al. (2009)			**					
Zsidisin et al (2004)	*							

Proactive Supply Chain Risk Management

Article	Definition of Business Continuity	Definition of Business Continuity Management	Definition of Business Continuity Plan	Business Continuity Management Process	Proactive Supply Chain Risk Management Process	Risk Mitigation Strategies
Christopher and Lee (2004)						*
Christopher and Peck (2004)						**
Chen et al. (2013)						*
Chopra and Sodhi (2004)						**
Ghadge et al. (2013)					**	
Gibb and Buchanan (2006)		**		**		
Hallikas and Lintukangas (2016)						*
Hiles (2011)		**	*			
Kleindorfer and Saad (2005)					**	
Knemeyer et al. (2009)					**	
Manuj and Mentzer (2008b)						**
Manuj and Metnzer (2008a)					**	
Miller (1992)						*
Mishra et al. (2016)						**
Norrman and Jansson (2004)					**	*
Sheffi and Rice (2005)						*
Swedish Standards Institute (2013)				**		
Swedish Standards Institute (2014a)	**					
Swedish Standards Institute (2014b)		**				
Stanton (2005)			**			
Tang et al. (2006a)						*
Tang et al. (2006b)						**
Yu et al. (2009)						*

Reactive Supply Chain Risk Management and Connections Between Proactive and Reactive Supply Chain Risk Management

Article	Actions/Process to Manage Risks Reactively	Strategies to Manage Risks Reactively		Connections on how Proactive Supply Chain Risk Management affects Reactive Supply Chain Risk Management
Bland (2013)	*	*		
Hattpon (2016)				*
Hopp et al. (2012)	**			
Musson (2001)		**		
Olson and Anderson (2016)				*
Ponis and Ntalla (2016)		*		*
Singhal et al. (2011)				*
Tang (2006a)		*		

APPENDIX II – CASE STUDY PROTOCOL

The case study protocol was developed according to suggestions by Yin (2007, p. 94).

Overview of the Case Study Project

Research Questions

The case study is designed to answer RQ_3, RQ_4 and partly RQ_5 as presented in section 1.5.

RQ_3: How has Axis worked proactively with risk management of supply disruptions?
RQ_4: How has Axis worked reactively with risk management of supply disruptions?
RQ_5: Which proactive factors facilitated the reactive work at Axis?

Selection of Cases

The cases were selected according to the following criteria:

1. *The disruption was caused by a supplier's inability to deliver*. This criterion was set in order to limit the study to the upstream supply chain.
2. *The incidents occurred after 2010.* Since data accuracy has a negative correlation with the time past, this requirement was chosen in order to increase the data accuracy.
3. *The supplier was hit by a natural or technological disaster.* This provided a limitation to the nature of the studied disruptions.
4. *The supply was disrupted for more than a month*. By having a restriction on the timeframe, the purpose is to find cases which have had a high impact on Axis' business.
5. *The disruption of supply was on strategic components or the disruption of a contract manufacturer*. This criterion was also chosen in order to ensure a high impact of the selected cases.

Preparations for Unexpected Events

Interviewee Not Showing

In the case of an interviewee not being able to do the interview at the scheduled time, there are three different actions that can be taken. First of all, the interviewee will be asked to move the interview to another date. If that is not possible, or if the date proposed is too far away, the second action will be to try and find another person who has the same perspective (having a similar role as Axis) and information as the interviewee, hence providing similar results. If this is not possible, the third action will be to try and find the information needed by that interviewee in a different type of source, for example through documentation.

Researchers not Being Able to Interview

One situation which will need to be addressed is if for some reason, for example illness, one of the researchers cannot participate at an interview session. Since there are two different roles during the interviews, that of the secretary and that of the interviewer, the interviews will not be optimally done with only one researcher. In a situation like this, the first action taken is to see if the interviewee is possible to reschedule the interview. If the proposed date is too far away, alternative sources, similar to the current interviewee will be investigated. If none as adequate as the current interviewee is found, the final solution will be for the researcher to perform the interview alone.

Schedule

Activity	Time Period	Description
Initial research and development of RQs	November 2 – November 11	Study the area of risk management to define scope
Literature review	November 7 – December 16	Reviewing supply chain risk management literature and writing the report section
Develop methodology	November 7 – December 12	Reviewing literature on the constructive approach and case studies and writing the article
Develop case study protocol	November 21-November 22	
Develop interview guide	December 1-2	The construction of questions for the case study interviews
Seminar with university supervisor	December 20	
Conduct case study interviews	December 8 – February 10	Interviews discussing the proactive and reactive work of the selected disruptions, as well as the connections between the proactive and reactive work
Documentation of Case study interviews	December 8 – March 14	Summarizing the information received from the interviews and writing the chapter on the empirical findings
Within-case analysis	February 16-March 16	Finding patterns and writing the within-case analysis chapter
Cross-case analysis	February 24-March 16	Finding patterns and writing the cross-case analysis chapter
Development of guidelines	February 27 - March 3	Constructing the first and second versions of guidelines
Workshop	March 7	Validation of guidelines
Survey	March 7 - March 17	Validation of guidelines
Finalizing guidelines and conclusions	March 13 – March 31	Constructing the final version of the guidelines and writing the guidelines and conclusions chapters
Presentation at Axis	April 20	Presenting the results of the study to Axis

Case Study Questions

5 Levels of Interview Questions

The overall scope of the interviews was created through a structure described by Yin (2009, p. 87). The purpose of this framework is to define what questions the researchers want to answer by conducting a case study. This later helps when conducting the interviews, since the researchers know what information is wanted from the specific interview. (Yin, 2009, p. 87)

1. *For specific interviewees:*
   parts of
   a. RQ_3,
   b. RQ_4 and/or
   c. RQ_5

2. *By the individual case:*
    a. RQ_3,
    b. RQ_4
    c. RQ_5
3. *By multiple cases:*
    a. RQ_1
4. *By the entire study:*
    a. RQ_1
    b. RQ_2

Questions in Depth

1. *For specific interviewees: (here, the entire picture of processes and actions taken etcetera is not expected to be attained, since the interviewee is expected to only know parts of them.)*
   Name, title, earlier experience from SCRM, which disruption?
    a. How has Axis worked proactively with risk management of supply disruptions?
        i. How does the interviewee notice the proactive supply chain risk management at Axis in their daily work?
        ii. Does Axis have a proactive supply chain risk management process?
        iii. Does Axis do the proactive actions found in theory?
        iv. Does Axis do any other actions than those found in theory?
    b. How has Axis worked reactively with risk management of supply disruptions?
        i. Does Axis have a reactive supply chain risk management process?
        ii. Does Axis do the proactive actions found in theory?
        iii. Does Axis do any other actions than those found in theory?
        iv. Was there anything Axis should/could have done differently which would have lessened the impact?
        v. How did the reactive supply chain risk management affect Axis internally, according to the interviewee?
        vi. How much was Axis' customers affected by the supply disruption according to the interviewee?
    c. Which proactive factors facilitated the reactive work at Axis?
        i. Do you believe some proactive actions benefited the reactive supply chain risk management?
        ii. Has Axis experiences the connections found in theory?
        iii. Were there any proactive actions which you felt that Axis should have done that would have aided the reactive supply chain risk management?
2. *By the individual case: (the same as by the individual cases with the difference that the entire picture is attained when adding together the specific interviews.)*
3. *By multiple cases:*
    a. How does proactive supply chain risk management aid the reactive management at Axis?
        i. Are there similarities between the studied cases?

- What similarities are there regarding the reactive supply chain risk management?
- What similarities between the connections were experienced?

ii. Are there differences between the studied cases?

- What differences are there regarding the reactive supply chain risk management?
- What differences between the connections were experienced?

4. *By the entire study:*
   a. How should companies work with risk management according to theory?
      i. What does theory say about the connection between proactive and reactive supply chain risk management?
         - What does theory suggest about proactive supply chain risk management?
         - What does theory suggest about reactive supply chain risk management?
      ii. How does this compare to the findings of this study?
         - Can the findings of this study refine the current theory guidelines regarding the connections between proactive and reactive supply chain risk management?

Case Study Design

Outline of the Report

- Proactive Supply Chain Risk Management
  - Which steps did the proactive supply chain risk management process have?
  - Which strategies were used to mitigate risk?

- Reactive Supply Chain Risk Management
  - About the Disruption
    - Background information of the disruption
  - Description of the reactive supply chain risk management process
    - Which steps did they go through to minimize the impact of the disruption?
  - Impact on Axis Internally
  - Impact on Axis' Customers

- Connections
  - Which proactive choices could Axis benefit from when trying to minimize the impact of the supply disruption?
  - Which proactive actions were connected to which reactive actions?
  - Was there anything that Axis could have done proactively that would have eased the reactive supply chain risk management?

APPENDIX III – INTERVIEW GUIDE

Background information

1. Have you changed position within Axis since 2010? If so, what were your previous position(s)?
2. Years employed at Axis?
3. Previous experience of risk management
    a. How much have you worked with supply chain risk management in former employments?
        □ Nothing
        □ Smaller discussions/involvement
        □ Handles one or a few major crises
        □ Core part of role description

    b. Did your education include supply chain risk management?
        □ Nothing
        □ Included in one course
        □ Included in several courses
        □ Main area of education

    c. How have you worked with supply chain risk management within Axis?
        □ Nothing
        □ Smaller discussions/involvement
        □ Handles one or a few major crises
        □ Core part of role description

General Proactive Supply Chain Risk Management at Axis

1) How do you notice the proactive supply chain risk management at Axis in your daily work?
2) Does Axis have a proactive supply chain risk management process?
    a. If yes:
        1. What does Axis' proactive supply chain risk management process look like?
        2. Which actions does Axis take under each step?
        3. Has it changed since 2010?

3) Initiation

Action	Y/N	Do not know	Comments (have you tried it previously?)
Has Axis made a conscious decision on the unit that you analyze for risks?			
Have you or any you know within Axis created a program charter?			
Have you or any you know within created a program plan?			
Does Axis have defined objectives with its risk management?			
Other?			

4) Risk Identification

a. Which tools/methods does Axis use to identify risks?

Method	Y/N	Do not know	Comments
Does Axis study recorded risks in literature?			
Does Axis study historical events within the company?			
Are thoughts from employees gathered?			
Are risk experts used?			
Are specific webpages used?			
Is risk mapping used?			
Other?			

5) Risk Assessment

a. Do you evaluate the identified risks?
   i. If yes:
      a. How?
      b. Does Axis do anything in the table below?
   ii. If no:
      a. Does Axis do anything in the table below?

Method	Y/N	Do not know	Comments
Do you find probability distribution function based on historical data?			
Do you use simulation models?			
Do you use expert estimates?			
Do you estimate internally within the organization?[5]			
Do you use quantitative loss estimation?			
Do you use qualitative loss estimation?			
Other?			

[5] This was not included in the literature review but was added to the literature guide after suggestions from the university supervisor

6) Selecting Risk Mitigation Strategies

a. Which strategies does Axis use to minimize risk of natural and technological disruptions?

Action	Y/N	Do not know	Comments
Does Axis have joint process improvements?			
Does Axis have joint quality improvements?			
Does Axis have open communication?			
Does Axis work to create long-term relationships and trust?			
Does Axis have a collaboration of risk management to suppliers?[6]			
Does Axis have multiple manufacturing locations?			
Does Axis have multiple warehousing locations?			
Does Axis have multiple suppliers?			
Has Axis increased its safety stocks to handle risks?			
Does Axis have strategic stocks?			
Does Axis use modular design?			
Has Axis worked/Do Axis work to remove intervening stocks?			
Does Axis work increase internal visibility?			
Has Axis worked/Do Axis work to reduce inbound lead-times?			
Has Axis worked/Do Axis work to reduce non-value adding activities?			
Is top management involved in the proactive supply chain risk management?			
Does Axis have a special supply chain risk management team?			
Has Axis ever refrained from selecting locations due to high risks?			
Others?			

[6] This was not included in the literature review but was added to the literature guide after suggestions from the university supervisor

7) Implement and Educate

a. What actions does Axis perform as the strategies are implemented?

Action	Y/N	Do not know	Comments
Does Axis create performance measures?			
Has Axis created a business continuity plan?			
Has Axis implemented ways to help detect disruptions?			
Other?			

b. Are Axis' employees educated in supply chain risk management?

i. If yes:

1. How?
2. Does Axis do anything in the table below?

ii. If no:

1. Does Axis do anything in the table below?

Action	Y/N	Do not know	Comments
Are Axis' employees yearly trained?			
Does Axis train new employees?			
Other?			

8) Monitoring, Testing and Evaluation

a. Does Axis Monitor its risk management?

i. If yes:

1. How does Axis monitor your risk management?
1. Does Axis do anything in the table below?

ii. If no:

1. Does Axis do anything in the table below?

Action	Y/N	Do not know	Comments
Does Axis conduct periodic auditing?			
Does Axis review implementation plans?			
Does Axis review ongoing results?			
Other?			

b. Does Axis test its risk management?

i. If yes:
    1. How often does Axis test its risk management?
    2. Does Axis do anything in the table below?

Action	Y/N	Do not know	Comments
Do you do testing within three months of implementation?			
Do you do yearly testing?			
Other?			

c. Does Axis evaluate its risk management?
    i. How does Axis evaluate its risk management?
        1. Does Axis do anything in the table below?
    ii. If no:
        1. Does Axis do anything in the table below?

Action	Y/N	Do not know	Comments
Do you use benchmarking?			
Other?			

Crisis Specific Questions

Proactive Supply Chain Risk Management

1) What specific actions did Axis take to minimize this risk?

Reactive Supply Chain Risk Management

1) Did Axis have a reactive supply chain risk management process in place?
    a. If yes:
        i. What did that reactive supply chain risk management process look like?
        ii. Which actions did Axis take under each step?

2) Recognize and Initiate

Action	Y/N	Do not know	Comments
Did Axis identify that a disruption had happened?			
Did Axis prepare for the coming steps in the process?			
How did Axis learn the degree of impact from the supplier?[7]			
Other?			

[7] This was not included in the literature review but was added to the literature guide after suggestions from the university supervisor

3) Create a Team

a. Did Axis create a team which should handle the disruption?

i. If yes:

1. How was it created?
2. Did Axis do anything in the table below?

ii. If no:

1. Did Axis do anything in the table below?

Action	Y/N	Do not know	Comments
Did Axis communicate with suppliers?			
Did Axis communicate with competitors?			
Did Axis put together a team?			
Other?			

4) Develop an Initial Plan

a. Did Axis create a plan which should handle the disruption?

i. If yes:

1. How was it created?
2. What actions did it consider?
3. Did Axis do anything in the table below?

ii. If no:

1. Did Axis do anything in the table below?

Action	Y/N	Do not know	Comments
Did Axis make use of spare capacity within the organization?			
Did Axis shut down marginal product lines and transfer key products to those production facilities?			
Did Axis ask for assistance from competition?			
Did Axis ask for advice and assistance from trade organizations?			
Did Axis outsource to subcontractors, job shops, etc.?			
Did Axis do re-labeling of competitors' products?			
Did Axis establish temporary facilities when production capabilities could be established with acquired equipment?			
Did Axis communicate in the supply chain?			
Did Axis retain the company's values?			
Did Axis collaborate within the supply chain?			
Did Axis conduct assortment planning?			
Other			

5) **Revise the Plan**
    a. Did Axis ever revise the previously mentioned plan?
        i. If yes:
            1. When and how did Axis revise it?
            2. Did Axis do anything in the table below?
        ii. If no:
            1. Did Axis do anything in the table below?

Action	Y/N	Do not know	Comments
Did Axis identify when new information was available?			
Did Axis evaluate if planned actions had become obsolete?			
Did Axis create new, up to date, actions?			
Other?			

6) **Analyze and Learn**
    a. Did Axis learn from the disruption?
        i. If yes:
            1. What did Axis learn?
            2. How did Axis learn?
            3. Did Axis do anything in the table below?
        ii. If no:
            1. Did Axis do anything in the table below?

Action	Y/N	Do not know	Comments
Did Axis analyze what went well in the reactive management?			
Did Axis analyze what could have been done better in the reactive management?			
Did Axis find ways to incorporate this analysis into future risk management?			
Other?			

7) Was there anything Axis should/could have done differently which would have lessened the impact?
8) How did the reactive supply chain risk management affect Axis internally, according to you?
9) How much were Axis' customers affected by the supply disruption, according to you?

Which proactive factors facilitated the reactive work at Axis?

1) Do you believe some proactive actions benefited the reactive supply chain risk management?
    a) If yes:
        i) Which proactive ones benefitted which reactive ones?
        ii) Did you experience any of the connections in the table below?
    b) If no:
        i) Did you experience any of the connections in the table below?

Proactive	Reactive	Y/N	Do not know	Comments
Creating trust and long-term relationship	Develop an Initial Plan			
Create a business continuity plan	Develop an Initial Plan			
Implement ways to detect disruptions	Develop an Initial Plan			
A special supply chain risk management team	Develop an Initial Plan			
Yearly training	Recognize and Initiate			
Training of new employees	Recognize and Initiate			

2) Were there any proactive actions which you felt that Axis should have done that would have aided the reactive supply chain risk management?

If we were to create guidelines for how you should work with proactive supply chain risk management - what aspects do you think are important in the evaluation of the guidelines applicability? Choose three of the four categories and rank them from 1 to 3, where one is the category you value the most. If there are parameters that you think are missing, write them after 'Other' and include them in the ranking

□ Use of resources (for example how much they cost to implement or time needed to conduct them)
□ User-friendliness (for example how easy they are to understand or follow)
□ Communication (the level of communication that the guidelines create)
□ Comprehensiveness
□ Other

APPENDIX IV – CONDUCTED INTERVIEWS

Below are the interviewees for the case study listed. In the four columns furthest to the right, if marked with an 'X', the interviewee answered questions for the corresponding disruption.

			Disruptions			
Name	**Position**	**Date(s) of Interview (s)**	Earthquake/ tsunami 2011	Flooding 2011	Fire 2014	Earthquake 2016
Anders Johannesson	Senior Expert Engineer	February 14, 2017	X			X
Andres Vigren	Global Product Manager	February 1, 2017	X	X	X	X
Anna Björklund	Senior Project Manager	February 1, 2017				X
Anna Jeppsson	R&D Director	January 25, 2017	X	X	X	X
Christian Loftorp	Supply Chain Director	December 12, 2016	X	X	X	X
Helena Wedin	Production Preparation Manager	February 10, 2017		X	X	X
Jesper Lindström	Director Core Technologies Imaging	February 1, 2017				X
Johan Paulsson	CTO	February 8, 2017	X	X	X	X
Kent Ljunggren	Director Global Sales Operations	February 6, 2017	X	X	X	X
Kjell Johannesson	Retired - Sourcing Director until 2014	January 9 & February 8, 2017	X	X		
Lars Jeppsson	Commodity Manager Optics	January 27, 2017	X	X	X	X
Marcus Göransson	Engineering Director	January 30, 2017				X
Mats Thulin	Director Core Technologies	January 31, 2017				X
Mikael Arnfelt	R&D Director	January 30, 2017	X			X
Nerzesa Dzinovic	Sourcing Manager, Electronics	January 25 & January 26, 2017			X	X
Nicklas Olofsson	R&D Director	January 25, 2017			X	X

Per Ädelroth	Vice President, Operations	February 6, 2017	X	X	X	X
Sara Jakobsson	Demand Manager	January 27, 2017		X		X
Stefan Nilsson	Director of Sourcing and Production Preparation (since 2014)	December 8, 2016 & January 31, 2017	X	X	X	X
Tommy Örjas	Commodity Manager, Electronics	January 31, 217			X	X
Ulrika Magnusson	Manager Material Supply	February 6, 2017				X

APPENDIX V – THE FIRST VERSION OF THE GUIDELINES

The proactive supply chain risk management actions are divided into groupings which were considered enabling the process of designing the second version, as can be see appendix VI. The actions new to Axis are in italics.

Processes

- *Keep track of indicators for disruptions, for example rain levels*
- *Have a proactive supply chain risk management process*
- *Prepare a reactive supply chain risk management process*
- *Have workshops on what-if scenarios*

Strategies

Buffering

- Keep stock
    - At the distributors
    - At the contract manufacturers
    - At Axis
    - Of components
    - Of equipment
    - Of tools for testing

Hedging

- Have production at multiple geographical locations
- Have production of high volume products at more than one contract manufacturers
- *Require suppliers to produce at more than one location*
- Have stock at more than one geographical location
- Have dual sourcing of strategic components
- Refrain from becoming a too small customer while at the same time not too big
- *Refrain from designing in unique components*
- Test alternatives to the strategic components currently used in products, for example sensors
- Not using a certain component in too many of the products

Collaboration

- *Have contact with second tier suppliers*
- Increase cooperation of risk management with suppliers
- Have good relationships with suppliers, contract manufacturers and CLCs currently employed by Axis
- Have relations with suppliers not currently employed by Axis
- Jointly develop processes with suppliers, contract manufactures and CLCs
- Jointly develop quality with suppliers, contract manufactures and CLCs
- Have open communication with suppliers, contract manufactures and CLCs
- Create long-term relationships with suppliers, contract manufactures and CLCs

Culture

- Involve top management in supply chain risk management
- *Create a supply chain risk management team*
- Have a company culture which encourages cooperation and lack of prestige

Postponement
- Make use of modular design

Agility
- Remove intervening stock
- Work actively on increasing internal transparency
- Reduce lead times
- Remove non-value-adding activities
- *Practice on doing redesigns regarding strategic components, for example sensors*

Other
- Conduct *Risk Assessment*s of the geographical locations in which production and/or storages is planned on being placed
- *Refrain from having production and/or keeping stock at certain geographical locations*

Information
- *Appoint a person at the supplier's responsible for communicating the occurrence to Axis once a disruption has happened*
- Tools to discover disruptions
- Documentation of how products are produced at the contract manufacturers
- Documentation of the equipment at contract manufacturers
- Documentation on the need for components at the contract manufacturers
- *Documentation on the availability of components in the supply chain*

Organizational
- Develop cross-functional teams
- Knowledge on how to find components on venues as for example the spot market
- *Preparedness for sending an employee to the disrupted site*
- Offices in other geographical areas
- *Have an agreement with Canon on Canon aiding Axis in the case of a disruption*
- Have key employees at the same site, for example in Lund
- *Have decided that Axis takes control of the communication and collaboration in the supply chain in the occurrence of a disruption*
- *Appoint one Axis' employee responsible for aiding suppliers in their risk management*

General
- *Define unit-of-analysis*
- *Have defined objectives for the supply chain risk management*

Monitoring
- Conduct audits/reviews
- *Conduct benchmarking*
- *Have defined KPIs for the objectives regarding proactive supply chain risk management*

APPENDIX VI – THE SECOND VERSION OF THE GUIDELINES

The proactive supply chain risk management actions are divided into groupings which were considered enabling the process of designing the second version. The actions new to Axis are in italics.

Processes

- *Have a proactive supply chain risk management process*
- *Prepare a reactive supply chain risk management process*

Strategies

Buffering

- Have stock of finished products in the supply chain (of at least one month of demand)
- Have stock of strategic components (of at least one two months of demand)
- Have stock of equipment in Lund, Sweden

Hedging

- Have production at multiple geographical locations
- Have production of high volume products at more than one contract manufacturer
- Have stock at more than one geographical location
- Have dual sourcing of strategic components
- *Refrain from designing in unique components*
- Not using a unique component in a disproportionate amount of the product volume

Collaboration

- *Increase cooperation of risk management with suppliers*
- Have good relationships with suppliers, contract manufacturers and CLCs currently employed by Axis
- Have relations with suppliers not currently employed by Axis
- Jointly develop processed with suppliers, contract manufacturers and CLCs
- Jointly develop quality with suppliers, contract manufacturers and CLCs
- Have open communication with suppliers, contract manufacturers and CLCs
- Create long-term relationships with suppliers, contract manufacturers and CLCs

Culture

- Involve top management in supply chain risk management
- Have a company culture which encourages cooperation and lack of prestige

Agility

- Work actively on increasing internal transparency

Information

- *Appoint a person at the supplier's responsible for communicating the occurrence to Axis once a disruption has happened*
- Documentation of how products are produced at the contract manufacturers
- Documentation of the equipment at contract manufacturers
- *Documentation on the availability of components in the supply chain*

Organizational

- Develop cross-functional teams
- *Have decided that Axis takes control of the communication and collaboration in the supply chain in the occurrence of a disruption*
- *Appoint one Axis' employee responsible for aiding suppliers in their risk management*

General

- *Have defined objectives for the supply chain risk management*

Monitoring

- *Having defined KPIs for the objectives regarding proactive supply chain risk management*

APPENDIX VII – REMOVED GUIDELINES FROM THE FIRST VERSION

The table below describes the guidelines which were removed when creating the second version and the motivation to why they were removed.

Guideline	Motivation
Keep track of indicators for disruptions, for example rain levels	This solves a very specific type of risk and is therefore not considered to be effective from a supply chain risk management perspective
Have workshops on what-if scenarios	This is very similar to a risk identification and a risk assessment meeting, which could be included in a proactive supply chain risk management process
Keep stock at the distributors	These are merged to the guidelines concerning keeping stock in the supply chain
Keep stock at the contract manufacturers	
Require suppliers to produce at more than one location	In previous discussions with Axis employees, this has been stated to be difficult as Axis often is a small customer to its component suppliers
Refrain from becoming a too small customer while at the same time not too big	As been proven to not be important as Axis has managed to be prioritized even though they have been small customers
Test alternatives to the strategic components currently used in products, for example sensors	This is today mainly conducted at Axis to keep up with technology development, and the supply chain risk management perspective is only a positive side-effect
Have contact with second tier suppliers	Is not needed since Axis relies on information from its suppliers
Create a supply chain risk management team	Thought to be a too big change for Axis, and therefore difficult to implement
Make use of modular design	This has been described to be difficult to implement by Axis employees
Remove intervening stock	The effects that this gives can be achieved through good relationships
Reduce lead times	This is done continuously at Axis, though not with the purpose of reducing risk
Remove non-value-adding activities	The effects that this gives can be achieved through good relationships
Practice on doing redesigns regarding strategic components, for example sensors	This has previously not been done with a risk perspective at Axis. Also, it becomes very specific to certain suppliers.
Conduct Risk Assessments of the geographical locations in which production and/or storages is planned on being placed	Axis has described that it is difficult for them to refrain from certain regions as many industries have regional clusters

Refrain from having production and/or keeping stock at certain geographical locations	By having multiple production location, this risk is already managed
Tools to discover disruptions	Axis has, by the studied disruptions, been proven quick to recognize disruptions, which makes this unnecessary
Documentation on the need for components at the contract manufacturers	Has been stated by Axis' employees to be difficult to implement
Knowledge on how to find components on venues as for example the spot market	Is mostly based on the purchasers' experience and the disruptions that they have managed previously
Preparedness for sending an employee to the disrupted site	This has been stated difficult by Axis employees to conduct, as different knowledge has been needed in different disruptions
Offices in other geographical areas	The effect is small compared to the required change.
Have an agreement with Canon on Canon aiding Axis in the case of a disruption	This becomes very specific to disruptions to suppliers which Canon has a relationship with, and is therefore not considered to be effective
Have key employees at the same site, for example in Lund	The main reason for this is not from a risk perspective
Define unit-of-analysis	Removed as it was a new action to Axis which was not considered to be as important as others
Conduct audits/reviews	Is moved into *Increase cooperation of risk management with suppliers*
Conduct benchmarking	A new guideline to Axis which was not prioritized