

Managing supply chain risks

Creating a supply chain risk management method for
the process industry



MSc Thesis Management Studies

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Course code:	MST-80433
Credits:	33 Ects
Keywords:	Supply chain risk management, risk management, supply chain management

Preface

In front of you lies the master thesis report which contains the results of my graduation project. This graduation project was the last phase of my study Management, Economics and Consumer studies. Within this study I have chosen the specialization Management Studies.

Now that my master thesis report is finalized I can honestly say that I could not have done it without the help of a wide variety of people, and I would like to use the rest of this page as an opportunity to thank them.

First of all I want to express my gratitude to my company supervisors Michael Nieuwboer and Robbert Jan Kok. They have been very supportive throughout the whole project and have inspired and motivated me on the subject of supply chain risk management and my personal development. I would also like to thank my colleagues at Coppa Consultancy for their enthusiasm concerning this project. Secondly I would like to thank dr. Nel Wognum and Prof. dr. Paul van Beek from Wageningen University. They were always available for support and motivating feedback during the writing of this thesis.

I would also like to mention all interview partners, who spend their time and effort to give me insight in their opinions concerning the SCRM method. Without the cooperation of these interview partners the outcome of this research would not be achieved.

Last, but definitely not least, I would like to thank my friends and family who always supported me during this last phase of my study.

Yvonne Loman
Arnhem, August 2009

Summary

Representatives in the chemical industry have asked Coppa Consultancy to help them think about how to handle and finally implement SCRM. The questions, which they wanted to get answered, were: What does a SCRM method for the chemical industry look like? What kind of risk categories should we be aware of? And what can we do to mitigate or avoid these risks? The main problem is that Coppa Consultancy, at this time, does not yet have an outlined method available which can be used for SCRM in the chemical industry. This thesis research will contribute to the development of a SCRM method, which can be used in the chemical industry and in the wider process industry. To find an answer to the main problem described above, the following research objective is formulated:

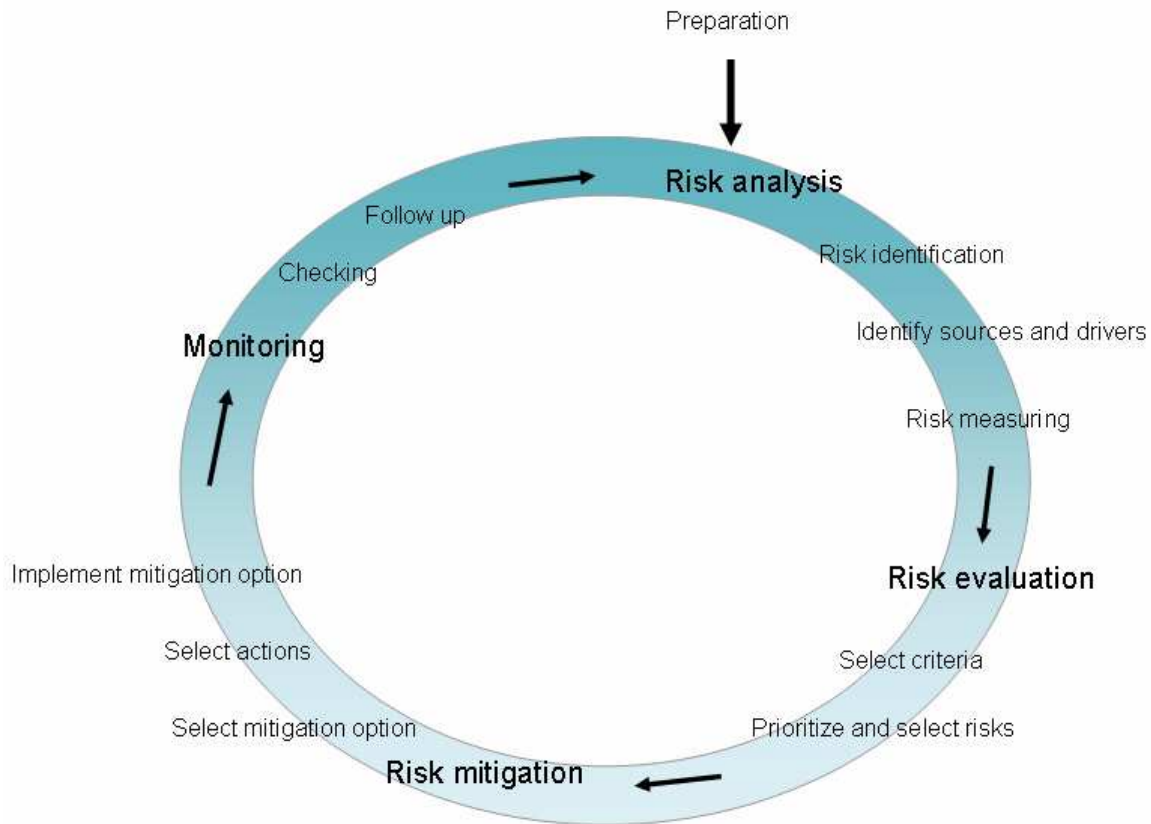
The aim of this thesis research is to contribute to the development of a method for SCRM in the process industry by using available literature concerning SCRM and giving insight in the opinions and ideas of several supply (chain) managers and experts, concerning the usability and importance of a SCRM method in the process industry.

After a literature study and theoretical information on SCRM, risk management and SCM, a conceptual SCRM method is developed. This conceptual method consists out of four phases: risk analysis, risk evaluation, risk mitigation and monitoring. Each phase has its own steps and tools and techniques which can be used to guide the organization through the SCRM process. In order to determine whether the SCRM method is useful for consultants and for the process industry, two expert interviews and two case studies are conducted.

The experts used for the expert interviews are two consultants with a supply chain expertise. The main goal of the expert interviews is to check whether the consultants find the SCRM method useful to work with, especially in the process industry. Each element of the method is validated. Besides the expert interviews there are also two case studies. These case studies have two specific goals. The first goal is to get insight in the current supply chain risk procedure of the participating organizations and the most important supply risks they identify with this procedure. The second goal is focused on whether the elements of the conceptual SCRM method are suitable elements for managing SCRM in the participating organizations. The organizations participating in the case studies are two chemical fiber producing organizations.

After the expert interviews and the case studies are conducted, the results are compared and used to revise and modify the conceptual SCRM method. Each phase of the method is discussed and changes are made when this is recommended. The four phases of the method stayed the same. The main changes are made in the steps, belonging to the different phases. Finally all these changes lead to the final SCRM method. The SCRM process in Figure 1.1 shows the different phases of the method and the steps belonging to these phases.

Figure 1.1: SCRM process



The case studies also focused on the current supply chain risk procedure of the participating organizations and the most important supply risks they identified with this procedure. The two organizations that participated in the case studies have different experiences with SCRM or risk management. Although they have different experiences, both organizations do acknowledge the importance of proper risk management or SCRM. The supply risks that the two chemical fiber producing industries mentioned as being the most important are very divers. It is therefore not possible to give a general overview of the most important supply risks of the chemical fiber producing industry.

It is to conclude that the experts and respondents find the SCRM method useful in the process industry. When consultants want to use the SCRM in practice there are a few aspects they have to consider. The SCRM method is a method that can be used for different types of organizations. The tools, techniques and examples make the method useful for specific industries and organizations. When working with the method it is important that the context of the specific organization is included in the SCRM method and that the different stakeholders are familiar. Besides that it is important to make organizations aware of the importance of SCRM. When organizations are then interested in the SCRM method, the next important aspect is the information access an organization provides the consultants with. The last aspect is the importance of external risks.

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Abbreviations

AIRMIC	The Association of Insurance and Risk Management
ALARM	The National Forum for Risk Management in the Public Sector
CEO	Chief Executive Officer
COSO	The Committee of Sponsoring Organizations of the Tread way Commission
CPO	Chief Procurement Officer
IRM	The Institute of Risk Management
MT	Management Team
REACH	Registratie, Evaluatie, Autorisatie en beperkingen van Chemische stoffen
SC	Supply chain
SCOR	Supply-Chain Operations Reference-model
SCM	Supply chain management
SCRM	Supply chain risk management
SHE	Safety, Health and Environment
USCG	United States Coast Guard

1. Introduction

In this 'Introduction' chapter the problem that underlies the thesis research, the field in which the research will be conducted and the goal of the thesis research are described. The research questions, research framework, research method, strategy and materials are outlined to give a clear view of the whole research.

1.1 Background

Coppa Consultancy is a consultancy agency with customers in the high-tech process industry, business services and health care. Coppa Consultancy provides services concerning purchasing, logistical or supply chain issues.

In the area of supply chain issues Coppa Consultancy has out noticed an increase of interest concerning supply chain risk management (SCRM), which is emerging as a critical supply chain management (SCM) discipline. Subjects as outsourcing, lean manufacturing and Just-In-Time inventory have made customers more aware of the risks of their supply chain and the importance of managing these risks.

Focusing on the supply chain, SCRM incorporates all aspects of risk in the supply chain. According to Kersten, Held, Meyer and Hohrath (2006) SCRM is *"a part of Supply Chain Management which contains all strategies and measures, all knowledge, all institutions, all processes, and all technologies, which can be used on the technical, personal and organizational level to reduce supply chain risk"*.

1.2 Research problem

Representatives in the chemical industry have asked Coppa Consultancy to help them think about: how to handle and finally implement SCRM. The questions, which they wanted to get answered, are: What does a SCRM method for the chemical industry look like? What kind of risk categories should we be aware of? And what can we do to mitigate or avoid these risks?

The main problem is that Coppa Consultancy, at this time, does not yet have an outlined method available, which can be used for SCRM in the chemical industry. This thesis research will contribute to the development of a SCRM method, which can be used in the chemical industry and in the wider process industry.

1.3 Research design

This thesis research will be a practice oriented-research. Practical research usually focuses on solving one aspect of the intervention cycle (Verschuren & Doorewaard, 2007). The intervention cycle is defined as a series of process steps (1- problem description, 2- diagnosis, 3- design, 4- intervention and 5- evaluation) that can be taken to solve a practical problem. Each of these steps requires different kinds of research and research questions.

The focus of the thesis research is on the third step of the intervention cycle: design. The design is focused on contributing to the development of a SCRM method which Coppa Consultancy can use in the process industry, to help them manage their risks. The first step in the design phase is the development of a conceptual SCRM method. This will be done with the input of different literature and expert knowledge. This method will then be validated with the help of several case studies and expert interviews.

The case studies consist of in-depth interviews with supply chain/supply managers of several chemical enterprises. The expert interviews will be conducted with SC experts. Chapter 4 describes the expert interviews, the case studies and the methodology in more detail. The result of these expert interviews and case studies will be analyzed and compared. This will lead to recommendations and a revised SCRM method.

In a design research four types of requirements are essential: functional, contextual, user- and structural requirements (Verschuren & Doorewaard, 2007).

Functional requirement: the method should help Coppa Consultancy to guide SCRM at their customers and together with their customers bring the most important SC risks to the surface. Because of the variety of customers, the SCRM method should be widely applicable.

Contextual requirements: the SCRM that will be developed in this research will first of all be applicable for the process industry. Coppa Consultancy can use the SCRM method in this industry, but with a few modifications the method should also be useful in other type of industries. The consultants should be able to place the method in a wider context and translate the method to that context.

User requirements: the consultants should be able to guide to SCRM process for their customers. Clear steps should help them follow all steps in the SCRM process and to focus on the issues that are the most important. The consultant should be able to apply the method even when the organization is not familiar with SCRM or risk management. The different steps should be clear and there should be no room for misinterpretations. The consultants working with the SCRM method should be familiar with general SC and risk management tools and techniques, like for instance brainstorming and process mapping.

Structural requirements: the method should have a clear structure, from identifying the risks till the process of handling these supply chain risks. The different steps of the method can be seen as separate phases which are sequential applicable.

1.3.1 Research objective

To find an answer to the main problem described above, the following research objective is formulated:

The aim of this thesis research is to contribute to the development of a method for SCRM in the process industry, by using available literature concerning SCRM and giving insight in the opinions and ideas of several supply (chain) managers and experts, concerning the usability and importance of a SCRM method in the process industry.

1.3.2 Scope and restrictions

The initial question for a SCRM method came from the chemical industry. Ideally it would be interesting to create a SCRM method and assess that method in different industries. After which lessons learned are used to revise and modify the method to a final method useful for all types of industries. Due to time constraint of this thesis research this is, in total, not possible. In alignment with several stakeholders I have chosen to place the scope of the research within certain boundaries.

The first scope is focused on the specific industry for which the method will be created and assessed. The second aspect is related to the supply chain risks which will be included in the SCRM method.

Process industry

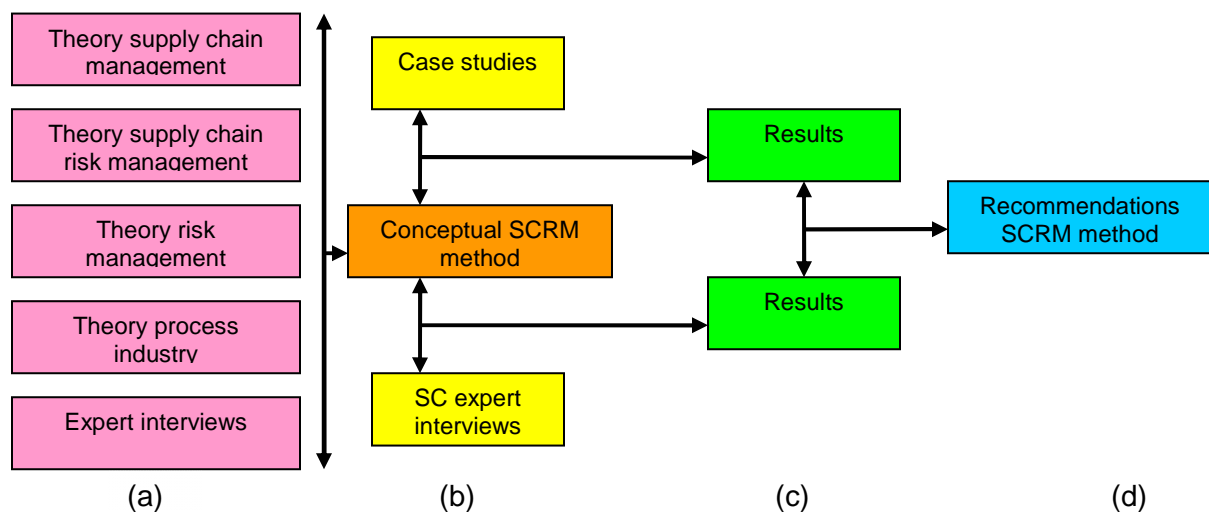
Because of the fact that the initial question came from the chemical industry, it is important that the SCRM method can be applied in that industry. Creating a SCRM method purely for the chemical industry makes the research possibly too narrow, since other industries can also benefit from a SCRM method.

The chemical industry has some characteristics that are not only seen in the chemical industry but in the wider process industry (of which the chemical industry is part) in general. That is why we have chosen to create the method with a focus on the process industry. The conceptual method will be validated in a specific part of the chemical industry; the chemical fiber producing industry. After verifying the method lessons learned will be used to revise and modify the SCRM method.

Internal and external risks

Looking at risks in the supply chain a lot of different risk categories can be identified. One of the things that these different categorizations have in common is the distinction between external and internal risks in the supply chain. Internal risks are those risks that are internal to the firm or internal to the supply network. External risks are risks that are external to the whole supply chain network (more about the different types of risks in Chapter 2.3.2). In this thesis research the focus will be on the internal environment (the supply chain environment) and risks that are present in this environment. Risks in the external environment are not included in the development of the SCRM method, since these risks are not always predictable and are very difficult to prevent. External risks are seen as important risks that have their influence on the supply or demand side of the supply chain or on the internal operation of the focal firm. These influences are taken into account.

1.3.3 Research framework



(a) A study of supply chain risk management in the process industry, based on existing theories concerning SCRM and the related management disciplines of risk management and SCM, together with theory concerning the process industry and expert interviews, will lead to elements of a conceptual SCRM method for the process industry. This conceptual SCRM method (b) will be validated with the help of in-depth interviews with two SC experts and two case studies. (c) An analysis and comparison of the expert interviews and the case studies will result into (d) recommendations concerning a SCRM method for the process industry.

1.3.4 Research questions

In order to fulfil the research objective three central research questions, and several sub-questions, are formulated. Answering these three research questions will generate the research objective.

1. *What elements can be part of a method for supply chain risk management in the process industry, according to literature and expert knowledge?*
 - 1.1 What are the main characteristics of SCRM and the process industry?
 - 1.2 What SCRM elements can be derived from SCM, risk management and SCRM theories?
 - 1.3 Which elements are interesting for SCRM in the process industry?
 - 1.4 What elements are essential for the SCRM method?

2. *What is the value and quality of the elements of the conceptual method, according to supply (chain) managers and -experts?*
 - 2.1 What is the usability of the conceptual SCRM method according to the SC experts?
 - 2.2 What is, according to the SC managers, the importance of SCRM in their organization and how is SCRM imbedded in their organization?
 - 2.3 What are the most important supply risks these organizations signal?
 - 2.4 In what way are the elements of the conceptual method useful for SCRM in these organizations?

3. *What lessons are learned in validating the method and what are the recommendations concerning the SCRM method?*
 - 3.1 What are the main opinions of the respondent concerning the SCRM method?
 - 3.2 What are differences and similarities in the opinions of the respondents and why?
 - 3.3 What are the limitations and failures of the method?
 - 3.4 What modifications are needed in the SCRM method?

1.4 Technical design

The goal of the research is to develop a theoretical method for SCRM, applicable in the process industry. Coppa Consultancy should be able to use this SCRM method to analyze, evaluate and mitigate the supply chain risks of their clients.

1.4.1 Research methodology and strategy

There are two types of research, qualitative and quantitative. For this thesis research qualitative research is the best option because qualitative research makes it possible to gather an in-depth understanding of human behavior and the reasons that govern such behavior. Quantitative research is less useful for this research because the aim of quantitative research is to classify features, count them, and construct statistical models in an attempt to explain what is observed (Neill, 2007).

To do this, data in the form of numbers and statistics is used. In this research it is not possible to capture the opinions of the respondents in a numerical form.

Theoretical research

The method that is used for capturing the theoretical information, in order to develop the conceptual SCRM method, is a combination of desk and field research. General literature about SCM, process industry, risk management and SCRM will be gathered with the help of desk research. The sources of the information, used in the desk research, will be the university library, internet and in-house information of Coppa Consultancy. Besides desk research there will also be some field research. Several interviews will be held with experts on the subjects of process industry and SCM.

Empirical research

The empirical research is based on several interviews with supply chain experts (consultants) and case studies in the chemical fiber producing industry. The goal of these expert interviews and case studies is to validate whether the conceptual SCRM method is useful for the consultants to work with and if the method is suitable for usage in the chemical industry. Finally the results of the interviews and case studies will lead to recommendations concerning the SCRM method. The form in which this will be done is with the help of several in-depth interviews. In Chapter 4 the methodology of the empirical research is described in more detail.

1.4.2 Research material

During the research different research materials will be used, varying from persons, media, documents and literature. This chapter gives a general overview of the different research materials for the three research questions.

Theoretical research

In the desk research, books, scientific articles and scientific journals will help determine what is already known about SCRM and what kind of methods and models have already been used. To determine what methods are most suitable for the process industry it is important to gain insight in SCM and the process industry. Interviews with experts on the areas of SCM and the process industry will be held to gain this insight. The desk research and field research together determine what the critical elements of the SCRM method will be.

Empirical research

In the empirical research the focus will be on the supply (chain) managers of chemical fiber producing organizations and supply chain experts (consultants). These supply chain experts will be other experts than the ones used for the theoretical research. The last part of the research is focused on the results of the interviews and case studies. These results are compared and analyzed and this will finally determine the recommendations concerning the SCRM method.

1.5 Outline

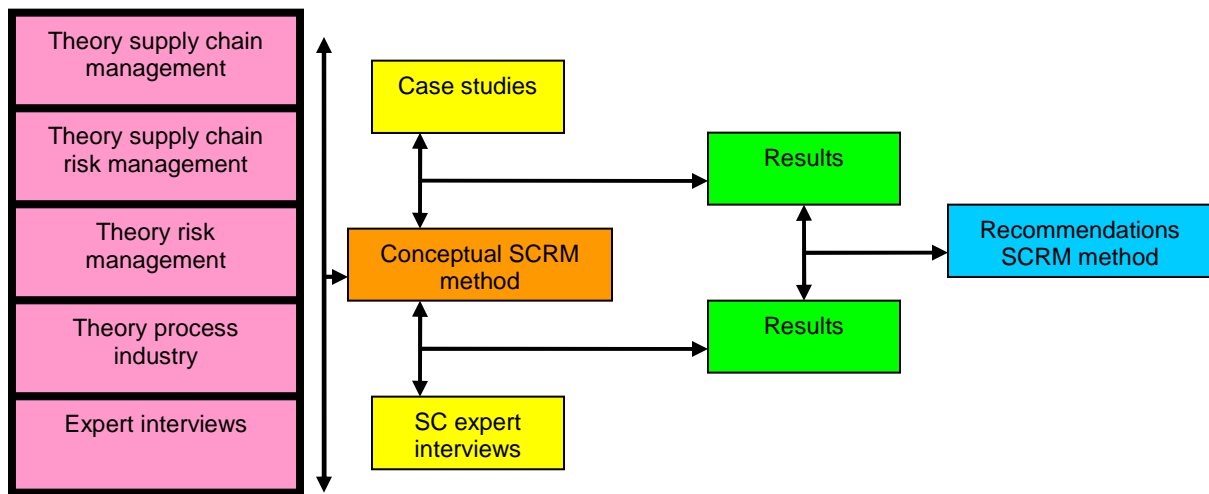
This thesis research consist of an introduction (Chapter 1), a theoretical framework (Chapters 2 and 3), the methodology (Chapter 4), the results of the expert interviews and the case studies (Chapter 5) and finally the conclusion and discussion (Chapters 6 and 7).

Chapter 1 gives the introduction to the research. The problem, the research objective and research question are outlined in this chapter. The theoretical framework includes Chapter 2 and 3. In the theoretical framework the focus is on creating a method for SCRM for the process industry. Different theories concerning SCM, the process industry, risk management and SCRM, supplemented with expert interviews, are used to create a SCRM method. Chapter 2 first gives an insight in the research areas; SCM and the process industry. After which the tools that are used in the research area; risk management and more specifically SCRM, are described. Chapter 3 focuses on the supply chain risk management process and the different phases that are essential for the SCRM method. The empirical part of the research focuses on the validating the conceptual SCRM method. This is done with the help of expert interviews and two case studies. Chapter 4 describes the methodology of the empirical research and the results are outlined in Chapter 5. The final chapters are Chapter 6, which gives the conclusion of the thesis research and recommendations for the consultants and Chapter 7, which describes the discussion and recommendations for further research.

2. Literature study

This chapter gives information on the area of the research and the management tool used in the research. The area of the research is the supply chain of the process industry. Chapter 2.1 focuses on the supply chain in general and some important elements of supply chain management. Chapter 2.2 describes the process industry and the supply chain characteristics of this industry. The management tool used in this research is SCRM. Chapter 2.3 describes the most important aspects of SCRM. Figure 2.1.1 shows the elements of the research framework that are outlined in this chapter.

Figure 2.1.1: Focus of Chapter 2 Research framework



2.1 Supply chain management

Supply chain and supply chain management (SCM) are terms that can be defined in several ways. Chapter 2.1.1 will focus on the definitions of supply chain in general and on the definition of SCM. Chapter 2.1.2 describes the elements that are important in SCM. The final part of this chapter (Chapter 2.1.3) gives an overall conclusion.

2.1.1 Definition

In literature a lot of different definitions, focusing on different perspectives or attributes, can be found for the terms 'supply chain' and 'supply chain management'.

Supply chain

A definition that can be found in different literature, concerning supply chain related items, is the definition of Christopher (1992) who describes a supply chain as: *"a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumers"*. In other words, a supply chain consists of multiple firms, both upstream (i.e., supply) and downstream (i.e., demand), and the ultimate consumer. The focus is on both the supply and demand side of the supply chain and the cooperation that the different tiers in the supply chain must develop to create optimal value for the final customer. Figure 2.1.2 shows the different tiers of the supply chain and the business processes that should be managed in order to create optimal value for the final customer.

Supply chain management

SCM focuses on the different business processes, shown in Figure 2.1-1. By managing these processes, throughout the supply chain, the different partners in the supply chain try to achieve the following goals: lower costs, increased customer value and satisfaction, and ultimately competitive advantage (Mentzer et al., 2001). A definition for SCM, which includes all the different goals and elements of SCM is not defined yet. Different definitions exist next to each other and an international survey of specialist educators by Larson and Halldorsson (2004) suggests that an agreed definition—even amongst academics—is not determined yet (Peck, 2006).

Figure 2.1.2: Integrating and managing business processes across the supply chain



(Source: Lambert & Cooper, 2000).

2.1.2 Managing the supply chain

Successfully managing a supply chain consists, according to Lambert and Cooper (2000), of three interrelated elements: the supply chain network structure, the supply chain business processes and the SCM components. Risks that might be present in the supply chain are influenced by the way the partners in the supply chain deal with these different elements.

Supply chain network structure

Every company is part of one or, most likely, more supply chains. The supply chains, a company is part of, can be very complex. For an organization it is important to decide how many of these supply chains, and which parts, need to be managed. This depends on several factors including the length of the supply chain, the number of suppliers and customers, the complexity of the product, and the availability of raw materials (Lambert & Cooper, 2000). The influence an organization has on the supply chain depends on their position and role in the supply chain. In the supply chain there has to be an organization that assumes the leader role (Lambert, Stock & Ellram, 1998). Ellram and Cooper (1990) state that a supply chain leader plays a key role in coordinating and overseeing the whole supply chain.

Supply chain business processes

Creating successful SCM has to do with integrating activities into key supply chain processes (Lambert, Guinipero & Ridenhower, 1998). Activities that were first managed individually should be part of the supply chain process, which in turn helps to create the best product flows. This requires a continuous flow of information between the different supply chain members.

Supply chain management components

The level of integration and management of business processes depends on the number and intensity of management components added to that business process. Lambert and Cooper (2000) identify nine management components for successful SCM: planning and control; work structure; organization structure; product flow facility structure; information flow facility structure; management methods; power and leadership structure; risk and reward structure; and culture and attitude. These different management components can all create their own risk for the organization and the supply chain.

2.1.3 Conclusion

The different partners in the supply chain want to achieve the following main goals: lower costs, increased customer value and satisfaction, and ultimately competitive advantage. SCM can help them accomplish these goals by managing the three interrelated SC elements: the supply chain network structure, the supply chain business processes and the SCM components. The way these elements are managed influences the risks that are present in the supply chain. In Chapter 2.4 the different supply chain risks and the essence of SCRM are described.

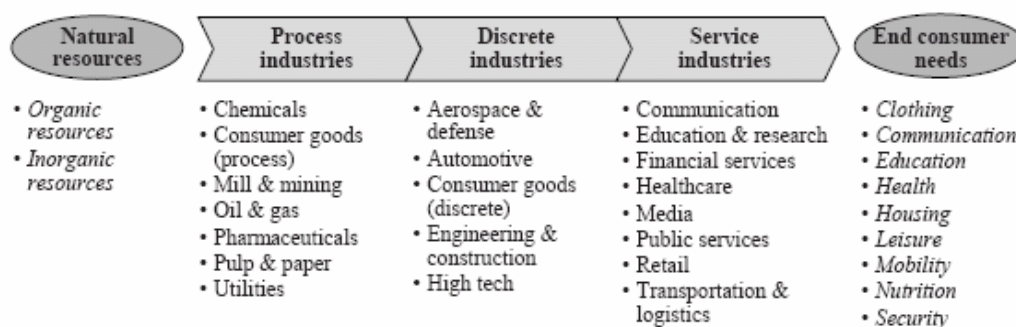
2.2 Process industry

This paragraph describes the process industry, which is central in this research. Chapter 2.2.1 gives the definition of process industry and then some of the main characteristics of the process industry supply chain are outlined in Chapter 2.2.2. Chapter 2.2.3 gives an overall conclusion of the important aspects of the process industry.

2.2.1 Definition

According to Encarta (2009) the process industry is an industry in which raw materials are treated or prepared in a series of stages, e.g. using chemical processes. Process industries include oil refining, chemicals, water and sewage treatment, food processing, pharmaceuticals and pulp and paper manufacturing. Figure 2.2.1 shows some of the different industries that are part of the process industry.

Figure 2.2.1: Process industries



(Source: Kannegieser, 2008)

2.2.2 Process industry supply chain

Since the process industry consists of very different industries, as shown in Figure 2.2.1 there is no typical process industry supply chain. The supply chains of the different industries all have their own characteristics and typical problems. Organizations in the process industry are often located in the middle of wider supply chains. As a result of this position the process industry companies traditionally perform differently compared to companies operating at the final end of the chain. Process industry supply chains, involving manufacturers, suppliers, retailers and distributors, are striving to improve their efficiency and responsiveness (Shah, 2005).

In the process industry risks that have to do with the safety of the process are very important. When things go wrong in the production process of the process industry this can have huge effects on the products and on the people working with or using the products. Several companies use a SHE (Safety, Health and Environment) policy to prevent risks in these areas (M. Plasier, 2009).

Besides these resemblances the supply chains of the process industry are very different. To give an idea of the differences in the supply chain, the supply chain aspects of two different process industries are described in Appendix 1: the chemical industry and the pharmaceutical industry. One of the main differences between the chemical industry supply chain and the pharmaceutical industry supply chain is that in the chemical industry the different chemical organizations are highly dependent on each other. They need each other to create their products and to survive. In the chemical industry supplier and customer can be one and the same organization. In the pharmaceutical industry there is a clearer distinction between the different supply chain members. Pharmaceutical organizations are less dependent on their competitors; the focus is more on getting patents before the competitor does.

2.2.3 Conclusion

The area of the thesis research is the process industry supply chain. The process industry is an industry with a wide variety of industries and therefore with very different supply chains. The supply chain network structure, supply chain business processes and the supply chain management components depend on the specific process industry, like for instance the chemical or pharmaceutical industry. The way these different supply chains are managed varies, just as the risks present in these supply chains. One aspect, organizations in the process industry often have in common, is the fact that these organizations are often located in the middle of wider supply chains.

2.3 Supply chain risk management

SCRM is the management discipline which combines risk management with SCM. According to Brindley (2004) *“Supply chain risk management is the intersection of supply chain management and risk management and has the intention to help organizations handle the uncertainties and risks in the supply chain”*.

To better understand SCRM, it is important to know more about the term ‘risk’ in general. Many definitions of risk exist, but risk is mostly contextualized within the area of decision making (individual or organizational), (un)predictability and potential loss. Sitkin and Pablo (1992) define risk as *“the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realized.”*

2.3.1 Definitions

This paragraph gives some definitions of supply chain risk and SCRM.

Supply chain risk

Combining SCM and risk management means that the focus is on managing the different risks that might occur in the supply chain. As described in Chapter 2.1 a supply chain is a network of organizations that are involved in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumers (Christopher, 1992). According to Kersten et al., (2006) supply chain risk refers to: *“the damage - assessed by its probability of occurrence - that is caused by an event within a company, within its supply chain or its environment affecting the business processes of more than one company in the supply chain negatively”*. Looking at this definition of Kersten et al. (2006), the first part focuses on the elements of risk: the probability of occurrence and the caused damage. The second part says that the risk is caused by an event within a company, within its supply chain or its environment. As described in Chapter 1.3.2 this thesis research only takes the internal risks (internal to the company and to the supply chain) into account. Finally the definition of Kersten et al. (2006) describes that it is only a supply chain risk when more than one company in the supply chain is affected by the risk. This gives a difference between supply chain risk and general risk. On other difference between supply chain risk and other risks is given by Jüttner, Peck and Christopher (2003) who states that *“supply chain risks refer to the possibility and effect of a mismatch between supply and demand”*. So the risk has an influence on the supply and demand in the supply chain.

Supply chain risk management

Since supply chains are exposed to new risks due to changes as outsourcing, lean manufacturing and Just-In-Time inventory, SCRM is emerging as a critical SCM discipline. Focusing on the supply chain, SCRM is responsible for all aspects of risk in the supply chain. According to Waters (2007) *“the overall aim of supply chain risk management is to ensure that supply chains continue to work as planned, with smooth and uninterrupted flows of all materials from initial suppliers through to final customers”*. This definition does not merely focus on preventing risk but on the supply chain working as planned, which is the main goal of SCM. In my opinion, the definition needs an additional element. It is not only the flow of materials but also the flow of information that needs to run efficiently. In this thesis the definition is therefore revised into: *“The overall aim of supply chain risk management is to ensure that supply chains continue to work as planned, with efficient and uninterrupted flows of all materials and information from initial suppliers through to final customers and vice versa”*. This definition shows the strong connection between SCM and SCRM. Kersten et al. (2006) make this connection extra visible by defining SCRM as *“a part of Supply Chain Management which contains all strategies and measures, all knowledge, all institutions, all processes, and all technologies, which can be used on the technical, personal and organizational level to reduce supply chain risk”*.

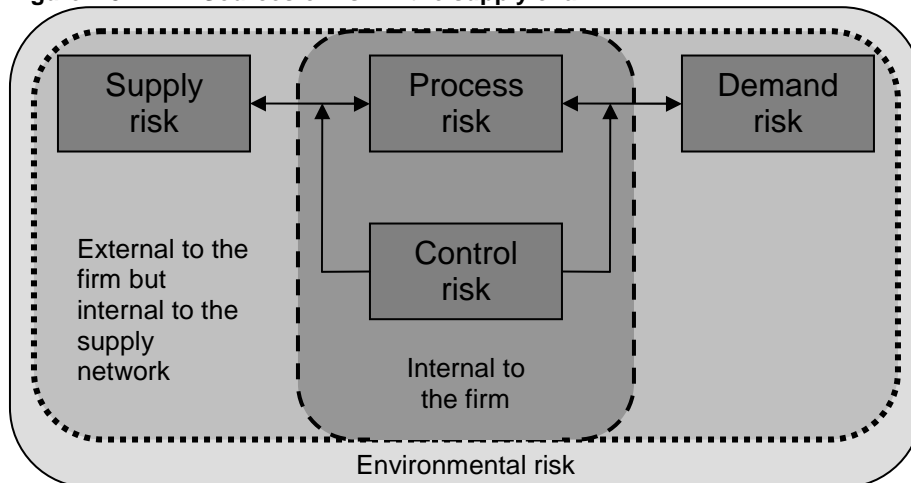
SCRM does not only have strong connections with SCM but also with risk management. The main link between SCRM and risk management is the general goal, which is to help organizations understand, evaluate and take action on the different risks, focusing on reducing failure and sustain successful business. The difference is that SCRM focuses on the risks in the supply chain and the failure and success of the whole supply chain instead of the risks of one individual organization, as is the case in general risk management.

2.3.2 Supply chain risk categories

Risks can occur in, or between, the different tiers of the supply chain and can have a huge influence on the different members of the supply chain. It is therefore important to know where in the supply chain, the risks occur and what causes them.

In risk management literature different ways to categorize risk are described (Brindley, 2004, Christopher & Peck, 2004, ISO International Standard, 2007). One of the things that a lot of these different categorizations have in common is the distinction between external and internal risks. The risk categorization of Christopher and Peck (2004) is the most used and accepted categorization in SCRM. Figure 2.3.1 shows the supply chain risk sources of Christopher and Peck (2004).

Figure 2.3.1: Sources of risk in the supply chain



(Source: Christopher & Peck, 2004).

Internal risks

Internal risks can be divided into risks that are internal to the firm and risks that are internal to the supply network. Supply chain risks that occur internal to the firm can be very diverse. Christopher and Peck (2004) divide risks that are internal to the firm into control and process risks. This internal element can also be compared with the 'make' element of the SCOR model. Supply chain risks that are internal to the firm are risks that occur between the walls of the firm and have their influence on more than one supply chain member.

Risks that are external to the firm, but internal to the supply network are the risks that occur up- or downstream the initial firm. Christopher and Peck (2004) call these risks the supply and demand risks. These risk areas can be compared to the 'source' en 'deliver' elements of the SCOR model.

External risks

External risks are the risks that are external to the whole supply chain network. As described in Chapter 1.2 the focus of this thesis research is on the internal environment and risks that are present within this environment. Risks in the external environment are not included in the development of the SCRM method, since these risks are not always predictable and are very difficult to prevent. External risks are seen as important risks that have their influence on the supply or demand side of the supply chain or on the internal operation of the focal firm. Different external risks will be identified as being sources and drivers of certain risks (more on sources and drivers in Chapter 3.2.2).

Risk categories

Looking at risks in the supply chain a distinction can be made between risks that occur:

- at the supply side of the supply chain;
- at the demand side of the supply chain;
- internal to the firm; or
- external to the network (not included in the research).

Having three areas where supply chain risks can occur (supply, demand and internal) makes it possible to place different supply chain risks under these areas. But the type of risks, present in each of these three risk areas, are still very divers. That is why it is interesting to categorize the risks even further.

Testing different categorizations

In literature different other risk categorizations were found. Deciding on which categorization is most suitable for categorizing supply chain risks, different categorizations were tested. The categorizations that are tested are the categorizations of Waters (2007), Cavinato (2004) and Yates and Stones (1992). These three authors are chosen because their categorizations focus specifically on supply chain risks. A fourth categorization, which was not specially focused on supply chain risk, but on risk management in general, is the categorization used by COSO (The Committee of Sponsoring Organizations of the Tread way Commission). The expectation is that this last categorization will not be suitable for supply chain risk identification because it leaves out important aspects as transportation and collaboration between supply chain members.

Before testing the usability of the different categorizations a list of supply chain risks was established with the help of a brainstorming session with two supply chain experts. The risks that came out of this brainstorming session were, in agreement with the supply chain experts, first placed under the three risk areas: demand, supply and internal (see Appendix 2). They were then categorized further, following the categorizations of the four earlier mentioned authors. Waters (2007) uses the following risk categories: financial, physical, informational, and organizational. Cavinato (2004) uses similar categories: physical, financial, informational, relational and innovational. Yates and Stones (1992) state that supply chain risks can be divided in the following categories: financial, performance, social, physical and time. Finally COSO uses: financial, strategic, operational and external risks.

When placing the different risks in the categorizations it appeared that some categories were not as useful as others. As expected the COSO categories were not very useful because certain risks did not fit any of the categories. Focusing on the other categorizations it became clear the risk categories that could not be neglected were the financial en physical risks. Some other risks, like the relational, innovational and performance risks can be summarized as organizational risks. An other category of risks that is important in the supply chain is information risk (Waters, 2007 and Cavinato, 2004), these risks have to do with the processes and electronic systems, data movement triggers, access to key information, capture and use of data, enabling processes and market intelligence.

Comparing the three categorizations and focusing on the practical application of the risk categories the final choice has become: financial, physical, organizational and informational. These are also the categories that Waters (2007) indicates.

So under the three risk areas, four risk categories are placed. This means that within the risk area 'supply', there are financial supply risks, physical supply risk, organizational supply risks and informational supply risks. The same counts for the internal and the demand risks. In the next chapter several supply chain risks, found in the process industry, are placed under these categories.

2.3.3 Supply chain risks in the process industry

As described in the previous Chapter a list of risks was established in order to determine which risk categorization was the most interesting and applicable for this research. The list of risks was established with the help of several literatures and a brainstorming session with supply chain experts. Literature that was used to create the list includes articles of Kersten et al. (2006), Muthukrishnan and Shulman (2006) and Chopra and Sodhi (2004). This literature mainly focuses on supply chain risk in general and not for a specific industry. In the brainstorm session with two supply chain experts the goal was to focus specifically on supply chain risks in the process industry. During the brainstorm session the scope was that the focal firm is responsible for getting the products from the supplier to their own organization. The next organization in the chain is responsible for getting the products from the focal firm (their supplier) to their own organization.

Table 2.3.1 shows some of the supply chain risks in the process industry, categorized under the earlier mentioned categories. This list of supply chain risks is not complete and will be different for different organizations. The list gives an indication of some of the risks that are present in the supply chain of the process industry.

Table 2.3.1: Risk framework

	Supply risks	Internal risks	Demand risks
Financial risks	<ul style="list-style-type: none"> - Supplier bankruptcy - Increasing product prices - Fluctuations in foreign exchange rate - Increasing transportation costs 	<ul style="list-style-type: none"> - Inventory costs - Cost of labor - Cost of changeovers 	<ul style="list-style-type: none"> - Lack of , or late payments - Decreasing prices
Physical risks	<ul style="list-style-type: none"> - Product quality - Supplier capacity constraints - Late deliveries - Damaged goods - Missing products - Problems with supply chain infrastructure 	<ul style="list-style-type: none"> - Insufficient production capacity - High capacity utilization - Waste 	<ul style="list-style-type: none"> - Changes in demand - Availability of substitutes
Organizational risks	<ul style="list-style-type: none"> - Non-sustainable behavior of suppliers (SHE regulations) - REACH approved suppliers - Nonconformity to specifications - Excessive handling due to border crossings or to change in transportation modes - Increasing supply lead times - Lack of collaborative planning - Possibility of supplier to adapt to requirements - Partnership failure 	<ul style="list-style-type: none"> - Decreasing quality/availability internal services - Rate of product obsolescence - Labor dispute - Mechanical failure - General availability of labor - Quality of labor - Availability of capital - Failure of logistics service provider - Intellectual property infringement / theft - Lack of collaborative planning - Low degree of resilience - Ineffective scheduling 	<ul style="list-style-type: none"> - Customer dependency - General availability of labor - Lack of collaborative planning - Partnership failure
Informational risks	<ul style="list-style-type: none"> - Inaccurate forecast - Data errors - IT failure 	<ul style="list-style-type: none"> - Data errors - IT failure 	<ul style="list-style-type: none"> - Inaccurate forecasts - Data errors - IT failure

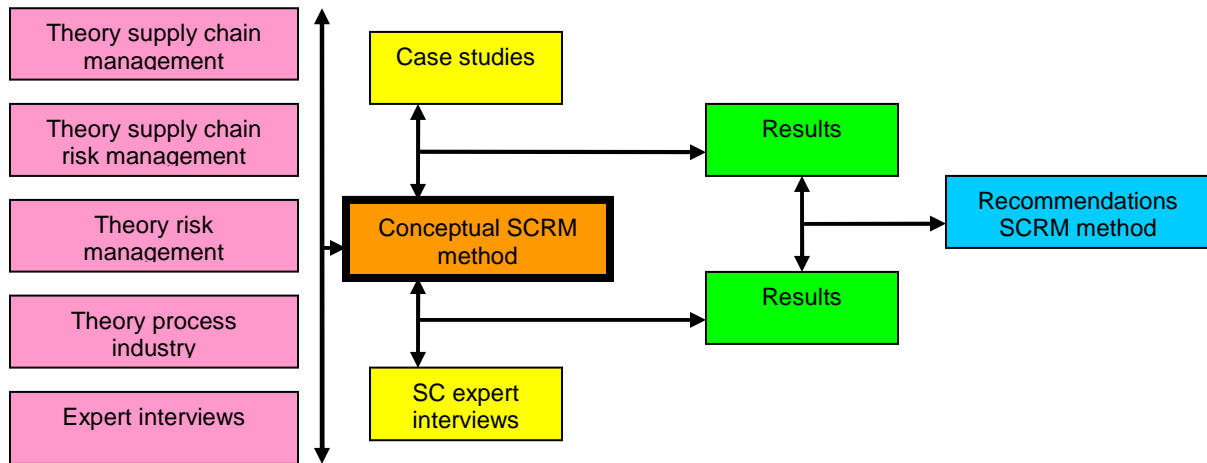
2.4 Conclusion

When using SCRM it is important to realize that a risk is only called a supply chain risk when it affects more than one company in the supply chain. The different aspects of SCM, like the suppliers, customers, processes, the relationships and the integration, all have an impact on the risks that are present in the supply chain. Determining what the risks in the process industry supply chains are is depending on the specific industry. The different risks that are present in the specific supply chain can be categorized in 12 different risk types, as shown in Table 2.3.1.

3. Theoretical SCRM method

When organizations want to work with SCRM it is essential that they have a useful method. This method should help organizations deal with supply chain risk and implement SCRM in their organization. In this chapter the SCRM process is introduced after which the separate elements of the process are outlined, resulting in the conceptual SCRM method. Figure 3.1.1 shows the step in the research framework.

Figure 3.1.1: Focus of Chapter 3 Research framework



3.1 Supply chain risk management process

There are a lot of different frameworks and systems that deal with risk management. Some of these systems might also be applicable for SCRM. According to M. Meuwissen (2009), there is not one specific risk management system or framework that is the most suitable and applicable for all situations. The practical application of risk management determines what kind of system or framework suits the situation the best. This has also to do with personal preference, as the different systems and frameworks all have their advantages and disadvantages.

3.1.1 Preparing/setting-up

Before starting with SCRM there are a few aspects that need to be prepared, organized or checked.

Importance of SCRM

At first it is essential that the whole organization acknowledges the importance of SCRM. Senior management should approve SCRM and the organizational infrastructure has to be suited and ready for risk management. SCRM should, just as risk management, be a continuous and developing process which runs throughout the organization's strategy and the implementation of that strategy (AIRMIC, ALARM, IRM, 2002). According to Dani (2009) it is important that the organizations have a culture and attitude which provides resources and which motivates employees to work with risk management.

Risk attitude

Before starting with risk management it is important to know more about the risk attitude and the risk policy of the organization. Risk attitude is: “*the chosen response of an individual or group to uncertainty that matters, driven by perception*” (Hillson & Murray-Webster, 2007). Understanding the risk attitude of the organization will help make effective decision concerning supply chain risks. Whether the organization is risk averse, risk seeking, risk tolerant or risk neutral has an influence on how the organization deals with these risks. Besides having insight in the risk attitude of the organization, the risk policy should also be clear. The risk policy depends extremely on the risk attitude of the organization.

Supply chain

Before the supply chain risks can be identified, the supply chain that has to be analyzed should be defined (Jüttner & Ziegenbein, 2009). An organization is part of more than one supply chain, as described in Chapter 2.1. When starting supply chain risk analysis it should be clear which supply chain is analyzed. After the critical supply chain is chosen the supply chain should be described and visualized, before focusing on the supply chain risks, this is also called supply chain mapping. With supply chain mapping the ins and outs of the supply chain are made clear and this will lead to input for the step of risk identification.

3.1.2 The SCRM phases

When comparing different systems and frameworks (Mullai, 2009, Hallikas, Karvonen, Pulkkinen, Virolainen & Tuominen, 2004, Normann & Jansson, 2004, Ale, 2002) it is interesting to see that these different systems and frameworks almost always focus on the following subjects: identifying, measuring, analyzing, mitigating, planning and checking the risks. The ways these phases are described differ among the authors.

In order to create a clear structure the different phases are summarized into four distinctive phases: risk analysis, risk evaluation, risk mitigation and monitoring. Each of these four phases has its own specific elements and its own specific goal. Before the organization can start with SCRM it should first be prepared.

Risk analysis

Risk analysis, as mentioned by Mullai (2009) and Normann and Jansson (2004), is the phase in which the risks are determined. The goal could be a list of all risks present in the supply chain. But a list alone is not enough. Risk analysis contains aspects as: risk identification, identifying the sources and drivers and risk measuring (Jüttner & Ziegenbein, 2009, Waters, 2007, AIRMIC, ALARM & IRM, 2002). After the risks analysis the organization should have insight in their supply chain risks, the sources and drivers of these risks and the way these risks can be measured. Chapter 3.2 describes the phase of risk analysis more thoroughly.

Risk evaluation

After the risks are analyzed the risks should be evaluated (Mullai, 2009 and Normann & Jansson, 2004). After the evaluation the organization should have a clear view of the risks that have priority and that should be mitigated. In order to do this the following steps are necessary: selecting the criteria and prioritizing and selecting the risks. Chapter 3.3 describes the risk evaluation. The risk evaluation phase in combination with the ‘Risk analysis’ phase is also known as ‘Risk assessment’.

Risk mitigation

The third phase of the risk process is the phase in which the decisions concerning the mitigation of the, earlier selected, risks are taken. This phase is called the risk mitigation phase. This phase includes choosing the appropriate mitigation strategy, deciding on the actions needed, creating an implementation plan and finally implementing that plan (Hallikas et al., 2004, Alle, 2002). The risk mitigation options and examples of mitigation actions are described in Chapter 3.4.

Monitoring

A phase that has an influence on all the other phases is the monitoring phase. This phase or something similar, can be found in many risk systems and frameworks (Hallikas et al., 2004, Ale, 2002, COSO framework). The monitoring phase includes elements as checking and follow-up. Chapter 3.5 describes this further.

A very important aspect in the risk management process is communication. Mullai (2009) states that communication is at the center of the risk system because it is an important integrated element of every form of management. Risk-related information generated at each phase, stage or step should be communicated continuously and effectively to all parties concerned because this might have an influence on decisions and actions. The different phases of the risk process are interrelated and overlapping, they continuously influence each other.

3.2 Supply chain risk analysis

Risk analysis is the first step in the risk management process. The goal of risks analysis is to create an overview of the risks that are present in the organizations supply chain. There are different ways to analyze these risks. In the risk analysis process the two most important and most common steps are: risk identification and risk measuring (Jüttner & Ziegenbein, 2009, Waters, 2007, AIRMIC, ALARM & IRM, 2002). Besides these two steps it is also important to look at the sources and drivers of the risks. After the risk analysis there should be a list of supply chain risks, an idea of the drivers and sources of these risks and a way to measure the different risks. Chapter 3.2.1 describes the risk identification, Chapter 3.2.2 the identification of source and drivers and Chapter 3.2.3 describes how the risks can be measured. Finally Chapter 3.2.4 will give a conclusion of the 'Risk analysis' phase.

3.2.1 Risk identification

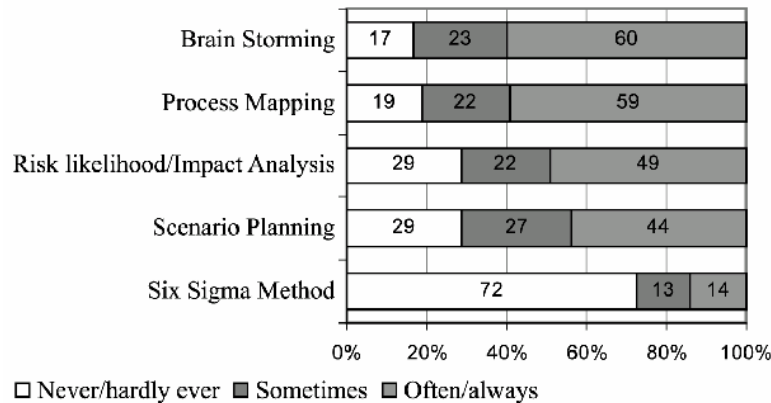
The first step of the 'Risk analysis' process is identifying the supply chain risks. According to the Committee Draft of ISO 31000 (2007) the aim of risk identification is: *“to generate a comprehensive list of risks based on those events and circumstances that might enhance, prevent, degrade or delay the achievement of the objectives”*. According to Waters (2007) it is almost impossible to list all the risks that are present in the supply chain, but with the help of certain tools and techniques the most significant supply chain risks should be identified. This list is a dynamic list and changes over time. When identifying the supply chain risks it is important to keep in mind that a risk is only a supply chain risk when it affects more than one company in the supply chain.

There are different tools and techniques to analyze risk. Most of them focus on risk in general and some specifically on risks in the supply chain. A very useful technique to identify risks is a brainstorming session and process mapping.

Figure 3.2.1 shows that these two techniques are used most often to support supply chain risk analysis. A description of these different tools and techniques can be found in Appendix 3. Consultants working with the SCRM method should be familiar with these different tools and techniques, as mentioned in the requirements in Chapter 1.3.

Figure 3.2.1: Tools and techniques used to support supply chain risk analysis

How often are the following processes/tools or techniques used in your organisation to support supply chain risk analysis?



□ Never/hardly ever ■ Sometimes ■ Often/always
(Source: Jüttner, 2005)

Besides the tools and techniques mentioned in Figure 3.2.1, it is also possible to support organizations in the identification of supply chain risks with the help of a risk identification framework.

Risk identification framework

The risk identification framework has been established with the help of the risk categories, mentioned in Chapter 2.3.4. The supply chain risk areas and types are outlined in Table 3.2.1. Organizations can use the framework as an instrument that gives structure in the identification of supply chain risks. By already placing different categories in the table, organizations are triggered to think in the right direction. The categories that are used in Table 3.2.1 are categories that are mentioned by Chopra and Sodhi (2004). They identify the following risk categories: disruptions, delays, systems, forecast, intellectual property, procurement, receivables, inventories and capacity. In Table 3.2.1 the categories are placed in the framework, these categories are not complete and are only used as a trigger. The fact that ‘Systems’ is only placed under ‘Internal risks’ does not mean that there are no ‘System’ risks possible under the ‘Supply’ or ‘Demand’ side of the framework. By giving organizations a direction in which they can think organizations are triggered to think for themselves instead of giving them a ‘ready to use’ overview.

Table 3.2.1: Risk identification framework

	Demand risks	Internal risks	Supply risks
Financial risks	Disruptions Forecast Intellectual property Procurement Receivables	Disruptions Systems Intellectual property Procurement Inventories Capacity	Disruptions Delays Forecast Intellectual property Procurement
Physical risks	Disruptions Forecast Intellectual property Procurement Receivables	Disruptions Systems Intellectual property Procurement Inventories Capacity	Disruptions Delays Forecast Intellectual property Procurement
Organizational risks	Disruptions Forecast Intellectual property Procurement Receivables	Disruptions Systems Intellectual property Procurement Inventories Capacity	Disruptions Delays Forecast Intellectual property Procurement
Informational risks	Disruptions Forecast Intellectual property Procurement Receivables	Disruptions Systems Intellectual property Procurement Inventories Capacity	Disruptions Delays Forecast Intellectual property Procurement

3.2.2 Identify sources and drivers

When focusing on supply chain risks it is important that the focus is not only on identifying the direct risks, but also the potential causes or sources of those risks at every significant link along the supply chain (Christopher et al., 2002). Supply chain risks are influenced by different sources and drivers. After the risks have been identified it is important for organizations to understand what the sources or drivers of these risks are, this can help them prevent the risks from happening.

With regards to these risk drivers, Ritchie and Marshall (1993) suggest that risk drivers are associated with the seven sources: environment characteristics; industry characteristics; organization strategy; problem specific variables; decision making unit; supply chain configuration and supply chain members. Any one of the seven sources may generate new risks at any time on a continuous basis, affecting the profile of the organization (Ritchie & Marshall, 1993). Guiniero and Eltantawy (2004) identified a similar set of supply risk sources. The risks that these different sources establish can be separated into systematic and unsystematic risks, this gives an idea of the nature of the risk sources. According to Ritchie and Brindley (2004) it is not always possible to differentiate the risks into one of the two (systematic or unsystematic) because the passage of time may alter the position of the risk. When an organization is aware of the fact that these sources and drivers are related to the risks in the organization and in the supply chain, they can determine to mitigate the risk by changing the source or driver responsible for the risk. Knowing the sources and drivers makes the supply chain and the organization more transparent, which makes it easier to deal with risks. In Chapter 3.4 the risk mitigation options are outlined, some of these strategies focus on the drivers and sources of risks and how to influence them in order to mitigate the risk.

3.2.3 Risk measuring

In the previous steps the risks and their sources and drivers were presented. In order to determine the consequences of the risks the risks should be measured. Measuring the risks is done after identifying the sources and drivers, because these sources and drivers might influence the probability and impact. Risks can be measured in two different ways: qualitative and quantitative (Waters, 2007).

Qualitative risk measuring

Measuring risk in a qualitative way is useful for describing the nature of the risk and its effects and consequences. The absence of numerical data makes it difficult to compare the different risks. Qualitative measurements are for instance the image of a certain suppliers, or the way the supplier deals with safety issues.

Quantitative risk measuring

Quantitative analyses gives a more precise and objective description of the different risks and makes it possible to compare the risks and rank them based on the quantitative outcome. Quantitative risk assessment measures the risk based on a monetary or discrete value (Jallow, Majeed, Vergidis, Tiwari & Roy, 2007). According to Kendrick (2003) quantitative methods strive for greater precision, and they reveal more about each risk. Stakeholders that should be involved are, among others, subject matter experts and the person who identified the risk (Jallow et al., 2007). Together these stakeholders should determine what the most appropriate way is to measure the risk. Risk could be measured in, for instance, terms of money, time, image and sustainability.

Probability/impact

Using a quantitative analysis makes it possible to measure the risks on two aspects: the probability of occurrence and the consequences when the event occurs (Waters, 2007). With these two factors the risks can be calculated and it makes it possible to rank the risks. It is however not always easy to determine the likelihood (probability of occurrence) and the consequences (business impact) of the event.

According to Waters (2007) there are three approaches to find the probability of events:

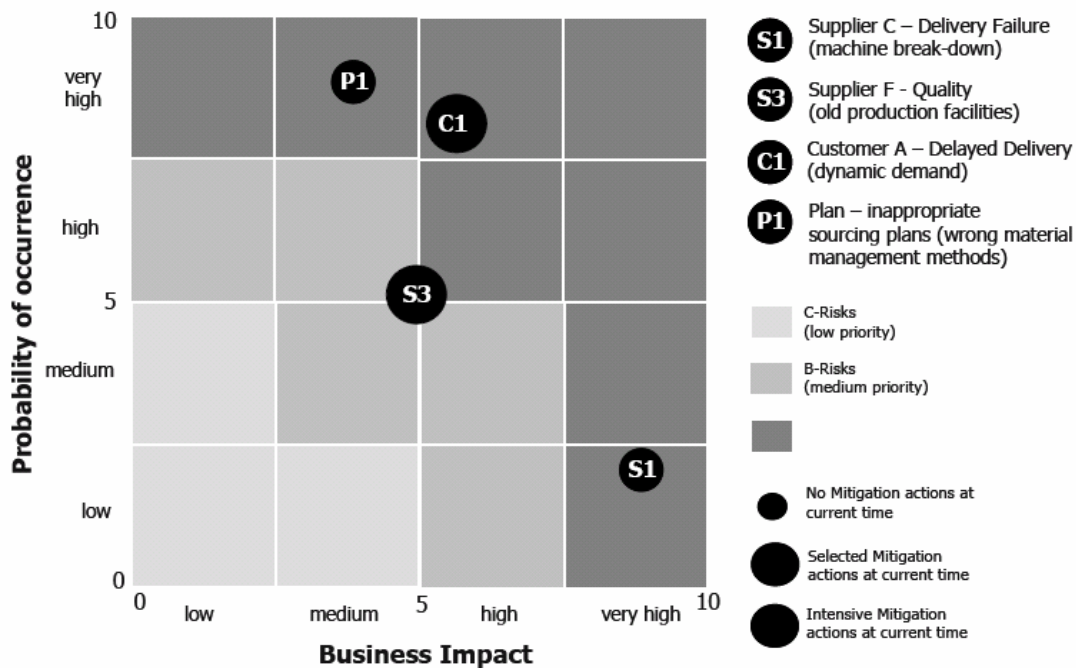
- Use knowledge of a situation to calculate a theoretical or a priori probability. The disadvantage is that real circumstances are complicated, which makes it difficult to do calculations that cover all circumstances.
- Use historical data to see how often an event occurred in the past and use this to estimate the probability of it occurring in the future. It is important to realize that conditions might have changed over time and that this can influence the probability of the event.
- Ask people for their subjective opinion about the probability of an event. This method is not very reliable since the objectivity is very low. The advantage of this method is that there are almost always people, and therefore data, available.

The impact of a risk depends on the consequence of the risk. Consequences can be seen as opportunities or as threats (AIRMIC, ALARM & IR, 2002). According to Hallikas et al. (2004) the potential consequences should be assessed from the viewpoint of the enterprise. So looking at what the consequences for the company are. Often the essential loss factors from the company's point of view are financial consequences like costs.

Important factors to be considered are also immaterial consequences such as trust, reputation and degradation of knowledge, which are hard to convert into monetary value, but which indirectly may cause financial losses (Hallikas et al. 2004).

The impact of an event is based on interpretation, as is the probability. Ranging the impact of an event can also be done with help of predetermined ranges or categories. After the impact and probability are estimated the different risk can be placed in the probability/impact chart, as shown in Figure 3.2.2.

Figure 3.2.2: Probability/impact chart

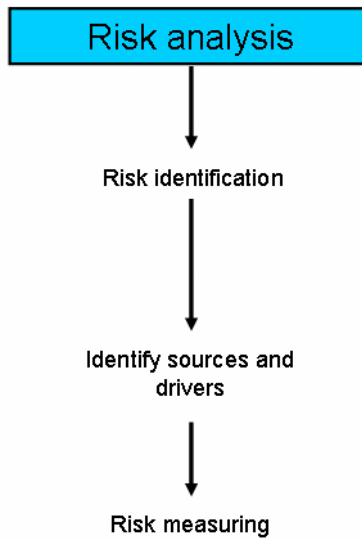


(Source: Jüttner & Ziegenbein, 2009)

3.2.4 Conclusion

Figure 3.2.3 shows the steps of the 'Risk analysis' phase. The first step is the risk identification. In this first step the organization should get an overview of the supply chain risks present in their supply chain. This can be done with the help of different tools and techniques, like for instance brainstorming and process mapping. After the supply chain risks are identified the second step is to identify the sources and drivers of these risks. Knowing where the risks come from and what triggers them will help select risk mitigation strategies in a later phase of the SCRM process. After the risks are completely known the risks should be measured. Measuring risks can be done in a qualitative or quantitative way. The most used form of measuring risks is by determining their probability and impact. Now that these steps are completed the organization should have a clear view of the supply chain risks in their supply chain, the sources and drivers of these risks and the organizations know how the risks are measured.

Figure 3.2.3: Risk analysis



3.3 Supply chain risk evaluation

In order to make decisions whether a risk should be mitigated or not, the supply chain risks should be compared with certain risk criteria. Selecting criteria and comparing and ranking the risks are mentioned by Mullai (2009) as some of the key stages of risk management. With the help of these criteria an organization can decide about which risks needs mitigation. Chapter 3.3.1 will describe the process of selecting risk criteria. Chapter 3.3.2 describes the essence of prioritizing and selecting the risks. In Chapter 3.3.3 a summary of the risk evaluation phase is given.

3.3.1 Select criteria

In the previous phase the risks were based on their probability and impact. These two dimensions give an idea of the importance of a risk. But the question which risk needs to be mitigated has to do with much more dimensions. According to the AIRMIC, ALARM & IRM (2002) risk criteria may include aspects as: associated costs and benefits, legal requirements, socioeconomic and environmental factors and concerns of other members of the supply chain.

The risk criteria can be summarized into the following four criteria categories: rules and regulations, industry criteria, company criteria and supply chain criteria. Rules and regulations include criteria determined by specific countries. These criteria can focus on aspects as human safety and health, environmental and property risks (Mullai, 2009). An example of rules and regulations is the new European chemicals regulation REACH. Industry criteria are determined by a certain industry like for instance the SHE regulation (Safety, Health and Environment), which focuses on accomplishments in the field of environmental protection, health, or safety (Society of petroleum engineers, 2009). Besides the risk criteria of a certain country or industry, organizations might have their own risk criteria. These criteria have to do with the organization's values, objectives and resources. Looking at supply chain risks there are also supply chain criteria. When organizations collaborate they might determine certain standards or agreements for their supply chain. Before organizations can determine which risks are the most important to mitigate, the organization should have a clear view of these criteria.

3.3.2 Prioritize and selecting risks

Now it is time to determine which risks need to be mitigated. In order to do this the risks need to be prioritized, based on qualitative and quantitative aspects. Prioritizing the risks is based on the criteria selected in the previous phase and by the probability and impact of the risks. When prioritizing the risks organizations are influenced by their experience and attitude. Risk perception and risk attitudes are affected by different factors, like the types of risks involved, benefits of risk sources, the ability of people to control risks, familiarity with risks, the concentration of risks, the type and the severity of consequences, and uncertainty about the consequences (Mullai, 2009).

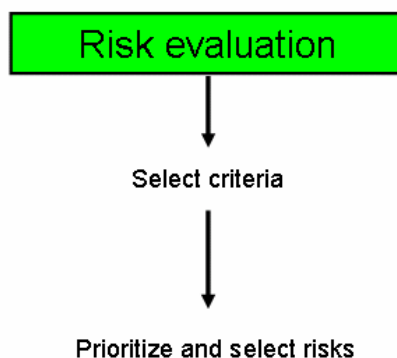
The different risks should be compared with each other and ranked according to their significance as well as their sensitivity, based on the criteria mentioned in Chapter 3.3.1 and the probability and impact of the risks. Usually the risks with the highest priority are the risks that have the highest impact on the supply chain and on the organization. The question whether these are also the risks that have the greatest probability, is more difficult to answer. According to Waters (2007) *“risks that have a low probability are unlikely to occur, so managers can pay less attention to them, even when the consequences are severe”*. The Albuquerque incident (Appendix 4) shows that this is not always the best way to deal with risks. It shows that when an event with a small probability occurs it can however have a huge effect on the financial situation of the company. It is therefore important that the organization does not only focus on the probability and impact but also looks at the other criteria.

Prioritizing risks makes it easier to allocate the resources that are available and the time and money that is put into managing the risks (Mullai, 2009). After prioritizing the risks the organization should determine whether the risks with the highest priority are indeed the risks that will be treated. This also depends on the aspects mentioned before by Mullai (2009).

3.3.3 Conclusion

In the risk evaluation phase the different supply chain risks are prioritized. The criteria that have an influence on the priority of the risks are: rules and regulations, industry criteria, company criteria and supply chain criteria. These criteria, together with the probability and impact of the risks are the most important criteria when prioritizing the risks. After the risk evaluation the organization knows which risk should be mitigated. Figure 3.3.1 shows the different steps in the risk evaluation.

Figure 3.3.1: Risk evaluation



3.4 Supply chain risk mitigation

In the previous phase a ranked list of risks was established. Risk mitigation focuses on the most suitable mitigation option and the way this mitigation option should be implemented. This chapter focuses on the different risk mitigation options and how to select the right option (Chapter 3.4.1). Chapter 3.4.2 describes implementation options. Finally Chapter 3.4.3 gives a conclusion of the risk mitigation phase.

3.4.1 Select mitigation option

Before choosing a risk mitigation option it is important to have insight in the different risk mitigation options. When the different mitigation options are familiar the organizations can choose an appropriate option for the different risks.

Mitigation options

In literature different risk mitigation options are outlined (Mullai, 2009, Waters, 2007, Kersten, Hohrath & Böger, 2007, Hallikas & Virolainen, 2004, Norrman & Lindroth, 2002). Risk mitigation options that are mentioned by almost all of these authors are: risk avoidance, risk transfer, risk reduction and risk acceptance. These different options can be applied individually or in combination.

Risk avoidance

The main goal of avoiding risk is to reduce the probability of occurrence (Kersten et al., 2007). Avoiding risk is to eliminate the type of event that could trigger the risk. The most effective way is to eliminate the causes of incidents pro actively. In order to effectively avoid risk it is important that there is transparency in the supply chain network, because otherwise organizations would not be able to recognize the risk sources in time (Kersten et al., 2006). Avoiding risk in the supply chain can be related to products, geographical markets and or supplier and customer organizations (Jüttner et al., 2003).

Risk transfer

Risk can be transferred to insurance companies or to supply chain partners. Transferring risk does not solve or eliminate the risk, looking at the supply chain as a whole. It only moves the risk away from the organization, on to another organization. The most common is transfer by insurance.

The essence of risk insurance is that an insurance company can pool the risks and share the costs, when the risk is too high for one organization to accept (Waters, 2007). According to Kersten et al. (2007) "*the transfer strategy is suitable when a potential damage is materially and the continuance of the firm is not affected.*" The transfer strategy is interesting when a potential damage is materially and the continuance of the firm is not affected (Kersten et al., 2007)

Risk reduction

Risk reduction can be realized by reducing the probability of the risk and/or by reducing the consequences. In reducing the probability of the risk, managers take actions to reduce the probability that an event, that might cause the risk, will occur. According to Waters (2007) there are two ways of reducing the probability. The first way is to take actions to reduce the probability. The second way is to avoid operations where the risk might occur. Mullai (2009) mentions that reducing the frequency of causes and eliminating some causes, are options to reduce the probability of risk.

Reducing or limiting the consequences of risk can be realized by reducing or mitigating the consequences or by reducing the frequency of the consequences (Mullai, 2009, Waters, 2007). In order to reduce risk to the highest extent, both the probability as well as the consequences of the event should be minimized.

Risk acceptance

In contrast to the other risk mitigation options it is also possible for organizations to accept, or even ignore, the risk. Accepting a risk means that the organization accepts the impact and consequences the risk has on the organization (Waters, 2007). The choice to accept risk might have to do with the costs of avoiding, reducing or transferring the risk or the lack of good risk management. Sometimes organizations have to accept a risk because they can not avoid, reduce or transfer the risk. When for example there is only one supplier for a specific material, and no substitutes, the company has no choice then to accept the possible risks that are related to this supplier.

Risk mitigation selection

The decision which risk mitigation strategy is chosen is influenced by several aspects, as: the risk portfolio, the supply chain network the organization is part of and the overall competitive strategy of the supply chain (Kersten et al., 2007). According to Mullai (2009) the process of decision making *“is complicated by the variety and complexity of choices and the environment in which they are made, multiple and often conflicting objectives, different perspectives on risks, the uncertainty and the sensitivity of decisions.”* Decision makers need to have reliable and accurate information to support their decision for a certain risk mitigation strategy.

A very important aspect in choosing a risk mitigation strategy is the financial aspect. According to the Committee Draft of ISO 31000 (2007) *“selecting the most appropriate risk treatment option involves balancing the costs and effort of implementation against the benefits derived”* but *“legal and regulatory requirements and social responsibility override financial cost benefit analysis”*. Organizations must consider which aspects weigh the most and on the basis of this, choose a risk mitigation option.

Another very important aspect is the opinion of the stakeholders. Choosing for a certain strategy will influence the whole supply chain and therefore the members of the supply chain. Ideally a supply chain risk mitigation option should be chosen in consultation with the different supply chain members.

3.4.2 Implement mitigation

After choosing the appropriate risk mitigation option it is important to decide on how to implement that option. The operation that will be chosen to reduce, transfer, avoid or accept the risk depends on several factors, like for instance the position of the organization in the supply chain, the degree of collaboration and the responsibilities in the supply chain. Different operations, found in literature, which could be used to mitigate risks are:

- Adjust the design of the supply chain
The design of the supply chain, where an organization is in, is partly responsible for the risks that are present. The design has to do with the supply chain structure, which is described in Chapter 2.1.2.

An important feature of a low risk supply chain is that it has parallel paths. In order to reduce certain risks, parallel paths that give routes around the problem, should be created. Examples of these parallel paths are multiple sourcing and outsourcing (Waters, 2007). The length of the supply chain also has a huge impact on risk. A higher degree of supply chain integration can reduce the risks of a long chain as well as transparency among the supply chain partners.

- **Increase collaboration**
Working closely together with suppliers and customers can reduce risks. Collaboration makes methods for reducing risk, such as sharing information, joint forecast and shared planning more effective (Waters, 2007). Having a close relation with key suppliers and key customers is important when treating risks in the supply chain.
- **Binding contracts**
Contracts can be helpful in deciding who is responsible when something goes wrong. Drawing up definite contracts is difficult because partners do not always agree on them. In times of trouble contractual arrangements sometimes break down and contract can become useless (Waters, 2007). Stable relationships are then more important than contracts. Strategic relationships are therefore important when it comes to treating risks.

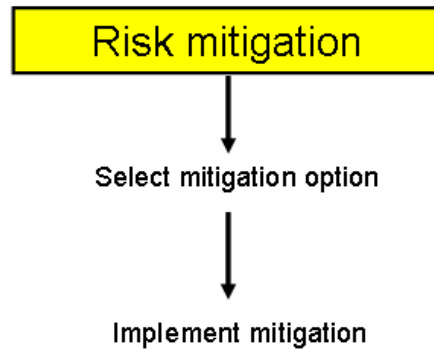
The actual operations should be included in the development of an implementation plan. According to Waters (2007) there are two stages in implementing a risk mitigation option: implementation and activation. Implementation has to do with introducing the aspects as the policies, measurements and procedures, that are needed to deal with risks or the events causing the risks. Activation focuses on monitoring the operations, and seeing whether a risk or event materializes and taking action when it does (Waters, 2007).

In the implementation phase it is important to have a clear view of the resources that are required to implement the risk mitigation strategy at the different management levels and within each business unit. In order to make the risk mitigation strategy a success risk management should be embedded within the whole organization, it must be reflected in the strategy and the budget processes (AIRMIC, ALARM, IRM, 2002).

3.4.3 Conclusion

The organization has to decide, on basis of the risk portfolio, the supply chain network the organization is part of, the overall competitive strategy of the supply chain, the financial aspects and the stakeholders, which risk mitigation strategy is the most appropriate for the different risks. The basic four mitigation options are: risk avoidance, risk transfer, risk reducing and risk acceptance. The decision is based on several aspects: the risk portfolio, the supply chain network the organization is part of, the overall competitive strategy of the supply chain, the financial aspect and the stakeholders. After deciding on the right option for the risks, it is important to determine how to implement the chosen option. There are different operations that might help the organization to avoid, transfer, reduce or accept the risk. The supply chain components described in Chapter 2.1.2 play an important role in choosing the right operation. Figure 3.4.1 shows the different elements of the mitigation phase.

Figure 3.4.1: Risk mitigation



3.5 Monitoring

After the risk analysis, risk evaluation and risk mitigation the risk management process has to be monitored. Monitoring is a combination of checking and follow-up. Chapter 3.5.1 describes the elements of checking SCRM and Chapter 3.5.2 the follow-up. Chapter 3.5.3 gives an overall conclusion of the monitoring phase.

3.5.1 Checking

Checking SCRM has to do with different aspects, like: analyzing and learning lessons from events that might cause risk and changes and trends in the supply chain, following and detecting changes in the external and internal context of the supply chain, including changes to the risk itself and ensuring that the SCRM method is effective in both design and operation (Committee Draft of ISO 31000, 2007).

Checking SCRM can be done on a regular basis or ad hoc. This depends on the type of risk and the developments internal and external to the supply chain. There are different ways to evaluate and monitor the SCRM strategy (Mullai, 2009). Besides checking the process it is also important to look at the results of the risk mitigation. The USCG (2001) has designed three principal criteria, which are:

- Efficacy. This is the degree to which the risks will be eliminated or minimized by the proposed actions in the SCRM strategy
- Feasibility. Has to do with the acceptability of implementing the proposed preventative action and staying within the boundaries of the budget.
- Efficiency. This is the cost-effectiveness of the proposed actions in terms of money lost if no action is taken versus the cost of the action.

3.5.2 Follow up

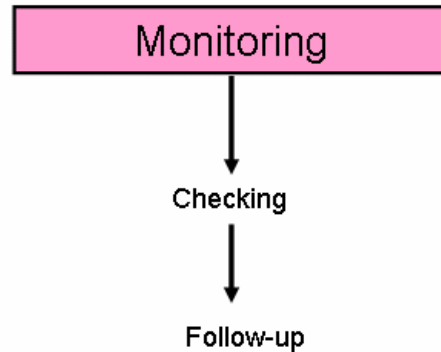
When the risk is not reduced, or cannot be reduced, to a, for the supply chain members, acceptable level a follow up is needed. This could mean that the risk has to be analyzed and evaluated again or that other risk mitigation options should be used to treat the risk.

Follow up is not only needed when the risk is not reduced. It is also important to keep checking whether the risk is stable or if the risk might change. This is also closely connected to monitoring SCRM. Follow-up has a strong relation with all the phases in the SCRM process because follow-up can have an effect on all these different phases.

3.5.3 Conclusion

The final phase of the SCRM process is monitoring. Monitoring exists out of checking and follow-up. Checking is divided into checking the process and checking the results on three levels: efficacy, feasibility and efficiency. After the process and results are checked a follow-up might be necessary. Figure 3.5.1 shows the different elements of the monitoring phase.

Figure 3.5.1: Monitoring



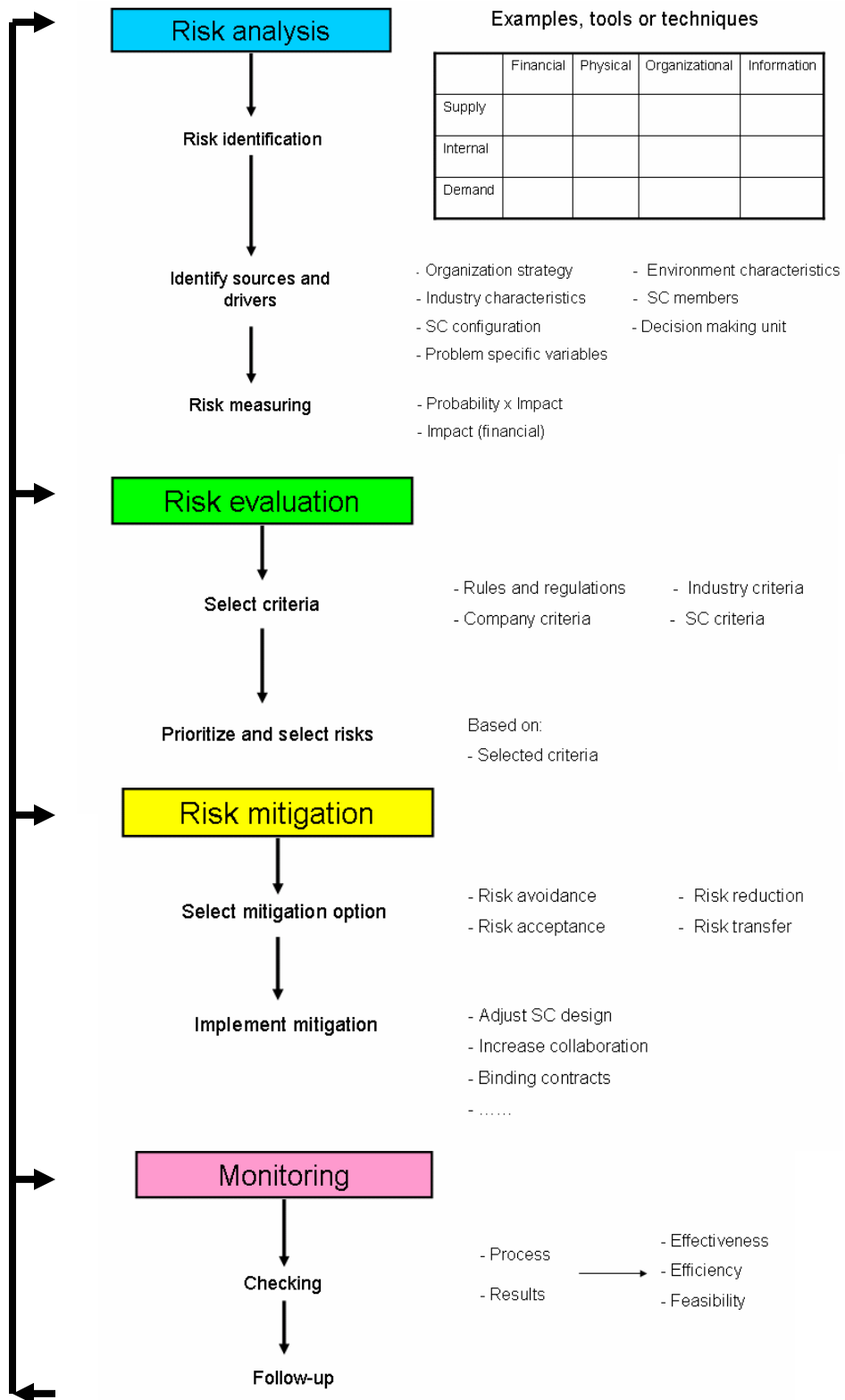
3.6. Conceptual SCRM method

The research question belonging to the theoretical framework is: *What elements can be part of a method for supply chain risk management in the process industry, according to literature and expert knowledge?* In this chapter the conceptual SCRM method is presented and the research question is answered.

The SCRM process consists out of four phases: risk analysis, risk evaluation, risk mitigation and monitoring. Each phase has its own goals and steps. The different steps are guided by examples, tools and techniques, on a dynamic basis, belonging to that specific step. These examples, tools and techniques are not exclusive and are intended to give the organizations a guideline.

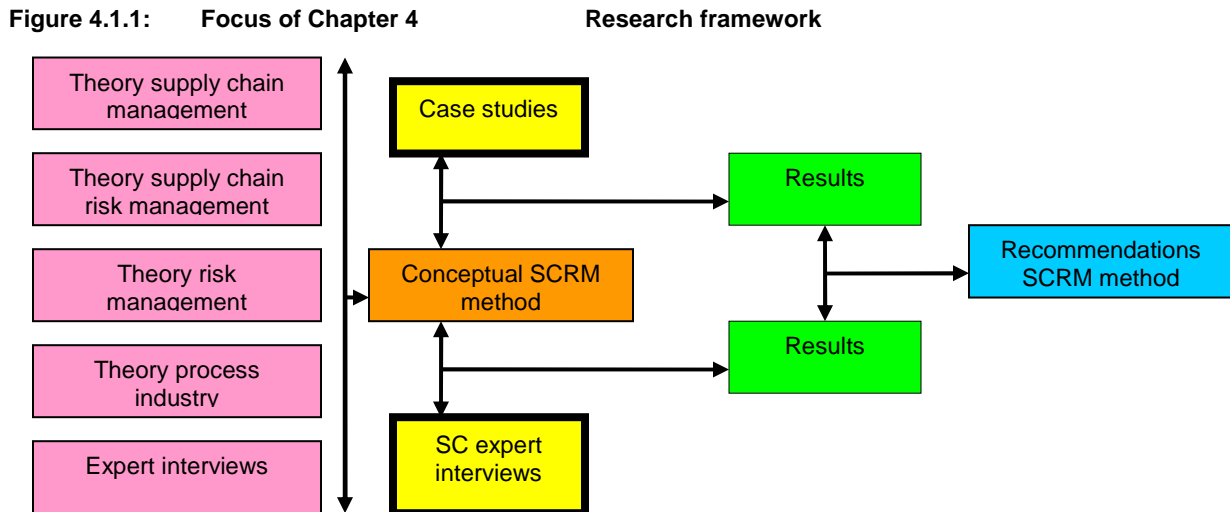
The conceptual SCRM method will be used as an input for the case studies and the expert interviews. The methodology is described in the next chapter. Figure 3.6.1 shows the conceptual SCRM method with the four phases, the different steps and the examples or tools and techniques guiding that step.

Figure 3.6.1: The conceptual SCRM method



4. Methodology

The empirical research consists of interviews with two SC experts and two case studies. This chapter first explains where the focus of the interviews and the case studies will be on. Then the goals of the expert interviews and the case study are described in Chapter 4.2. Chapter 4.3 introduces the interview partners. In Chapter 4.4 the type of interview and the structure are outlined. The final chapter (Chapter 4.5) gives an insight in the interview procedure. Figure 4.1.1 shows the focus of Chapter 4.



4.1 Focus

The expert interviews and the case studies have their own focus. This chapter describes where the focus will be on in the expert interviews and in the case studies.

4.1.1 Expert interviews

The experts are consultants of Coppa Consultancy who have an expertise in SCM and are familiar with the process industry. It is important that the consultants are able to determine whether the SCRM method is useful and suitable to work with, in the process industry. The focus of the interview will be on the structure of the SCRM method, the different elements and whether or not the available tools and techniques are useful for the different steps in the method.

4.1.2 Case studies

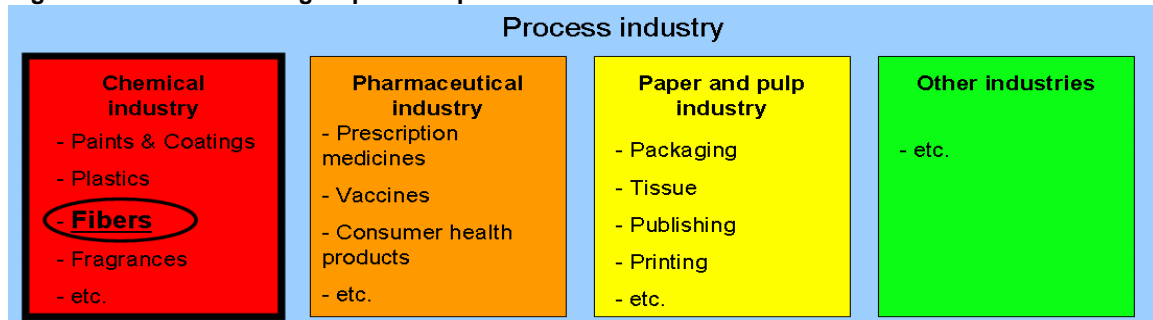
As described in Chapter 1 the case study will be performed in the chemical fiber producing industry and focused on exploration and the SCRM method. This chapter describes in more detail why the focus is on this typical industry and which type of risks will be outlined.

Chemical fiber producing industry

Within the chemical industry there are several product categories, like for instance: paints, coatings, plastics and fibers (see Figure 4.1.2). To make the research more specific, chemical organizations, which focus on one of these product categories, are chosen for the case study. Choosing a specific type of chemical organization makes the focus more specific and the conclusions better founded.

Generalizing the results of the case study to a larger group is not the purpose of a case study and therefore it is not harmful for the goal of the case study to focus on a specific group. The chemical organizations that are chosen for the case study are organizations producing chemical fibers. This choice was based on personal interest of the researcher and the chemical industries that are present in the network of Coppa Consultancy. In the Netherlands there are just a few chemical fiber producing organizations, two with which Coppa Consultancy has contacts. The chemical, fiber producing, organizations that will contribute to the case study are introduced in Chapter 4.3.

Figure 4.1.2: Product groups in the process industries



Supply risk

In Chapter 2.4.3 three risk categories were outlined: supply risks, demand risks and internal risks. To make the research more specific one of these three risk categories has been chosen for the focus of exploration aspect of the case study. It would be more accurate to take all supply chain risks into account, but due to time constraints this is not possible. The supply chain risk category that is chosen for the case study is the risk category 'supply risks'. This risk category is chosen because internal risks, that are present in the organizations, are often well known due to strict regulations. The risks that are external to the organization are expected to be less known. The second reason for choosing supply risks has to do with the fact that Coppa Consultancy, as a consultancy agency providing services concerning purchase and logistic issues, has a specific interest in risks related to these issues.

4.2 Goal

The expert interviews and the case studies have their own goals. These goals are described in this chapter.

4.2.1 Expert interviews

The main goal of the expert interviews is to check whether the consultants find the method useful to work with, especially in the process industry. Each element of the method will be validated. The consultants should give their opinion on the method, the structure and the examples, tools and techniques. Their recommendations concerning the SCRM method are used as input for the revised SCRM method.

4.2.2 Case studies

The case studies have two specific goals, these goals are outlined in this chapter as well as a few expectations related to these goals.

Exploration

The first goal is to get insight in the current supply chain risk procedure of the participating organizations and the most important supply risks they identify with this procedure. It is important to get insight in the current SCRM method because it might influence the respondent opinion of the conceptual SCRM method.

Linked to this goal there are a few expectations. The first expectation is that the participating organizations are familiar with SCRM but that SCRM is not fully integrated in the organization yet. This expectation is based on expert interviews. The second expectation has to do with the supply risks. The expectation is that the supply risks, that are the most important for the participating organizations, are comparable to the supply risks mentioned in an expert interview, which are:

- Increasing product prices
- Availability of raw materials
- Non-sustainable behavior of suppliers (SHE regulations)
- Availability of REACH approved suppliers
- Nonconformity to specifications

Usability of conceptual method

The second goal is focused on whether the elements of the conceptual SCRM method are suitable elements for managing SCRM in the participating organizations. Knowing whether the elements of the method are suitable gives an important view on the usability of the SCRM method and the possible bottlenecks that might come up when implementing this kind of method. The results will be an important input for answering the research question: *What is the value and quality of the elements of the conceptual method, according to supply (chain) managers in the chemical fiber producing industry?* To check whether the conceptual method is useful, the different steps (analyze, evaluate, treat and monitor) and the elements belonging to these steps will be discussed.

4.3 The interviews

Before interviewing the experts and the case study respondents a few aspects have to be made clear. Important aspects are the type of interview, the structure of the interview and the interview procedure. In this chapter all these aspects are described.

4.3.1 In-depth interview

The interview type most suitable for the interview goals is an in-depth interview. This type of interview is most suitable because an in-depth interview allows person to person discussion and it can lead to increased insight into people's thoughts, feelings, and behavior on important issues (Guion, 2006). The key characteristics of in-depth interviews, that have to be taken into account for this case study, are:

- Questions should be phrased in a way that respondents cannot simply answer yes or no, but must explain the topic. The questions should be open-ended.
- The interviews have a semi-structured format. Besides having some pre-planned questions to ask during the interview, it is important that the questions flow naturally, based on information provided by the respondent.
- Try to interpret what is said, as well as seek clarity and a deeper understanding from the respondent throughout the interview.
- Besides the verbal answers it is also important to record the non-verbal behaviors.

4.3.2 Structure

One of the characteristics of in-depth interviews is the semi-structured format. The fact that an in-depth interview is semi-structured means that it is not practical to make a list of interview questions, this does not influence the interview in a positive way. It is however important to create a certain structure in the interview.

Expert interviews

The structure that will be used for the expert interviews is the following (Appendix 5 gives an overview of the different steps and guiding questions. Appendix 7 shows the handouts for the interview):

Introduction (2 minutes)

The interview will start with an introduction in which the goal and the structure of the interview are outlined. The respondent will also be informed about the timeframe.

The SCRM method (45 minutes)

Each element of the method will be validated and the tools and techniques suitable for the different elements will be discussed. This will be done for each SCRM phase separately: risk analysis, risk evaluation, risk treatment and monitoring.

The main question for each phase is: *Can you explain how useful you find these steps and strategies for risk analysis/risk evaluation/risk treatment/monitoring?* As described in Chapter 9.2.1 the main goal is to check whether the consultants find the method useful to work with, especially in the process industry.

Conclusion (2 minutes)

Finally the interview concludes with a short summary of the interview, the further procedure and the interviewee will be thanked for his time and input.

Case study interviews

The structure that will be used for the interviews is the following (Appendix 6 gives an overview of the different steps and the guiding questions. Appendix 7 shows the handouts for the interview):

Introduction (2 minutes)

The interview will start with an introduction in which the goal and the structure of the interview are outlined. The respondent will also be informed about the timeframe.

Part 1 - Exploration (10 minutes)

The first part of the interview will focus on exploring the current SCRM situation at the respondents' organization. The main question that will be asked is: *In what way is your organization currently working with SCRM?* The purpose is to get full insight in the current methods and procedures, concerning SCRM, within the organization.

Part 2 - Supply risks (10 minutes)

After the respondent has described how his organization deals with SCRM, the focus is on the most important supply risks the organization identifies. The question to be answered is: *What are, at this moment, the most important supply risks within your organization?* This question should create insight in the supply risks, their importance and the reasons why these supply risks are the most important.

Part 3 - Method (30-40 minutes)

Now that the current SCRM method and the most important supply risks are clear the interview will focus on the usability of the conceptual method. The usability will be discussed separately for each SCRM phase: risk analysis, risk evaluation, risk treatment and monitoring. In each phase the different steps and elements will be discussed. The main question for each phase is: *Can you explain how useful these steps and strategies are for risk analysis/risk evaluation/risk treatment/monitoring within your organization?* The respondent is triggered to give his opinions and ideas about the phase, the elements and the examples, tools and techniques. As described in Chapter 4.2.2 the main goal is to explore the usability of the elements of the conceptual SCRM method.

Conclusion (2 minutes)

Finally the interview concludes with a short summary of the interview, the further procedure and the interviewee will be thanked for his time and input.

4.3.3 Interview procedure

In this chapter the following issues will be outlined: approaching the respondents, the interview procedure and the procedure after the interviews. The interview procedure is the same for the expert interviews as well as for the case study interviews.

Approaching the respondents

The expert will be approached directly to make an appointment for the interview. The case study respondents will receive an email (Appendix 8) or telephone call from their contact person at Coppa Consultancy. In this first contact it will be made clear why the organization benefit from participating in the research. The first benefit is that the organization gets insight in the SCRM method, which might be interesting for them to use. Secondly the organizations get insight in the supply risks that are the most important in their industry (and at their competitors). These results can be used as a kind of benchmark. After the respondents agree with participating in the research a date will be set for the interview.

Interview procedure

The interviews will be of the 'face to face' kind, held at the respondent's office to make participation as easy as possible for the respondents. The interview will be conducted in line with the earlier mentioned interview structure. The method will be constant during all the interviews.

Before the first interview with a respondent, a 'trial' interview is held with an expert of Coppa Consultancy, to see whether the procedure and questions are suitable. The interviews with the respondents will be recorded and notes will be made. At each interview the interviewer will be accompanied by a Coppa Consultancy colleague.

After the interviews

After the interviews are held the interviews need to be transcribed and analyzed before they can be used as input for the report. For each question the response from the interview will be written out, using the notes made during the interview and the recorded audio-tape. The transcribed interview will be sent to the respondent for verification. After the transcribed interview is approved by the respondent the interviews are analyzed. Analyzing the interviews involves determining the meaning in the information gathered in relation to the purpose of the study (Guion, 2001). The different interviews will be checked for commonalities and differences. These commonalities and differences will be the most important input for modifying the SCRM method and creating recommendations concerning the SCRM method.

In August 2009 all respondents will receive the final thesis document.

4.4 Interview partners

The experts that are used for the expert interviews and the organizations and respondents participating in the case studies are described in this chapter.

4.4.1 Expert interviews

The two experts that participate in the expert interviews are (ex) employees of Coppa Consultancy. Both consultants are briefly introduced and their expertise is described.

Drs. M.A.J. Nieuwboer

M.A.J. Nieuwboer is a senior consultant at Coppa Consultancy. He is a supply chain and sourcing expert. His main focus is on the following subjects: supply chain and operations, global sourcing, out and in-sourcing projects, supplier development and risk management. M.A.J. Nieuwboer has worked primarily in the process industry.

G.C. Ekhart, MBA

G.C. Ekhart is ex-managing partner of Coppa Consultancy. He is a supply chain and operations professional with his main expertise in supply chain transformation and supply chain redesign and restructuring. G.C. Ekhart has worked in different types of industries, like the process and food industry.

4.4.2 Case studies

The fact that the focus is on the supply risks has an influence on the type of respondents needed for the interviews. The respondents should have insight in the current SCRM procedure and a specific knowledge of the most important supply risks within their organization. Besides that the respondent should also be able to determine whether the conceptual method could be useful for identifying, evaluating and treating supply chain risks. Specific respondents with this knowledge could be a supply manager, supply chain manager, procurement manager, sourcing manager or even the CPO or CEO.

There are two organizations participating in the case study. These organizations are briefly introduced.

Teijin Aramid B.V.

Teijin Aramid produces four different aramids in a variety of formats. Aramid is used for a broad range of applications requiring a combination of high strength, durability, safety and/or light weight. Examples of applications of aramid are: tires, hoses, ignition cables and heat protection products (Teijin, 2009). Teijin Aramid places their products on the market under the following brands: Twaron®, Solfron®, Teijinconex® and Technora®. The respondent is the Supply Chain Manager of Teijin Aramid B.V.

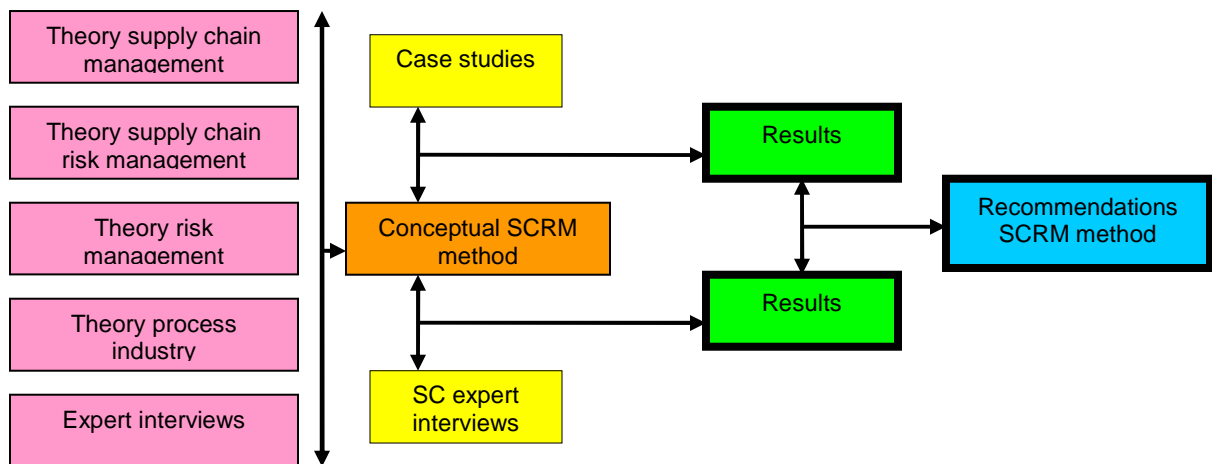
Colbond

Colbond is a globally active producer of industrial nonwovens for flooring, automotive and construction applications and 3D polymeric structures and composites for civil engineering, building and industrial applications. Colbond is part of the Technical Textiles division of Low & Bonar PLC, an international group manufacturing and supplying a wide range of high performance specialist materials. The respondent is the Purchasing Director of Colbond.

5. Results

The previous chapter described the empirical research methodology. The objective of Chapter 5 is to provide the results of the interviews carried out during the expert interviews and the case study research. First the outcomes of the expert interviews are presented in Chapter 5.1. Then the case studies are described in Chapter 5.2, starting with the exploration, of the participating organizations, and then the results belonging to the usability of the SCRM method are outlined. Chapter 5.3 describes the lessons learned, based on the results described in Chapters 5.1 and 5.2, and gives the revised SCRM method.

Figure 5.1.1: Focus of Chapter 5 Research framework



5.1 Expert interviews

In the interviews with the two experts the focus was on the research question: *What is the usability of the conceptual SCRM method according to the SC experts?* The experts have looked at the method and given their comments and remarks on the different phases and elements, and on the examples, tools and techniques belonging to these phases and elements. The reactions from the experts will first be described for the four separate SCRM phases and then the general comments on the SCRM method are given.

Risk analysis

The 'Risk analysis' phase of the SCRM method is a phase where experts have some question marks concerning the order of the steps and the risks involved.

Risk identification

When identifying risks it is important to determine what the scope is. What risks are seen as supply chain risks and are therefore included in the identification? And how many tiers in the supply chain does the organization want to focus on?

An important issue in the risk identification is the amount of risks the organization identifies. Is the organization going to list all the risks they can think of, and create a list of for instance 200 risks? Or is the risk identification already based on a certain criteria so that the list is, for instance, just 50 risks?

G. Ekhart believes that the organization should identify as many risks as possible, but these risks should be realistic risks, based on common sense. Suppliers and customers can help the organization identify these risks and broaden the horizon.

M. Nieuwboer states that the organization should first develop a long list of risks and that these risks should then already be plotted in the probability/impact chart, to create a shorter list. The sources and drivers can then be identified for the risks on the short list. The two experts agree on the fact that it is not useful to come up with a list of, for instance, 200 risks. The risk identification should already be based on certain criteria. Whether these criteria are quantitative or qualitative is difficult to determine. According to the experts this depends on the circumstances and should be experienced in practice.

Identify sources and drivers

When the risks have been identified these risks are investigated by identifying the sources and drivers. According to G. Ekhart the sources and drivers of internal risks are often already known by organizations. The sources and drivers of the supply and demand risks are often less familiar and therefore very challenging. Suppliers and customers can, again, help the organization identify these sources and drivers. Besides identifying the sources and drivers it is also essential to look at the coherence between the different risks. M. Nieuwboer states that these insights make it clear for the organization how certain risks are created and what the causes of these risks are. An addition to the types of sources and drivers is the legislation aspect. Legislation is often leading for certain risks and can therefore not be neglected.

Risk measuring

Measuring risks with the help of probability and impact makes the risks comparable. The impact is often determined in financial terms. Making the impact of risks financial creates a clear measurement and people are forced to think of risks in a financial way. It might also be possible to measure risks in several categories like for instance in money, time and image. Whether risk measuring is the third and therefore last step in the 'Risk analysis' phase can be discussed. This depends on the choice that is made in the first step of 'Risk identification'. When the long list is already reduced to a short list, with the help of the impact and probability, it is not necessary to measure the risk again. It could however be interesting to look at the consequences of the risk very precisely.

Risk evaluation

The 'Risk evaluation' is focused on evaluating the risks, selected in the 'Risk analysis' phase, by different criteria.

Select criteria

The four risk criteria groups are, according to the experts, complete. The different aspects that are important in risk management can be placed under one of these four risk criteria groups.

Prioritize and select risks

In the step of selecting the risks it is, according to the experts, not interesting to focus on the financial aspect (seen as the costs or profit related to mitigating the risk). When the financial aspect is already taken as criteria in this step of the SCRM process, important risks will be excluded from the list to soon. The selection of the most important risks should be based on the probability and impact and at the criteria determined in the previous step. These two aspects will determine which risks are the most important to take into account.

Risk mitigation

Looking at the 'Risk mitigation' phase, the experts determined that this phase is missing a step. After the mitigation option is selected, the organization has to determine which actions should be taken. When these actions are determined the organization can start implementing the conditions for these actions. So instead of two steps, this phase should consist out of three steps: 1. selecting the mitigation option, 2. determine on actions and 3. implementing the actions.

Select mitigation option

The four mitigation options are complete. The selection of the right mitigation option should be based on the feasibility. The organization should determine how feasible it is to transfer/reduce/accept or avoid the risk. Feasibility includes aspects as finances, people and sources.

Implement mitigation

The aspects that are included in the method are actions that organizations can take to mitigate the risks. After these actions are known the organization can create an implementation plan and implement this. When implementing the mitigation strategy it is important that it is not a stand-alone plan. According to G. Ekhart the plan should be imbedded in the processes of the whole organization and become a common goal. M. Nieuwboer states that there should be a senior manager responsible for the implementation, this will contribute to imbedding risk management within the organization. To create general support it is important that the whole MT supports the mitigation strategy. More about: people involved in, and responsible for the implementation of SCRМ is outlined under the 'General comments'.

Monitoring

Both experts find the 'Monitoring' phase a very important phase in the SCRМ process.

Checking

Checking the results can be done by checking the probability and impact of the risk after the mitigation. By doing this the results become clear and risks are managed in an active way. When the results are made clear SCRМ will generate a higher support within the organization. The process is closely related to the results. When the results are satisfying this implicitly means that the process was correct. When organizations are working with SCRМ, checking the process is especially important in the first couple of SCRМ projects. When the process turns out to be effective the check on the process is not necessary every time the SCRМ method is used.

Follow up

The follow up should be closer related to the 'Analysis phase'. It is not obvious enough that the follow up has an effect on the whole SCRМ process and that this starts with the 'Analysis phase'. The current SCRМ method does not show this relation explicitly enough.

General comments

Besides the reactions on the four SCRM phases there are also general comments on the whole SCRM method. The first comment has to do with the implementation of the SCRM method and the second aspect is the method itself.

Implementation

The first general aspect has to do with the implementation of SCRM. G. Ekhart states that SCRM should be placed at people who are operationally involved in the SC. These people experience the risks up close. Involving these people in the SCRM process creates a higher support and makes the people more aware of the importance of SCRM. When designing SCRM, the organization has to realize that people within the organization are often already using risk management for their own part of the work. They might however be unaware of this. SCRM gives these people a helping hand and clear structure. SCRM could start up as a project, but ultimately SCRM must be supported by the entire organization and not just by members of the project team or the MT. M. Nieuwboer states that SCRM should be carried out by a project team. This project team should include managers as well as general employees from the concerned departments. SCRM is a continuous process which is passed through once a while, in a group setting. The project team should meet periodically and check the rules (eg. risk policy, strategy). Although the two experts differ on the way SCRM should be carried out, they do agree on the fact that SCRM should be imbedded in the whole organization. More about implementing SCRM can be found in the Chapter 7.

The method

G. Ekhart's opinion is that the continuous character of the SCRM method should be made more explicit. This can be done by placing the phases in a circle or making the arrows more specific. It is also important to make the method a real SC method by using specific elements that are applicable in the SC.

M. Nieuwboer uses different phases in his SCRM method. The phases are Define, Analyze, Design, Treat and Monitor. A lot of these phases overlap the phases of the SCRM presented in this research. The main differences can be found in the Define phase, as already described in the 'Risk analysis' part of this chapter.

5.2 Case study results

The case studies consist of two separate parts. The first part was focused on exploring the organizations and their experiences with SCRM and the second part focused on the usability of the SCRM method. Chapter 5.2.1 will focus on the first aspect, the exploration, after which Chapter 5.2.2 describes the usability of the SCRM method.

5.2.1 Exploration

The exploration part of the interview was focused on getting insight in the current SCRM method of the organizations and the most important supply risks these organizations face. In this chapter an answer will be presented to the following research questions: *"What is, according to the respondents, the importance of SCRM in their organization and how is SCRM imbedded in their organization"* and *"What are the most important supply risks these organizations signal?"*. These questions will be answered for the two organizations separately.

Colbond and SCRM

Colbond is at this moment not working with SCM, but with separate components like purchase and logistics. The idea is to combine these different aspects in SCM in the future. According to Colbond this will increase the structure, gives a clear orientation and creates more security, which is of great importance in purchase and logistics. The concept of SCRM is also worked with within Colbond. Risk management in general is however a point of discussion with the MT, but Colbond has no systematic way to deal with risks. In some cases the risks are identified and defined, but they are often difficult to tackle. Colbond has no concrete policy on risk management.

The most important supply risks Colbond faces, are:

- Suppliers can not meet Colbonds specifications concerning e.g. requirements and volumes
- Market developments (resulting in shutdown of production and changing production lines)
- Not being able to meet customer's demands, with possible claims as a result.
- Technical risks, such as machine breakdown and technical failures.

According to Colbond these risks are not unique for organizations with polymer production. Supplier specifications do not describe the applicability for the production processes completely because they are mainly developed for other use and have no direct relation to the sales specifications. An important problem Colbond faces is the fact that several suppliers are strategic suppliers for Colbond, but Colbond is not seen as a strategic customer by these suppliers. Large strategic customers have more influence on the suppliers than Colbond has.

Teijin and SCRM

Teijin is working with risk management. Once or twice a year the MT creates a list with the most important risks factors for Teijin. The focus is broader than just the supply chain risks but include risks for the entire business in the broad sense of the word. The MT also looks at the actions that should be taken considering these risks.

Within Teijin there is no breakdown between supply, internal and demand risks. The way an organization deals with risks and whether these risks are supply chain risks depends, according to Teijin, on the chosen risk definition.

SCRM is not a term that is used within Teijin. The concept does get attention but that is especially on the supply side of the supply chain. So within Teijin it is more supply risk management instead of all embracing SCRM.

Looking at risk management at the supply side of the supply chain, Teijin takes two aspects into account. At first Teijin looks at the number of suppliers for a given product. For some products there are multiple suppliers, but Teijin sometimes only uses one of these suppliers. In other cases there is only one supplier available. Depending on the importance of the product for the company, Teijin looks at possible measures that should be taken. According to Teijin, the biggest risk, when there is only one supplier for a certain product, is an increase in prices. The chance that a healthy and successful supplier does not deliver his precuts is considered very small. The second aspect is the financial position of the suppliers. When the financial position of a supplier is not very good, but he is the sole supplier for a particular product, Teijin expects that, when the supplier might go bankrupt, the supplier will probably be taken over.

If necessary alternatives will be developed, or agreements regarding maintenance of certain stocks, or delivery guarantees are made.

The fact that the parent company of Teijin is established in Japan makes risk management an important issue. The Japanese culture is risk-averse and this has its effect on the business of Teijin in the Netherlands.

At this moment the main risks Teijin faces, are:

- Marketing sulfuric acid (which is released during production, when Teijin can not market sulfuric acid the production finally has to stop)
- Rising commodity prices. Suppliers have excess capacity and stopped (parts of) their plants, by doing this tightness arises, which leads to a lower flexibility.
- Suppliers going bankrupt, or ending their business.

5.2.2 SCRM method

The second part of the interview was focused on checking the usability of the conceptual method. The research question is: *“In what way are the elements of the conceptual method useful for SCRM in these organizations?”* The respondents were asked their opinion about the different phases and the steps belonging to these four phases. It was interesting to see that the opinions of the two respondents were on some aspects very different. The most important comments are described for each phase. Finally there are some general comments on the SCRM method.

Risk analysis

Before starting with the ‘Risk analysis’ it is important to have a clear view on the risk policy of the organization. Guidelines should be developed in order to determine the importance of certain risks and the risk attitude of the organization. The role of stakeholders should also be taken into account.

Risk identification

According to the respondents it is necessary when identifying risks to ‘think outside the box’. Risks that are not currently known could create huge problems in the future. It is therefore important that the risk identification is done by different people, with different expertise, ideas and opinions. A brainstorm session could be useful when identifying risks. The risk framework can help organizations think into certain directions. An other important aspect organizations should take into account is the psychological aspect of risk. Risk is often seen as something negative and that makes it difficult to assess risks objectively.

Identify sources and drivers

Both respondents find it important that the sources and drivers of the different risks are identified. Knowing the ins and outs of the risks you face, and realizing whether a risk is systematic or not, helps organizations understand the risks. When the risk identification brings up a couple of hundred risks it is not useful to check the sources and drivers for all these risks. Organizations should not only look at high risks but also at low risks when checking the sources and drivers. It might be the case that a certain driver will change the risk rapidly. When identifying the sources and drivers the role of the stakeholders should not be left out. It is possible to make stakeholders accountable for their responsibilities concerning the risk.

Risk measuring

Risks should be measured on their probability and their impact. Basing impact on financial aspects makes it possible to compare the different risks. When measuring risks on these two aspects there should be some kind of scale. By creating a scale every person in the organizations knows when a risk has a high/medium/low impact or a high/medium/low probability. These scales should be determined by the MT.

Risk evaluation

'Risk evaluation' is closely related to 'Risk analysis'. Teijin has combined these two aspects in their own risk management system.

Select criteria

The criteria that are mentioned in the SCRM method are clear. An addition to these criteria could be: processing criteria. These criteria have to do with hazardous, toxic or explosive substances.

Prioritize and select risks

Prioritizing and selecting the criteria is, according to the respondents, indeed based on the probability and impact and the selected criteria. But it is also based on feasibility. Feasibility includes aspects as the availability of employees, finances, knowledge and materials. When making a selection it is important to look at how feasible it is to manage a certain risk. The financial aspect can be seen as an overlapping aspect, it is already included in the impact and in the feasibility.

Risk mitigation

The mitigation strategy is determined by the company policy. The company's risk policy will determine the acceptance of risks and who has the right to accept the risk. In the steps of 'Risk mitigation' the actual implementation is missing. It is important to see when the actual action will take place.

Select mitigation option

The mitigation options are familiar to the respondents. These are the four most common mitigation options an organization can choose from. It is however important to realize that, when a risk is for instance reduced, the risk will generally not be reduced to zero so there might be a residual risk. This residual risk might have to be accepted. For some risks there is no mitigation option possible, organizations have to keep this in mind and know how to deal with these risks.

Implement mitigation

The implementation examples that are given, are clear. There are of course a lot of other actions that might lead to the desired mitigation. When looking at the implementation it might be interesting to involve suppliers in this process.

Monitoring

Checking

It is indeed very important to have a certain check at the end of the process. Checking should be focused on the results of the risk mitigation as well as on the SCRM method and process itself. It might be difficult for organizations to check the results. Checking how much the impact and probability has lowered can be very difficult to measure.

Follow up

The follow up is important because circumstances might change during a period. It is important to deal with risk management explicitly, to be able to offer a structure and to ensure that risk management also plays throughout the whole organization and not only in the MT.

General comments

In the method the SCRM process is in separate steps. One of the respondents mentions the fact that risk management is part of an iterative process. Some steps overlap each other and have an influence on each other. On other important aspect is that organizations must have a clear view on aspects such as: what is risk, where are the risks, who are involved in the risk and how can risk be avoided? Organizations must have answers to these questions before they start with SCRM.

5.3 Conclusion

This chapter gives an answer to the third research question: *“What lessons are learned in validating the method and what are the recommendations concerning the SCRM method?”* First the conclusion concerning SCRM and supply risks in the chemical fiber producing industry is discussed. Then the lessons learned are outlined for the different phases of the SCRM method and then finally the revised method is presented. Along with the lessons learned and the different phases of the SCRM method an example of a fictive organization and one of their supply chain risks will be given. This example shows how the different steps of the SCRM method can be used in practice.

5.3.1 Exploring the chemical fiber producing industry

The two organizations that participated in the case studies had different experiences with SCRM and risk management. Teijin, being part of a Japanese organization, works with risk management in a general context. Supply chain aspects are included in their general risk management method. With this method they list the most important risk they face in their organization and environment. Colbond on the other hand is not working with SCRM or risk management. The importance of risk management is recognized within the organization and there are ideas to implement SCRM.

Because of the fact that only two chemical fiber producing organizations were interviewed, and that these two organizations deal with SCRM in such a diverse way, it is not possible to give a general idea of the importance and usage of SCRM within the whole chemical fiber producing industry.

In Chapter 4.2.2 expectations concerning the most important supply risks were listed. The expected risks did partly match the actually mentioned supply risks. The increasing prices and nonconformity of specifications were indeed important supply risks, mentioned by the participating organizations. The supply risks that were mentioned were however very diverse for the two organizations. Even though Colbond states that the supply risks they mention are not unique for organizations with polymer production, these risks are not seen as the most important supply risks by Teijin. It is interesting to see that the supply risks Teijin mentioned as being the most important are not all real supply risks. The risk of marketing sulfuric acid is not a supply risk but a risk that has to do with marketing the released waste. The two organizations did not have any of their supply risks in common. It is therefore not possible to give a clear view on the most

important supply risks of the chemical fiber producing industry. More about the exploration during the case studies can be found in Chapter 7 'Discussion'.

5.3.2 Lessons learned

The expert interviews and the case studies provided lots of information that can be used to revise the SCRM method. In this chapter the recommendations that will be taken into account for the revised method, are outlined. This is first done for the SCRM method in general and then for the separate SCRM phases. The different phases are accompanied by an example. First the fictive organization, used for the examples, is described in the following box.

Description of example

Plastic-Creation is an (fictive) organization producing polyvinyl chloride plastics. Polyvinyl chloride is used to make flexible hoses and tubing, flooring, and electrical cable insulation. One of the main components of their polyvinyl chloride plastics is the vinyl chloride monomer. The new board of Plastic-Creation wants to increase the focus on supply chain risk management and is therefore introducing a SCRM method.

General

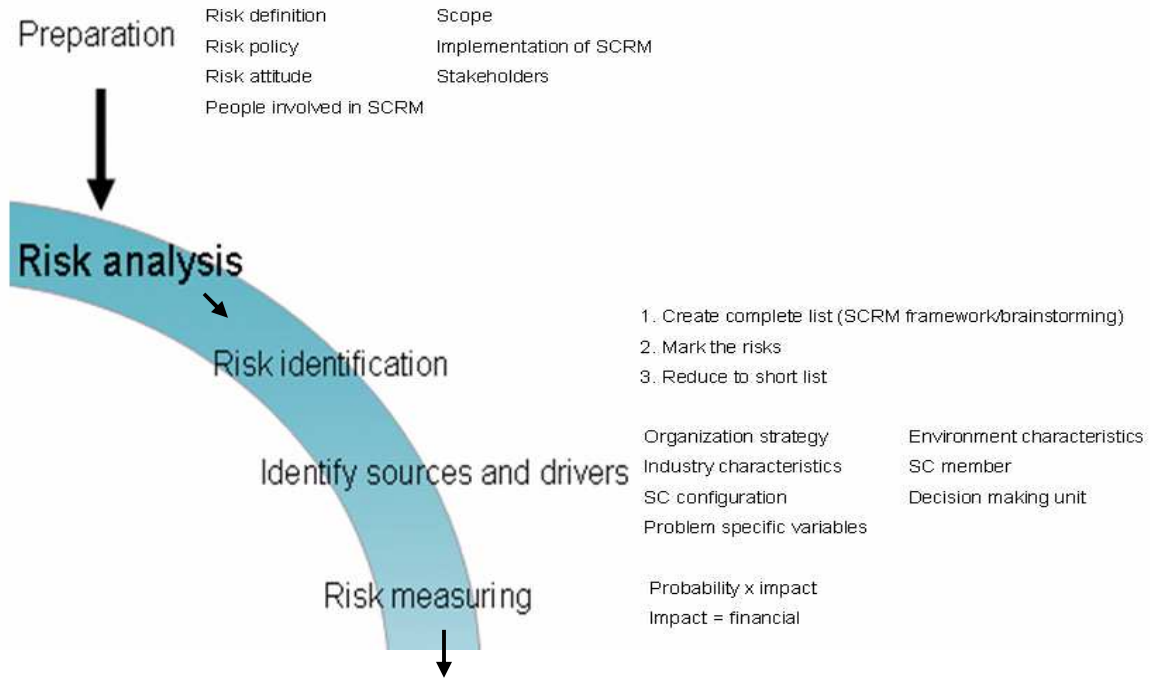
Before starting the SCRM process the organization should have to prepare the following aspects: a risk definition, the risk attitude, the risk policy, the people involved in the SCRM process, the scope, the implementation of SCRM and the stakeholders. Having a clear view on these aspects helps the organization to make decisions during the SCRM process. The preparation aspects should be taken into account each time the SCRM loop is taken. The SCRM process is a continuous process that should be imbedded in the whole organization. It is therefore important to create support among the employees. The SCRM method does yet not reflect this perpetual character as strongly as it should. The fact that the SCRM process is continuous also has its influence on the strict order of the steps belonging to the four phases. These steps are not as strict as they appear to be in the SCRM method, some steps overlap each other or are taken at the same time. This has to do with the iterative character of risk management. It is however important that the different elements are included in that specific phase.

Risk analysis

The 'Risk analysis' phase of the SCRM method is a phase where the opinions of the interviewed experts and respondents differ. The main concern is about the number of risks for which the sources and drivers are identified. It might not be useful to do this for every risk. The first step is to make a complete list of all the supply chain risks the organizations might face, this can be done with the help of the SCRM framework or a brainstorm session. This long list should then be reduced to a smaller list with the most important risks. This can be done by asking the people involved in the SCRM process to rank the different risks. The ranks are then counted for each risk. The risks with the highest grades can then be selected for the next step in the 'Risk analysis' phase; identifying the sources, drivers and the coherence between the different risks. The last step in the 'Risk analysis' is the risk measuring. The probability and impact of the different risks is closely related to their sources, drivers and coherence. Expressing the impact of the risks in financial terms makes the risks very comparable. It is however important that there is a certain scale for determining the probability and the impact. This scale should be the same for the whole organization.

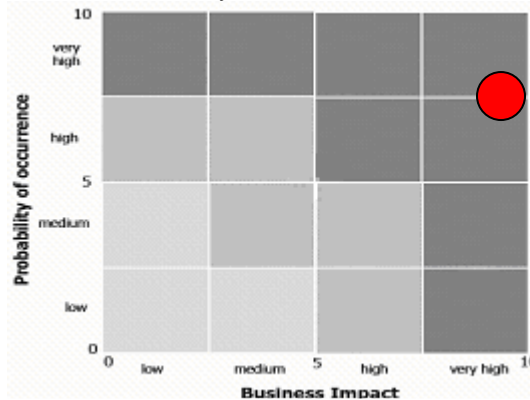
Figure 5.3.1 shows the revised 'Risk analysis' phase which is part of the complete SCRM method, presented in Figure 5.3.5.

Figure 5.3.1: Risk analysis



Risk analysis

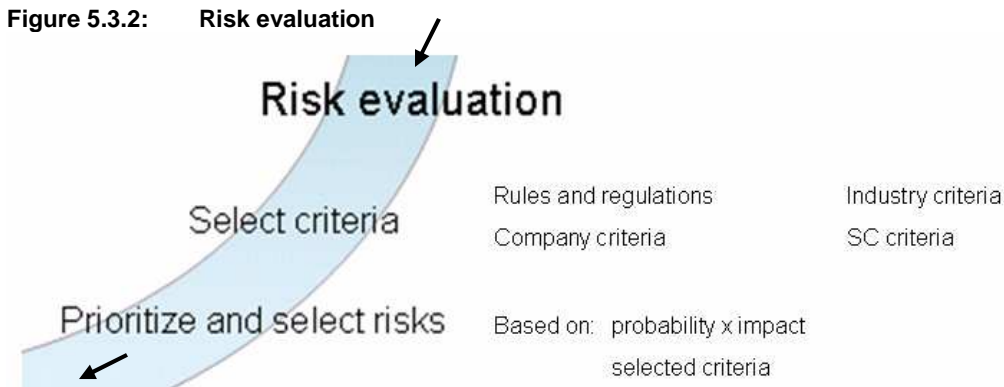
Plastic-Creation identified several risks in the risk identification step. One of these risks is the fact that Plastic-Creation has only one supplier for the vinyl chloride monomer. They have a single source strategy for this component. When this single supplier can no longer deliver the vinyl chloride monomer, Plastic-Creation has a huge problem because they then have to stop their production. The single source strategy creates high risks for the production of their polyvinyl chloride plastics. Looking at the sources and drivers of this risk the main risk source has to do with the organizations strategy. Their single source strategy could create a problem. The reason that Plastic-Creation has only one supplier for the vinyl chloride monomer, has to do with the fact that the strategic relation with this specific supplier is a long term relationship, which exists for over 25 years. The supplier knows exactly what Plastic-Creation wants and Plastic-Creation trusts this supplier completely. In the last 25 years the supplier was a very stable supplier with a solid financial position. In the last year their financial position became weaker and Plastic-Creation realized that this could lead to bankruptcy. The probability that their supplier can no longer deliver the vinyl chloride is getting higher and higher. The impact that this would have on Plastic-Creation is huge. When there is no vinyl chloride monomer, Plastic-Creation can no longer produce their polyvinyl chloride plastics. The position of the risk on the probability/impact chart is shown by the dot:



Risk evaluation

It is important to look at other criteria besides the probability and impact of the different risks. These criteria can be found in rules and regulations, industry criteria, company criteria (including processing criteria) and SC criteria.

Together with the probability and impact these criteria determine which risks are selected for the mitigation phase and what the priority of the risks is. The feasibility is not taken into account in this phase of the SCRM method but is very important in the selection of the risk mitigation option. Figure 5.3.2 shows the revised 'Risk evaluation' phase which is part of the complete SCRM method, presented in Figure 5.3.5.



Risk evaluation

The purchase of vinyl chloride monomer is depends on several criteria. At first there are legal criteria that have to be taken into account when purchasing vinyl chloride monomer. The supplier has to be REACH certified in order to deliver the vinyl chloride monomer to Plastic-Creation. Plastic-Creation is focusing on SHE regulations very narrowly and expects the same from their suppliers. Besides these criteria the new board of Plastic-Creation has determined that the company criteria concerning supplier dependency will be changed. The organization does not want to be dependent on a single supplier for their complete production. These criteria make the issue of the single supplier of vinyl chloride monomers a very important risk. The fact that the risk also has a high probability and a high impact makes the risk a priority for the organization.

Risk mitigation

Now it is time to select a mitigation option for the risks that were selected in the previous phase. The decision which mitigation option is the best depends on the feasibility of these options, the risk policy and the risk attitude of the organization. Organizations have to realize that certain risks can not be mitigated completely and that there might be a residual risk. After deciding on the right mitigation option the organizations has to determine how they want to implement that option. Appropriate actions have to be developed. These actions can then be implemented in order to reach the desired risk mitigation. There are two stages when implementing a risk mitigation option: implementation and activation. These are described in Chapter 3.4.2. Figure 5.3.3 shows the revised 'Risk mitigation' phase which is part of the complete SCRM method, presented in Figure 5.3.5.

Figure 5.3.3: Risk mitigation



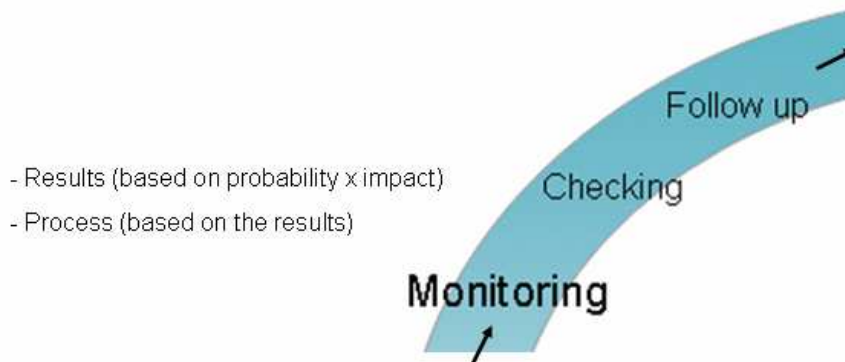
Risk mitigation

The company policy has already determined that the risk of having only one supplier for vinyl chloride monomer is not a risk that can be accepted. So the mitigation option of risk acceptance is not a reasonable option. There is no option to transfer the risk or to avoid the risk because the production of polyvinyl chloride plastics requires vinyl chloride monomer. It is not possible to avoid a certain degree of dependency on suppliers. The mitigation option that is the most reasonable is that of risk reduction. Plastic-Creation wants to reduce the risk, of having to stop their production, created by their single-sourcing policy. The possible action that has to be taken is to implement a dual-sourcing strategy in the organization. Instead of having just one supplier of vinyl chloride monomer Plastic-Creation has to find other suppliers.

Monitoring

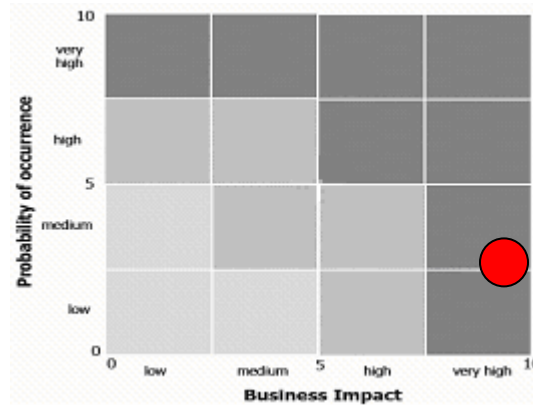
It is important to have a check on the results of the SCRM process. The results are based on the change in the probability and impact of the risks. The success of the SCRM method, the process, is partly determined by the results. The people participating in the SCRM process have to determine how successful the process was and whether changes have to be made in the method itself. The results and the evaluation of the process determine whether follow up is needed and how this affects the other phases in the SCRM method. Figure 5.3.4 shows the revised 'Monitoring' phase which is part of the complete SCRM method, presented in Figure 5.3.5.

Figure 5.3.4: Monitoring



Monitoring

After the dual-sourcing strategy is implemented the board wants to know what the results are of the risk mitigation, and whether the chosen strategy has changed the probability and impact of the selected risk. Looking at the results the organization can state that the probability is decreased because of the fact that they now have two suppliers for vinyl chloride instead of just one. If one supplier can not deliver the vinyl chloride monomer the other supplier probably can. The impact of not receiving the vinyl chloride is however still very high. If both suppliers can not deliver the product the production still has to stop. The probability/impact curve shows the new position of the risk:

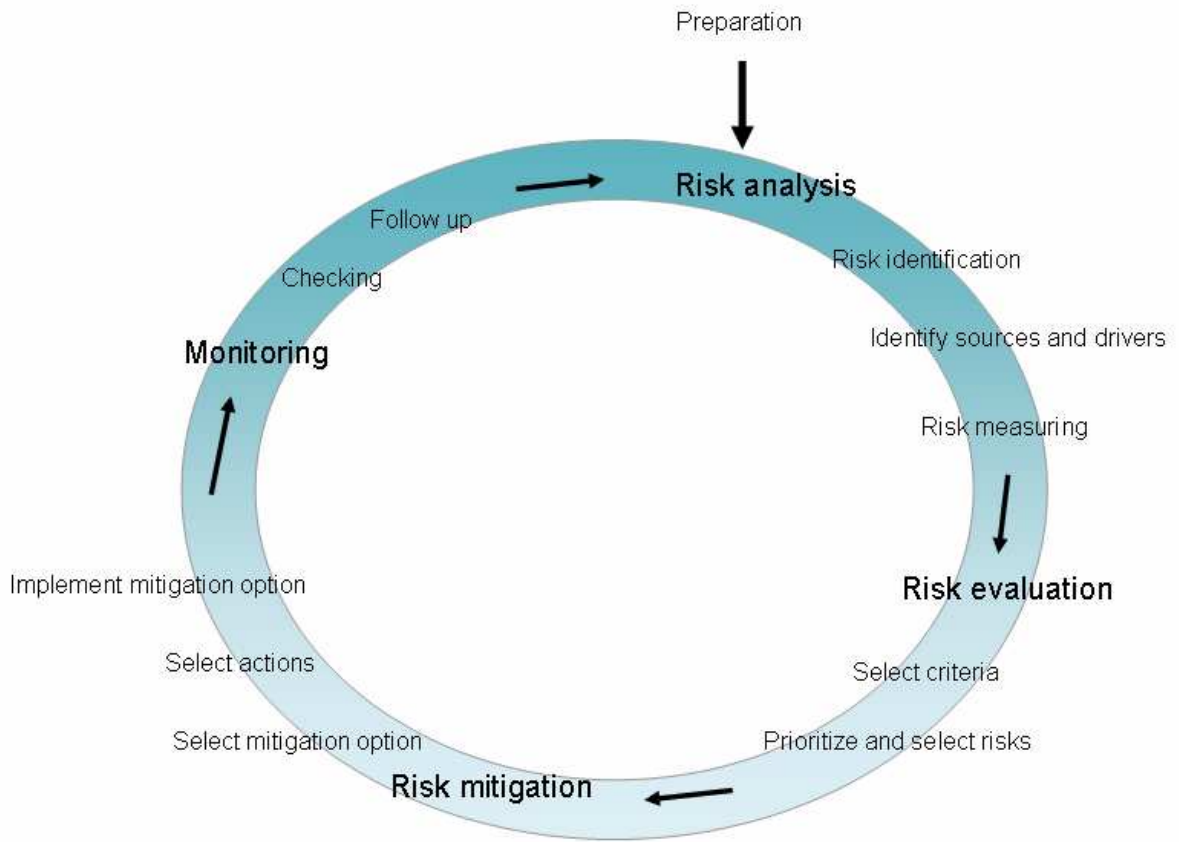


Because of the fact that the probability did decrease but the impact staid the same the organization might determine that a follow-up action is needed. In this follow-up plan the organization has to decide how they can lower the impact of the risk, instead of just lowering the probability.

5.3.3 Revised SCRM method

The revised phases of the SCRM method are outlined in the previous chapters. Together these different phases result into the complete SCRM method, as shown in Figure 5.3.5. This method shows the different phases in a continuous process. The steps belonging to the different phases are not placed in a strict order, as described in the previous chapter under 'General', this shows that SCRM is more of an iterative process. The complete method does not show the elements belonging to the different steps, these can be found in the figures of the separate phases.

Figure 5.3.5: SCRM process



6. Conclusion

In this chapter the final conclusions will be given. In Chapter 6.1 the conclusion concerning the research objective and the research questions is given. Chapter 6.2 focuses on the recommendations for the consultants who might use the SCRM method.

6.1 Research questions

This research project has been conducted to reach the following research objective:

The aim of this thesis research is to contribute to the development of a method for SCRM in the process industry by using available literature concerning SCRM and giving insight in the opinions and ideas of several supply (chain) managers and experts, concerning the usability and importance of a SCRM method in the process industry.

To reach this objective, the research was divided into three research questions. The conclusion for each of these three research question is now given.

RQ 1 → *What elements can be part of a method for supply chain risk management in the process industry, according to literature and expert knowledge?*

The first research question is focused on creating a SCRM method with the help of literature and expert interviews. In order to create the SCRM method it is important to know more about SCM and the process industry. The literature study revealed that there is not one general process industry supply chain. The supply chain network structure, supply chain business processes and the supply chain management components depend on the specific type of process industry and are different for, for instance, the chemical industry and the pharmaceutical industry. This means that the SCRM method has to be general enough to be used in different process industries. SCRM is defined as: “a part of Supply Chain Management which contains all strategies and measures, all knowledge, all institutions, all processes, and all technologies, which can be used on the technical, personal and organizational level to reduce supply chain risk” (Kersten et al. 2006). The different aspects of SCM, like the suppliers, customers, processes, the relationships and the integration, all have an impact on the risks that are present in the supply chain. Supply chain risks can be divided into three categories: risks that are internal to the firm, risks that are internal to the supply network and risks that are external to the whole supply chain network. Risks in the external environment are not included in the development of the SCRM method, since these risks are not always predictable and are very difficult to prevent. External risks are certainly seen as important risks which have their influence on the supply or demand side of the supply chain or on the internal operation of the focal firm. Supply chain internal risks can be divided into: risks at the supply side of the supply chain, risks at the demand side of the supply chain and risks internal to the firm. The type of risks, present in each of these three risk areas, are still very diverse. Therefore the risks are categorized further into: financial risks, physical risks, organizational risks, and information risks. These categorizations can help organizations determine what and where there risks are.

The background information on SCM, the process industry and SCRM helps determine the SCRM method. The conceptual SCRM method that is created has four phases. Each of these four phases has their own steps and elements belonging to these steps. The elements especially focus on the supply chain risks.

The four phases of the conceptual SCRM method, and the steps belonging to these phases, are:

1. Risk analysis, including: Identify risks, Identify sources and drivers and Measure risks.
2. Risk evaluation, including: Select criteria and Prioritize and select risks.
3. Risk mitigation, including: Select mitigation option and Implement mitigation.
4. Monitoring, including: Checking and Follow up.

RQ 2 → *What is the value and quality of the elements of the conceptual method, according to supply (chain) managers and -experts?*

The conceptual SCRM method is the input for the second research question. The focus of the second research question is on the validating the elements of the conceptual SCRM method, with the help of experts interviews and case studies. Besides the validation of the conceptual SCRM method the case studies also focus on exploring the importance of SCRM and on the most important supply risks of the chemical fiber producing industries. The two organizations that participated in the case studies have different experiences with SCRM and risk management. Although they have different experiences, both organizations do acknowledge the importance of proper risk management or SCRM. The supply risks that the two chemical fiber producing industries mentioned as being the most important are very divers. It is therefore not possible to give a general overview of the most important supply risks of the chemical fiber producing industry.

RQ 3 → *What lessons are learned in validating the method and what are the recommendations concerning the SCRM method?*

The results of the expert interviews and case studies are used to revise and modify the conceptual SCRM method, which is the focus of the third research question.

The opinions and ideas of the experts and the case study respondents vary for the different SCRM phases. The opinions and ideas are compared and together they determine the modifications, resulting in the revised SCRM method. This new SCRM method is similar to the conceptual SCRM method, but with a few modifications concerning the steps and elements belonging to these steps. The four SCRM phases stayed the same. The main changes were made in the first phase of the SCRM method 'Risk analysis', in the steps belonging to the 'Risk mitigation' and in the visibility of the continuous character of the SCRM method.

The four phases and their steps became (see Figure 5.3-1 till 5.3-4 for the complete revised SCRM method):

1. Risk analysis, including: Identify risks (1. Create a long list. 2. Mark the risks. 3. Create short list), Identify sources and drivers and Measure risks.
2. Risk evaluation, including: Select criteria and Prioritize and select risks.
3. Risk mitigation, including: Select mitigation option, Select actions and Implement mitigation option.
4. Monitoring, including: Checking and Follow up.

An important issue considering the complete SCRM method is that it has to have a continuous character. Managing risks is not something that is done once in a while, but it is a continuous process. An other important aspect is the people who are involved in the SCRM process and the way SCRM is implemented. More about these two subjects can be found in Chapter 7.

6.2 Recommendations

The SCRM method will be used by consultants at various organizations. The SCRM method is a general method that can be used for different types of organizations. The tools, techniques and examples make the method useful for specific industries. When working with the method it is important that the context of the specific organization is included in the SCRM method and that the different stakeholders are familiar. In this chapter a few recommendations for the consultants, concerning the usability of the method, are given. At first it is important to make organizations aware of the importance of SCRM. When organizations are then interested in the SCRM method, the next important aspect is the information access an organization provides the consultants with. The third aspect is the importance of external risks.

SCRM importance

Getting organizations interested in the SCRM method starts with getting them interested in SCRM. It is important that organizations realize that supply chain disruptions can reduce their revenue, cut into their market shares, increase their costs, threaten their production and delay their transportation. In the last couple of years this awareness has increased and organizations are placing risk management and SCRM on the agenda. Consultants should react to this increasing awareness and use it as a way to market their SCRM method and knowledge. When the organization and its employees acknowledge the importance of SCRM the support among the employees is higher, which will contribute to the success of the SCRM process.

Information access

When consultants want to use the SCRM method at an organization they first have to prepare a few aspects. It is important that the organization and the consultants have the same idea about the importance of SCRM and the definition of risk and supply chain risks. The organization should be able to give the consultants full access to the organization and to the people working there. This is important because the consultants need to understand where the risks take place, what the consequences of the risks are, how certain risks have an influence on each other and where the sources and drivers of the risks come from. The consultants should also know what the supply chains, the organization is part of, look like. The position of the organization in the supply chain is essential when they want to make decisions concerning the risk mitigation. Whether an organization is a supply chain leader or not makes a lot of difference in the possible mitigation strategies. So the consultants need to have access to information concerning: the organization, the supply chains, and the organization's position.

External risks

As mentioned earlier external risks are not included in the development of the SCRM method, since these risks are not always predictable and are very difficult to prevent. Consultants have to be aware of these external risks because they can have a huge influence on the organization and the environment the organization is part of. When the consultants know the environment and the trends and changes in this environment they might be better prepared when certain external events occur.

The three aspects mentioned in this chapter will help consultants to use the SCRM method. But there still are a few question marks concerning the method and the industry it was developed for. These issues are outlined in the next chapter.

7. Discussion and further research

When doing research and writing a paper, there are always points for discussion. The 'Discussion' focuses on points that can be done differently in the future or points that did not go as expected. In the end of this chapter some suggestions for further research are given.

7.1 Discussion

The first aspect that is a point of discussion is the focus on the process industry. As described in Chapter 2.2 the process industry is very diverse industry. This makes it difficult to focus on a general process industry supply chain, when developing the SCRM method. The chemical fiber producing industry was chosen to validate the method but the method could just as well be validated in another specific part of the process industry. It would have been interesting to validate the method in more than one type of process industry, like for instance the chemical fiber producing industry and the pharmaceutical industry. This would be interesting because of the fact that their supply chains, and with that also the supply chain risks are very different. When the method would be validated in different parts of the process industry it would be more valid to say that the SCRM method is a method for the process industry. This will come back in Chapter 7.2 'Further research'.

In the methodology there are a few things that can be discussed. The second point of discussion is the fact that the SCRM method would be validated with the help of two expert interviews and two case studies. The two experts were both Coppa Consultancy consultants, it would have been interesting to validate the SCRM method with other experts as well, like for instance a SCRM expert or professor. Due to time constraints this was not possible. More and different experts might have given new insights and different opinions concerning the SCRM method. Besides the expert interviews there were two case studies. The intention was to seek as many chemical fiber producing organizations as possible, but there were only three of these organizations in the Netherlands, of which one was not interested in participation due to time concerns. The two organizations that were interested had different ideas concerning SCRM. It is interesting to see that these differences probably had to do with the fact that one of the organizations was already working with risk management and SCM and the other organization was less. To check whether the experience of the organizations had a real influence on the validation of the SCRM method, more case studies are necessary.

The in-depth interviews with the experts and the case study respondents, is the third aspect to be discussed. The time planned for each interview was one hour. During the interviews it appeared that this was too short to really focus on the different aspect and to go into depth. With more time the different SCRM phases could have been discussed further in depth and the opinions of the experts and respondents could have been brought more to the surface.

When focusing on the term 'risk' it was difficult to get a clear and universal description of this term. The definition used in Chapter 2 was: "*Risk is the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realized*" (Sitkin and Pablo, 1992). Because of the fact that risks can be seen at different levels (strategic, tactical and operational) it was hard to get everybody on the same level and with the same definition in mind.

This also appeared in the case studies. The methodology described that the exploration part of the case studies was focused on supply risks. During the interviews, the term supply risks appeared to have different meanings for the respondents. This especially came to the surface when asking for the most important supply risks the organizations faced. It might have been a better idea to discuss the term first, before asking for examples.

So the most important points for discussion are:

- Validating the SCRM method in just one part of the process industry
- Number of respondents
- Time-aspect of the interviews
- Definition of risk

7.2 Further research

As described in the previous chapter, the SCRM method has been only validated in the chemical fiber producing industry, as being part of the process industry. To make sure that the SCRM method is also applicable in other parts of the process industry it would be interesting to validate the method in the other industries, like for instance the pharmaceutical industry or the paint industry. By having in-depth interviews with respondents from these industries it is possible to see whether there is a difference in the way they validate the SCRM method, compared to the way the chemical fiber producing industry validated the method. Besides the case studies there were also two expert interviews. As mentioned in the 'Discussion' the two experts were both Coppa Consultancy consultants. It would be interesting to validate the SCRM method with other experts as well, like for instance a SCRM expert or professor. These experts might have a different view on the SCRM method, also because they are not consultants who have to use the method.

Besides validating the method it would also be useful to really test the method in different industries to see whether the SCRM method is as useful as expected. By really using the method bottlenecks will come to the surface and the method can be revised to make it practical applicable. Especially the first part of the method, the 'Risk analysis', is a part that is interesting to test. This is interesting because of the different ideas and opinions concerning the order of the elements in this phase.

One of the goals of the case studies was to explore the chemical fiber producing industry. Because there were only two organizations willing to participate it is difficult to give a general view of the importance and usage of SCRM and the most important supply risks in this industry. In order to create an overview of these aspects it would be interesting to explore the chemical industry in combination with SCRM further. It might be interesting to take a broader industry because it is then possible to interview more organization instead of just two. This way the interest and importance of SCRM can be checked for the whole industry and it might be possible to give an overview of the most important risks in this industry.

The methods that were used in the participating organizations are also interesting input for the SCRM method, developed in the research. The fact was that only one of the two organizations used a risk method. It is interesting to see what other SCRM or risk management methods are used in practice. Doing research on different SCRM methods in different industries might help to create a SCRM method with the best aspects of all these other methods and useful in the different industries.

An important aspect that came back in the different interviews was the implementation of SCRM itself. Who are involved in the process? When there is a useful SCRM method it can only be successful when it is used in the right way. What this right way is, has not been determined yet. Coppa Consultancy can play an important role in this implementation. It would therefore be interesting to do research on the implementation of a SCRM method. What is the benefit of project teams and how can SCRM be imbedded in the whole organization? It is interesting to create an answer to these questions. It might also be possible to test these different implementation techniques. By really applying the different possibilities the most appropriate implementation technique could be found. This might however be different for different types of organizations. This could also be included in the research.

Concluding, the aspects that are recommended for further research are:

- Validating the SCRM method in different industries and with different experts.
- Testing the SCRM method.
- Investigating the importance of SCRM in the chemical industry.
- Researching different SCRM methods that are already used in practice.
- Implementing the SCRM method.

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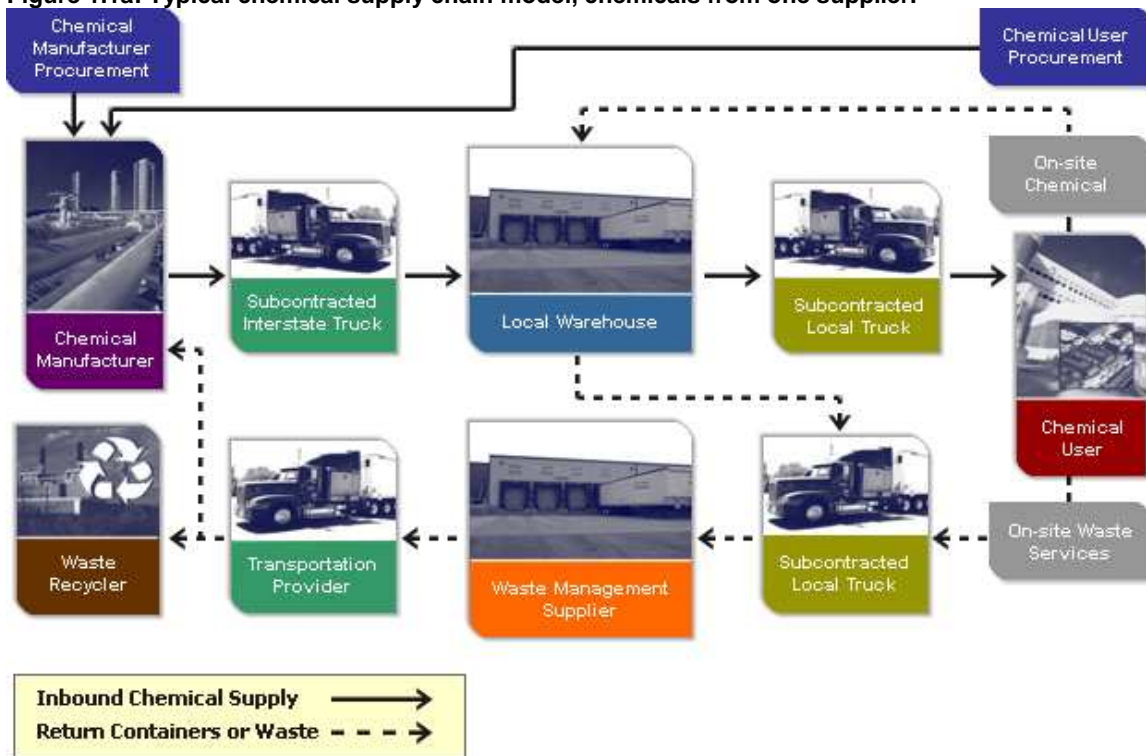
Appendices

Appendix 1 Process industry supply chains

Chemical industry

According to M. Plasier (personal communication, April 2009) it is very typical for the supply chain of the chemical industry that a supplier can, at the same time, be a customer as well as a competitor. This has to do with the large variety of chemical products that a chemical company produces. In the chemical industry there is a high dependency among chemical companies, they buy each others products and use it in their own products. Focusing on the supply side of the supply chain, there are a few suppliers. In the world there are not many companies supplying the raw materials that are used in the chemical industry, like oil. The demand side shows a wide range of customers, from the food industry to the furniture manufacturing companies. Another important aspect in the chemical industry supply chains is waste. The waste of one product can sometimes be used as a raw material for another product. Figure 1.1a shows the flows of the chemical products and of the waste created in the processes.

Figure 1.1a: Typical chemical supply chain model, chemicals from one supplier.



(Source: Chemical Lifecycle management, 2009)

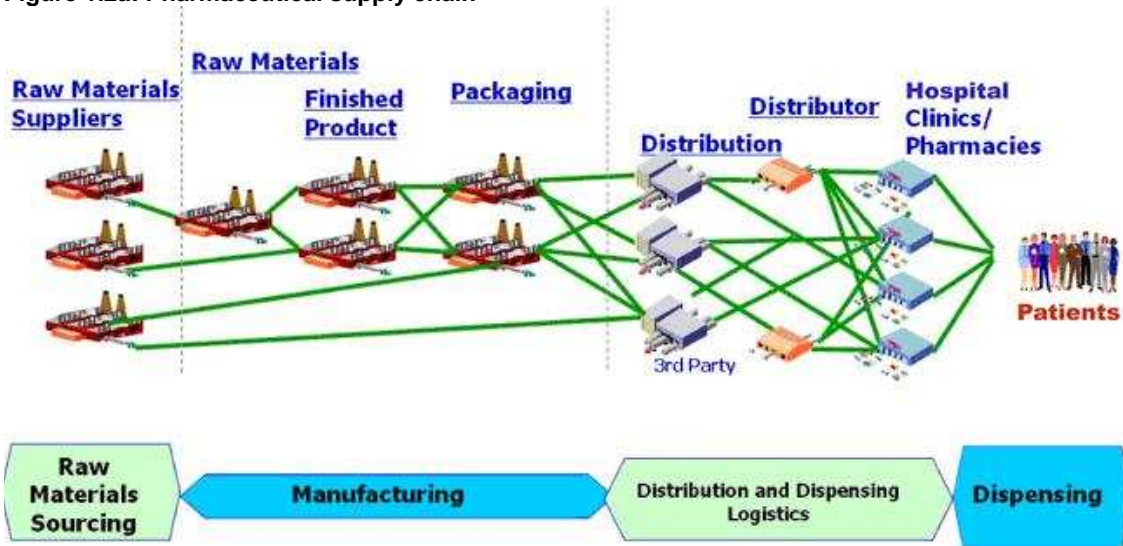
Pharmaceutical industry

In the pharmaceutical industry the most important aspect is getting patents on new pharmaceutical products. In this industry it is essential to be the first in developing a product and claiming the patents. Once a pharmaceutical company owns patents to a specific product they can produce it constantly, for a certain period, without having to worry about competitors taking their market share.

The key players in the pharmaceutical supply chain are the pharmaceutical manufacturers, the wholesale distributors and the pharmacies shops. Together they make sure that the right medicine gets to the right person.

The pharmaceutical industry has more suppliers than the chemical industry and a lot of chemical industries deliver their products to the pharmaceutical companies. The demand side of the chain is less extended, in the pharmaceutical industry the main customers are the wholesalers and pharmacies. The production process in the pharmaceutical industry is mainly batch production. Figure 1.2a shows an example of a pharmaceutical supply chain.

Figure 1.2a: Pharmaceutical supply chain



(Source: RxResponse, 2008)

Appendix 2 List of supply chain risks

Supply risks	Internal risks	Demand risks
<ul style="list-style-type: none"> - Supplier bankruptcy - Increasing product prices - Fluctuations in foreign exchange rate - Increasing transportation costs - Product quality - Supplier capacity constraints - Late deliveries - Damaged goods - Missing products - Problems with supply chain infrastructure - Non-sustainable behavior of suppliers (SHE regulations) - REACH approved suppliers - Nonconformity to specifications - Excessive handling due to border crossings or to change in transportation modes - Increasing supply lead times - Lack of collaborative planning - Possibility of supplier to adapt to requirements - Partnership failure - Inaccurate forecast - Data errors - IT failure 	<ul style="list-style-type: none"> - Inventory costs - Cost of labor - Cost of changeovers - Insufficient production capacity - High capacity utilization - Waste - Decreasing quality/availability internal services - Rate of product obsolescence - Labor dispute - Mechanical failure - General availability of labor - Quality of labor - Availability of capital - Failure of logistics service provider - Inflexibility - Intellectual property infringement / theft - Lack of collaborative planning - Low degree of resilience - Ineffective scheduling - Data errors - IT failure 	<ul style="list-style-type: none"> - Lack of, or late payments - Decreasing prices - Changes in demand - Availability of substitutes - Customer dependency - General availability of labor - Lack of collaborative planning - Partnership failure - Inaccurate forecasts - Data errors - IT failure

Appendix 3 Tools and techniques

Brainstorming

Brainstorming is a technique that can be used for the different steps in the risk analysis. Using brainstorming as a risk identification technique involves redefining the problem, generating ideas, finding possible solutions and conducting evaluation (Chapman, 1998). The idea behind the brainstorm principle, as a problem solving technique, is that in a brainstorming session much larger quantities of ideas are produced than with other problem solving techniques. In a brainstorming session it is important that criticism is ruled out, evaluation of ideas must be withheld until later. In a brainstorming session free-wheeling should be encouraged. The quantity of ideas should be as large as possible. If there are a lot of ideas the greater the chance is that some of these ideas are useful. In a brainstorming it is important that people try to 'build' on other people's ideas (Chapman, 1998). The advantage of brainstorming is that group thinking is more productive than individual thinking and the avoidance of criticism improves the production of ideas. Brainstorming can be used as a technique to identify the risks, their sources and drivers and to identify the consequences of a specific risk.

Process mapping

Process mapping is a workflow diagram to bring forth a clearer understanding of a process or series of parallel processes. Describing and visualizing the supply chain can create a transparent overview on the related organizations and processes. Supply chain mapping enables the organization to sketch the supply network both upstream and downstream. By doing this, the most important information for each supply chain partner is captured. Information such as products/materials sourced or bought, costs/prices, quantities, replenishment lead time and whether or not it is a sole or single source or a key customer. Supply chain mapping can be done in joint workshops, which will trigger individual task assignments (Jüttner & Ziegenbein, 2009). Mapping the supply chain can help determine what the risks in the supply chain are and it can visualize where different risks come from and who or what will be affected by the consequences of the risk.

Critical path supply chain analysis

Critical path supply chain analysis is a method that uses capacity and simulation models to identify the supply chains with the most potential to interrupt manufacturing and to explore the risks of interruption for critical supply chains (bnet.com, 2009). These critical paths are likely to have several characteristics, like: long lead times, high degree of concentration among suppliers and customers and high levels of identifiable risks (Christopher, 2005). This tool is especially useful in determining which supply chain the focus is going to be on, so to identify the supply chain. In a critical path analysis the logical sequencing of the activities in the supply chain is made visual. This might help in determining where risks come from and who they affect.

Scenario analysis

Scenario analysis is a process of analyzing possible future events by considering alternative possible outcomes. A scenario is specified as a set of 'paths' that will be taken by relevant risk factors. Once scenarios have been specified, the next step is to project what will happen under each one. Scenario analysis is highly dependent on assumptions. Output of the analysis is only as good as these assumptions. This technique is especially useful in identifying the risks and their consequences.

Appendix 4 The Albuquerque accident

On March 17, 2000, lightning hit a power line in Albuquerque, New Mexico. The strike caused a massive surge in the surrounding electrical grid, which in turn started a fire at a local plant owned by Royal Philips Electronics, N.V., damaging millions of microchips. Scandinavian mobile-phone manufacturer Nokia Corp., a major customer of the plant, almost immediately began switching its chip orders to other Philips plants, as well as to other Japanese and American suppliers. Thanks to its multiple-supplier strategy and responsiveness, Nokia's production suffered little during the crisis.

In contrast, Telefon AB L.M. Ericsson, another mobile-phone customer of the Philips plant, employed a single-sourcing policy. As a result, when the Philips plant shut down after the fire, Ericsson had no other source of microchips, which disrupted production for months. Ultimately, Ericsson lost \$400 million in sales. (Ericsson has since implemented new processes and tools for preventing such scenarios.)

(Source: Chopra & Sodhi, 2004)

Appendix 7 Interview handouts

The following Figures will be used as a guideline.

Figure 7.1a: SCRM method including the results of each phase

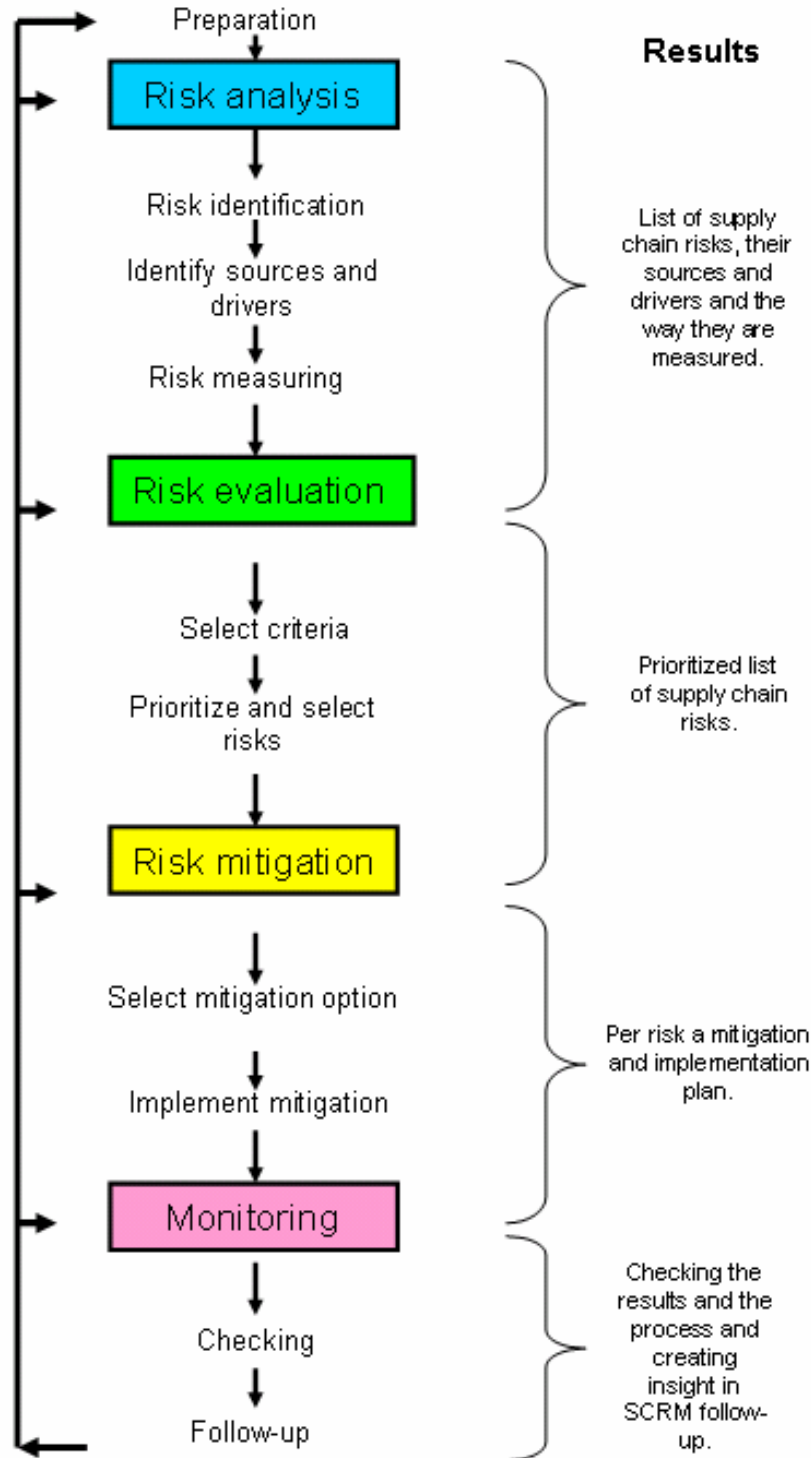
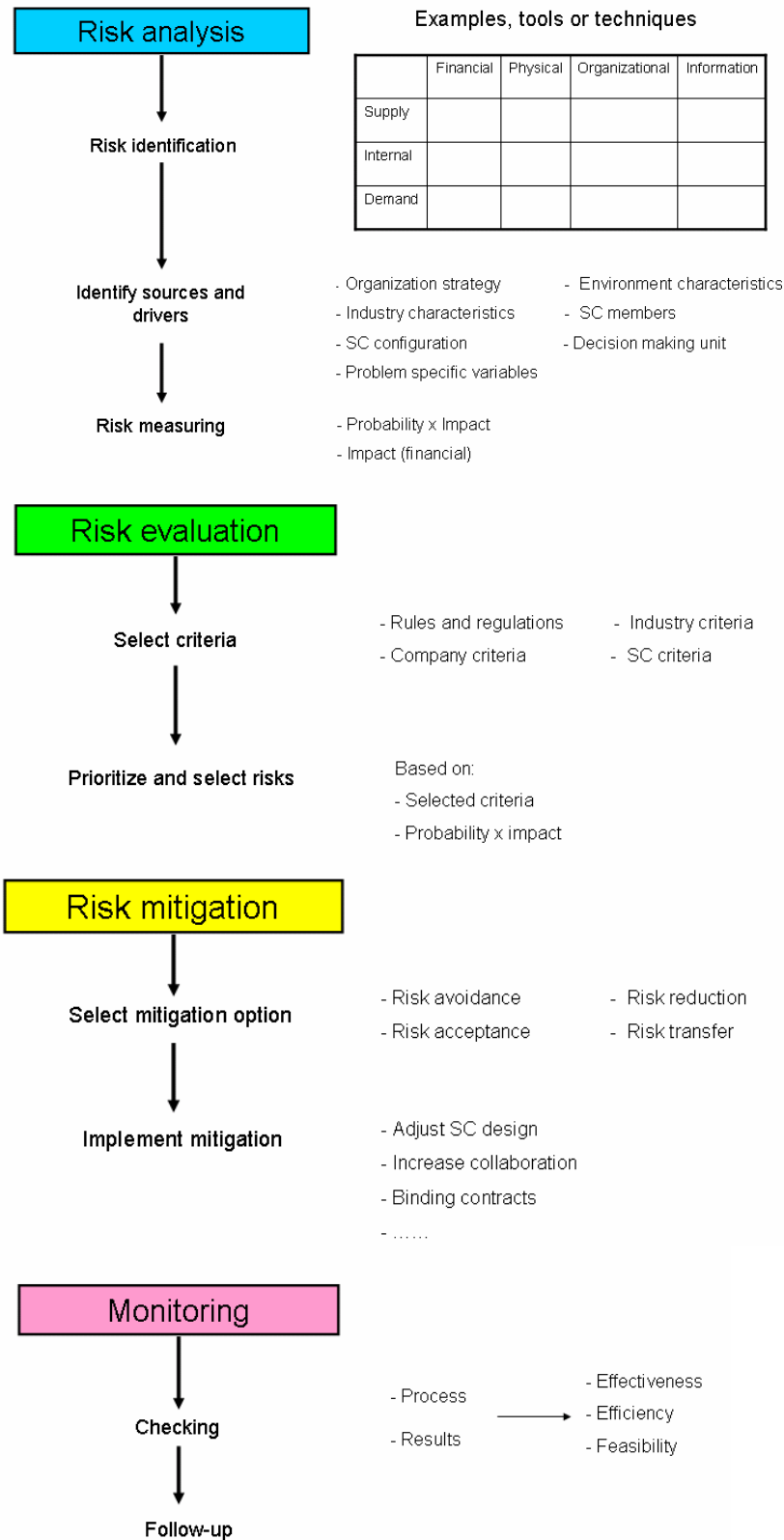


Figure 7.2a: SCRM method including examples for each phase



Appendix 8 Introduction email

Dear Mr.,

What are the most important supply risks within the chemical fiber producing industry? And what is the role of supply chain risk management in this industry?

My thesis research will give answers to these questions and will present a supply chain risk management method which might be useful for your organization.

My name is Yvonne Loman and I am currently working on my graduate thesis. The goal of my research is to develop a method which enables organizations to deal with supply chain risk management in a professional way. In order to obtain additional input for my research I would like to conduct interviews with purchasing/supply chain managers of chemical fiber producing organizations.

In this interview I would like to focus on the current supply chain risk management method Colbond/Teijin uses and the most important supply risk that are reported within your organization. Besides that I would like to discuss the theoretical supply chain risk management method, which was developed for this thesis research, and I am interested in your opinion and ideas concerning this method.

In summary, the following subjects will be addressed in the interview:

- supply chain risk management at Colbond/Teijin;
- Colbond/Teijin most important supply risks;
- the usefulness and appropriateness of the theoretical method.

As an appreciation for your input I will send you the final report, including an overview of the most important supply risks, based on the reduced interviews, within the chemical fiber producing organizations.

Yours sincerely,

Yvonne Loman