

AN EMPIRICAL ANALYSIS OF SUPPLY CHAIN RISK MANAGEMENT- A THEORETICAL AND APPLICATION-ORIENTED APPROACH

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ABSTRACT

Today companies face many critical challenges with respect to supply chain management. One of these challenges is the close cooperation between supply chain partners, exacerbating the risk exposure of companies in a supply chain.

In this paper, a framework for supply chain risk management is developed. Starting from theoretical risk classifications, companies' risk assessment and the description of companies' supply chains, suitable supply chain risk management strategies are discussed using the results of an explorative empirical study. One approach of how companies can deal with supply chain risk management is described to give recommendations for companies.

KEY WORDS

Supply Chain Risk Management, Risk Management, Empirical Approach, Knowledge Management

1. Introduction

Due to global markets, shorter product life cycles and dynamic environmental changes, companies are more and more forced to develop, produce and distribute their products in international supply networks in a fast and cost-efficient way and to a high quality. Moreover, consumers as well as corporate clients ask for more individual goods and services.

In this business environment, supply chain management has been recognized as a management approach to gain competitive advantage through an optimised vertical cooperation. Numerous techniques and strategies have been developed and subsumed under the term supply chain management. In the following, we refer to supply chain management as "the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole" [1]. Thus, supply chain management is an approach to design value chains by optimising the in-

ter-organisational flow of material, information and capital in order to reduce costs and to enhance customer value. Companies frequently offer a wider range of products to their customers. Production processes become more complex, while at the same time safety stocks are further eliminated. New information and communication systems are introduced faster to the production process, leading to an even higher complexity of production and logistics processes. Thus, the importance of outsourcing services such as logistics functions increases. Driver of this development are cost advantages on the one hand, and enhanced requirements for the logistics of manufacturing companies [2].

Outsourcing of components or logistics services and the cost-oriented optimisation of supply relationships, however, are not advantageous in any case. The close cooperation of companies and the increasing dependency of companies on each other result in an increased risk portfolio within a supply chain. In addition to the occurrence of new risks companies are faced with a high vulnerability of their supply chains, meaning the impact of existing risks is aggravated. To handle this increase, the supply chain management concept has to be extended by methods of complexity and risk management. However, to transfer these management concepts from the intra- to the inter-organisational level, some modifications are required.

The aim of this paper is to investigate deficits in the realisation of supply chain risk management and to point out fields of activities for companies. Based on a theoretical analysis of the supply chain risk management process, the results of an empirical study by the authors are presented. For this investigation, a paper-based survey was sent to 594 companies from the industrial sector and 229 logistics service providers. 50 companies from the industrial sector and 30 logistics service providers participated in the survey, meaning a rate of return of 8.4% and 17.0% respectively. The results show that there are still heavy deficits in the implementation of supply chain risk management in business practice. To overcome these deficits, the transfer of knowledge management methods to risk management is suggested as a resolution method.

2. A theoretical Framework for Supply Chain Risk and Supply Chain Risk Management

2.1 Risk versus Supply Chain Risk

In the literature, the definitions of the term “risk” as well as the instruments that are used for risk measurement strongly depend on the field of research [3]. Common definitions of risk are based on the volatility of possible return, the concept of information deficits and the willingness to accept a potential loss if positive returns are expected [4]. In traditional decision theory, risk is defined as the variation in the distribution of potential results, their probability of occurrence and their subjective value [5]. In this case, variance is an instrument for risk measurement that allows quantifying the deviation from an expected value. Thus, risk may indicate both positive and negative deviations from an expected outcome. However, an empirical investigation by March and Shapira showed that risk is often reduced to its negative component in business practice, whereas positive deviations are considered as “chances”. Correspondingly, risk may be defined as the product of the probability of occurrence of a (negative) event and the resulting amount of damage [6].

With respect to the value chain and based on March and Shapira’s general definition, we define supply chain risk as follows: Supply chain risk is 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 at least one company in the supply chain negatively [7]. In contrast to March and Shapira’s general definition of risk management, this definition includes the origins and sources of potential risks as well as all affected companies of a value chain.

A company’s risk can be classified according to their sources. A literature review provides several classifications. In the following, Christopher and Peck’s common classification is used. They identify five groups of risk sources within the three areas considered: company, supply chain and environment. The sources of process and control risks are located within the company. Process risks basically comprise disruptions within the production processes, while control risks include management failures and wrong or inflexible decision rules that lead to irregularities. Risks within the supply chain are mainly triggered by disruptions of the material, information or capital flow between the partners. According to the direction of the risks it is possible to distinguish between supply and demand risks [8]. In contrast, environmental risks

represent all potential damage caused by socio-political, macroeconomic or technical changes [1]. For instance, catastrophe risks such as the terrorist attacks of September 11th or Tsunamis fall in this category.

In recent years, the composition of the risk portfolio changed for most companies due to new market conditions. Besides “traditional” risks that arise from the business activity of each company, new risks emerge from sources that are often related to close cooperation [9]. The Cranfield School of Management identified the following drivers as causes for the emergence of these new risks [8]:

- Globalisation of supply chains
- Reduction of inventory holding
- Centralised distribution
- Reduction of the supplier base
- Outsourcing
- Centralised production

The combination of these risk drivers leads to an increasing vulnerability of supply chains and, hence, to an increasing risk portfolio of each company within that supply chain. For instance, globalisation leads to an increased geographical complexity in supply chains, while outsourcing and centralised distribution result in organisational and logistical complexity. Simultaneously, companies in a supply chain become more and more dependent on each other when they outsource functions and reduce their supplier base. Particularly the concentration on a small number of suppliers, or single sourcing in the extreme case, may result in a significant increase of supply risks [10]. The breakdown of one supplier may then lead to serious disruptions of the production process of a company. In addition, the ability to compensate disruptions through buffers decreases, e.g. due to a reduction of inventory. Companies which are unable to react to such problems might even collapse themselves and pass the initial disruption on to the next company in the production chain. Since these companies have reduced their risk buffers as well, disruptions may lead to significant damages. This effect can proceed through the entire supply chain and the breakdown of one company may hence lead to a damage of partners much further down the supply chain, although they may be geographically widely dispersed.

If companies pass their own, mostly internal risks on to their partners, it leads to a larger risk portfolio for all companies within this supply chain. However, companies are often unable to react to this part of their risk portfolio, because the respective risk sources are out of their range and in many cases also out of their visibility. Consequently, these risks can only be integrated into risk management indirectly as supply and demand risks.

The level of vulnerability of a supply chain and the extent of the described effect is proportional to the level of the temporal, functional and relational dependencies within the supply chain [11]. Since the mutual dependency of companies within a supply chain is closely linked to their cooperation and as the importance of this cooperation for the company performance is growing continuously, the vulnerability of the whole supply chain and individual companies will increase further. In addition, the growing intra-organisational complexity that may be caused by a high variety of variants leads to a higher complexity within the whole supply chain. This complexity, introduced to the supply chain by its members, is an additional risk driver in the supply chain context.

Hence, due to measures of a single company, the risk portfolio changes and risk might increase for all companies in the supply chain. The risk that arises for an individual company simultaneously becomes the risk of another company. Thus, companies have an interest that their supply chain partners manage their risks internally more effectively and efficiently. At the same time, the question arises of how to divide risks among the partners. In analogy to the concept of profit sharing, risk sharing becomes an issue in supply chain risk management. This aspect of managing cooperations has not yet been covered explicitly in the literature.

2.2 Supply Chain Risk Management

A recent investigation by Wildemann [12] shows that the importance of risk management is growing for most companies. The majority of the investigated companies expect an increased importance of risk management in the future for all areas considered. In this context, supply chain risk management (SCRM) is defined as a concept 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 organisational level to reduce supply chain risk [7].

The process of managing risk in the supply chain context takes place on the supply chain level as well as on the company level. On both levels the process contains similar steps: identification, analysis, assessment, handling and control of risks [12,13,14,15]. First, the individual process steps have to be performed by each company separately on the company level. Before starting the next step on the company level, all companies need to coordinate their activities. As mentioned in the previous section, there are many risks which are transferred along the supply chain. A single company is unable to identify and to

evaluate all risks to which it is exposed. Thus, it would be difficult for this company to manage and control these risks. This is the reason why each process step has to be repeated on the supply chain level after finishing it on the company level. The output of the process step on the supply chain level will be the basis for the logical next step on the company level (figure 1).

The process of risk management generally starts with the identification of potential risks, which are located within companies, the value chain or the environment. The process step analysis of the identified risks contains the detection of possible consequences for each risk. While the results of the first two process steps are mainly of qualitative nature, the objective of the next step is to quantify these results. For assessing the identified and analysed risks, an estimation of the likelihood of occurrence and its impact on the company performance is needed. Due to the large number of risks most companies are exposed to, it has to be prioritised which risks should be managed actively. During the fourth step, the risk handling, companies have to decide which strategy and which measures to chose for reducing the supply chain risks. An example for this is to transfer a risk to an insurance company. During the process step controlling, there should be a continuous comparison of the target and the actual risk portfolio in order to be able to react quickly if discrepancies occur. Due to the complexity of most supply chains and the resulting long response time of the whole system, an early reaction to such discrepancies is an important success factor for supply chain risk management.

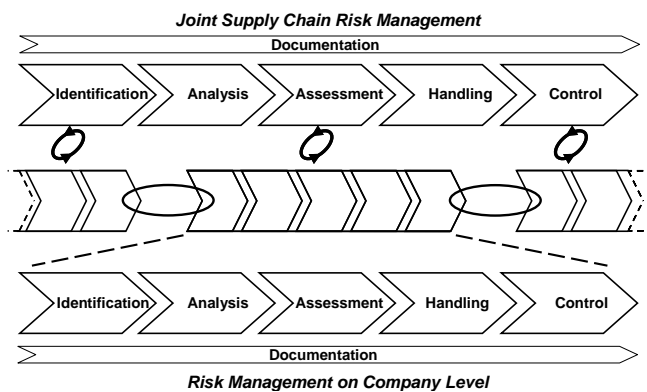


Figure 1: The Process of Inter-Organisational Risk Management

3. Results of The Mmpirical Study

In the explorative study conducted by the authors, companies were asked to assess different risk sources with re-

spect to their potential impact and their probability of occurrence. A scale from zero to four was used, where low values correspond to a low impact and to low probabilities of occurrence. Figure 2 shows the results of this survey for manufacturing companies and logistics service providers. The risks of the two internal sources “process” and “control” are aggregated in the category “company”. Around the average rating of the four sources, the variation of the individual risks is shown. Risks that combine high values with regard to both dimensions in figure 2 are considered dangerous, while risks with low values in both dimensions are less relevant to companies. Risks with ratings that vary heavily in both dimensions cannot be

classified clearly, since there is a strong dependence on the respective company. Figure 2 shows that risks emerging from the supply chain represent the biggest threat to both groups of companies. Manufacturing companies rated supply risks high with regard to both dimensions, while the logistics service providers assigned high values to demand risks. Likewise, the other source – that is demand risks in case of manufacturing companies and supply risks in the case of logistics service providers – was estimated to be comparatively threatening. Environmental risks, that were rated rather unimportant as well, are only a marginal threat from the point of view of both companies groups.

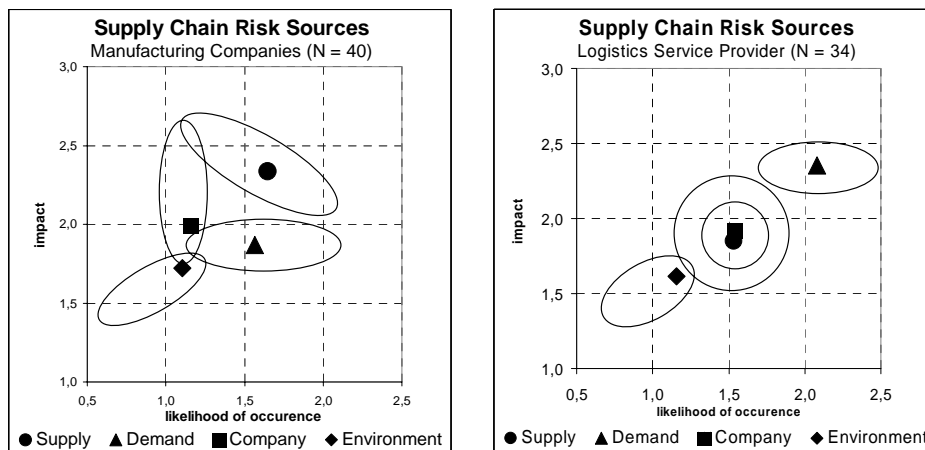


Figure 2: Assessment of Supply Chain Risk Sources

Another aspect of the study was to investigate the importance and the degree of implementation of SCRM. Both manufacturing companies and logistics service providers anticipate an increase of the importance of supply chain risk management. For example, 82% of managers from the industrial sector and 70% from logistics service industry who were interviewed believe that supply chain risk management will have a high or rather high importance for their company. However, according to figure 3, the increase of importance in the industrial sector is faster than in the logistics service industry. This leads to the assumption that for many industrial companies, the protection against damage on the supply side has the highest priority. In contrast to manufacturing companies, logistics service providers generally need fewer suppliers to offer their services. This could be the reason why the importance of SCRM increases by a lower

rate in the opinion of logistics service providers. The proportion of companies which state that SCRM has a certain importance for them already today is relatively small. The result of the investigation seems surprising, considering the results of the investigation regarding the risk assessment of companies described in the previous section. Here supply and demand side risks are estimated most dangerous to companies. The large proportion of companies which today believe that SCRM will have a certain importance for them in 2010 indicates that most companies have recognised the necessity for such an inter-organisational risk management. One possible reason for the late increase of importance could be the existence of barriers to implementation of SCRM. These barriers comprise company internal aspects as well as aspects of the supply chain level.

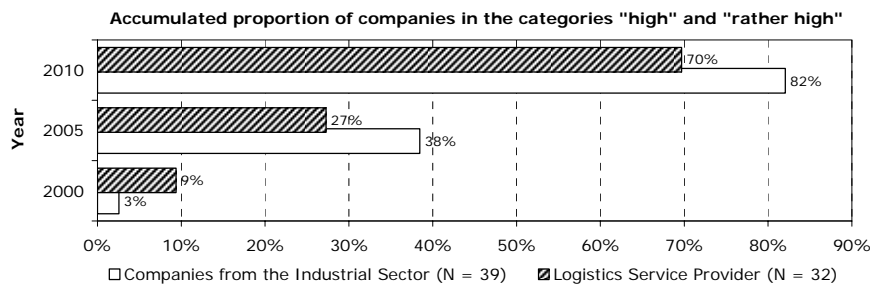


Figure 3: Importance of Supply Chain Risk Management

On the supply chain or *inter-organisational level*, barriers to implementation of SCRM are similar to those of supply chain management. A holistic perception as well as a broad visibility along the chain are essential for the realisation of both concepts [11]. This transparency is the basis for companies' confidence in each other. In most cases companies are not able to recognise the actual sources of their supply and demand side risks without transparency. Svensson [11] and Jüttner [8] assume that the majority of risks is invisible to companies. Currently, the visibility in supply networks still seems to be small and the transparency low. A majority of companies from the industrial sector shares information only with their tier one and tier two customers and suppliers. However, most supply chains comprise much more members.

Consequently, most companies can only take their own risks into account and those of their direct partners. It is therefore reasonable to assume that the partial view of companies on their supply chain is one of the major deficits in the implementation of SCRM. A lack of confidence may lead to the fear of companies that their partners behave opportunistically [16]. Another potential consequence of such a lack of confidence is competitive rather than cooperative behaviour in the supply chain. As Christopher and Lee [17] show by the risk spiral, the lack of confidence is one reason for the build-up of inventory buffers. These buffers lower transparency and may even lead to a further decrease in confidence.

Another barrier to implementation is a lack of trust in each other. As shown in the previous sections, reason for this is the missing transparency, competitive thinking and the fear of opportunistic behaviour in cooperative relationships. The relevance of these issues was also investigated in the study (figure 4). An interesting point is that logistics service providers consider these aspects more important than manufacturing companies. The trust of logistics service providers in their business partners seems to be smaller than that of manufacturing companies in each other. One possible reason is the information asym-

metry between logistics and manufacturing companies. In general, service providers as agents have better information on their capabilities and performance, whereas manufacturing companies as the principal have better knowledge on customers and their market segment [2]. Hence, the mutual trust in the relationship of the two kinds of companies is on a very low and insufficient level. Since logistics service providers – in contrast to other industries - are operating in many relationships with a lack of trust, this problem is of great relevance. But also manufacturing companies view this problem as important. Therefore, a lack of trust is the second barrier for the implementation of SCRM on the supply chain level.

On the company or *intra-organisational level*, the lack of understanding and the shortage of qualified employees are investigated as possible barriers of SCRM. Independent from the industry affiliation, companies attach great importance to these aspects. However, the lack of understanding seems to be more important than the insufficient qualified employees, especially for logistics service providers. In this context, understanding refers to motivation or corporate culture, whereas qualification means the availability of knowledge. Thus, deficits on the company level appear to be predominantly in the employees' commitment to implement such a concept and less in their capabilities.

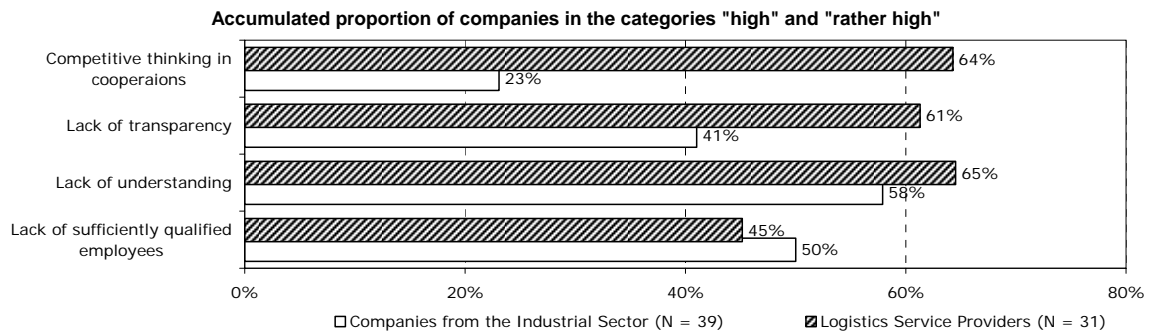


Figure 4: Barriers to The Implementation of Supply Chain Risk Management

Despite the barriers to SCRM discussed above, many companies apply individual measures of this concept. This holds for measures on the strategic as well as on the operational level. In figure 5, selected measures of SCRM and their frequency of implementation by the companies are shown.

Both industry groups identified the safeguarding of processes and data as the most important instrument of risk management. This aspect is not a separate measure within SCRM, but it describes a basic approach containing several company specific instruments and methods on the operational level. Other important instruments on the strategic level are internal (self-assessment) and external (independent) audits to determine a company's risk situation. Companies from the industrial sector prefer internal to external audits, whereas logistics service providers implemented both methods equally. The high ranking of internal audits indicates the relevance of the factor trust within SCRM. The audit of partner companies in the supply chain serves as a basis for additional strategic instruments. For instance, the information on another com-

pany's risk situation is a precondition for a risk-oriented examination of new businesses and projects. In addition, the check-up of contracts with suppliers is based on audits. Before signing a contract, standards for the reduction of risks can be set and the compliance of these standards can be verified by audits. For logistics service providers, this kind of measure is less important than for the industrial sector, since fewer suppliers are necessary for the provision of services. In addition to the strategic measures, operational instruments are implemented by most companies. As can be seen in figure 5 they are mostly used by logistics companies. An exception is the build-up of safety stocks. As services cannot be stored, this measure is largely irrelevant. Thus, logistics service providers rely more on other measures of SCRM, which may be one explanation for the higher percentage of use compared to companies from the industrial sector. For manufacturing companies, safety stocks are the most widely used operational measure, as it has buffering affects and is therefore capable to compensate disruptions for the supply chain. Of course, disadvantages of safety stocks like storage costs still exist.

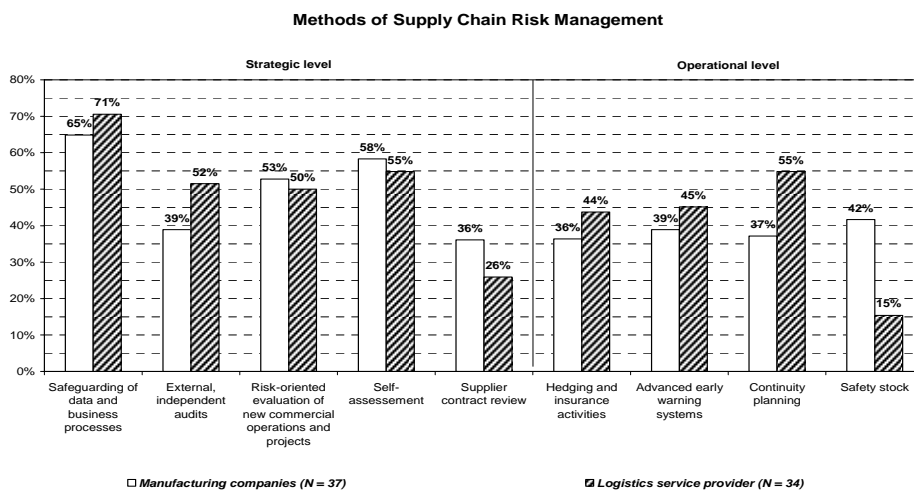


Figure 5: Frequency of The Application of Supply Chain Risk Management Measures

In conclusion, there are in fact several measures that are already used in management practice, but they are rarely part of an integrated concept. It is reasonable to assume that the low degree of implementation of SCRM approaches can be traced back to a lack of a support by practicable methods and instruments. In the following, some examples for existing concepts and their deficits are described.

For single companies an IT-supported approach is available. It is implemented in a web-based “risk-check” tool from Wildemann [12], which analyses the risk-profile of companies by examining its financial key figures against the background of the new equity guidelines defined by Basel II (full name: International Convergence of Capital Measurement and Capital Standard: A Revised Framework). However, this concept concentrates exclusively on internal risk-rating. Financial as well as legal aspects are examined by Pfohl [18] on the supply chain level. Christopher & Peck [3], Zsidisin & Ellram [19], Norrman & Lindroth [20], Peck & Jüttner [21] and Sheffi [22] developed rather descriptive approaches to SCRM. Thus, although structured approaches are demanded in literature, the present concepts still have deficits. They either:

- focus on a single company,
- take only certain categories of risk (e.g. financial risks) into account or
- have a rather descriptive character, i.e. a methodological framework is missing.

Finally, the approaches so far lack an application-oriented framework that integrates risk management from the level of supply chain to the level of the company and a systematic deduction of recommendations based on the specified risk exposure. A methodical concept to support companies is currently developed by the authors to resolve the above deficits in a systematic manner. The aim is to create a methodology that enables companies to determine their specific risk exposure by analysing the supply chain and the company characteristics. Existing risk management methods and tools are combined with specifically developed new methods to an overall concept to allow the derivation of concrete recommendations for inter-organisational risk management.

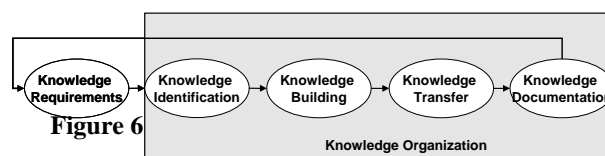
4. Derivation of Recommendations: A Knowledge Management Approach

The development of an integrated framework for SCRM would go beyond the scope of this paper, since it comprises a lot of separate components, ranging from management concepts on a strategic level and separate meas-

ures on an operational level. In the following, we will apply knowledge management as a management tool to SCRM and derive recommendations which should be part of an integrated framework to overcome the above-mentioned deficits.

Knowledge management has been recognized as an important concept by both the disciplines logistics and supply chain management. We consider knowledge management as a very important basis for supply chain risk management for several reasons. First, knowledge management is important for all steps in the SCRM process. For instance, knowledge about past disruptions or damages in a company is mostly employee specific, so that the identification of risks depends on the know-how of employees. Second, it was shown above that a lack of understanding and a lack of sufficiently qualified employees are two of the main barriers to the implementation of SCRM. This is exactly the starting point of knowledge management. Third, a holistic framework should not only have a theoretical basis, but it should ideally integrate these aspects into an all-embracing tool that supports the SCRM process. The application of knowledge management perfectly supports employees in the SCRM process.

The attempt to specify and narrow down the term “knowledge” is associated with some difficulties, since knowledge is viewed diversely in different scientific disciplines and even in the field of management theory. In this paper, we refer to knowledge as information which is processed and interpreted by an individual [23]. The different perceptions of knowledge consequently also apply for the term knowledge management. Since management disciplines develop their own approaches, there is no generally accepted foundation. Recent research is mostly focusing on process thinking [24]. Here, knowledge management comprises all information and knowledge related activities for maintaining future competitive advantages as well as all processes influencing the identification, creation, change, protection and provision of knowledge in a company. Using knowledge requirements as a starting point, the main tasks are the identification, build-up, transfer and documentation of risks (figure 6).



These steps can be summarised as knowledge organisation and involve process- as well as structure-oriented aspects. For a more detailed description of the knowledge

management process, see [18]. These process elements can also be adapted to create an inter-organisational knowledge basis, although there were developed for an intra-company knowledge management. The knowledge basis in the field of SCRM should involve the risk portfolio of the supply chain, the experiences and know-how of all partner companies, strategies and instruments of risk management as well as their affects on the company. To support the SCRM process, the information on past incidents should be collected, linked, documented and updated on a regular basis. If this kind of knowledge basis is established in an inter-organisational manner within the SCRM process, companies can benefit from the other companies' experience. The efficiency of risk management can be increased, the costs and possible failures reduced.

In table 1, the steps of the SCRM process are combined and linked with the elements of the knowledge management process. Concrete measures can be deduced for each field. In the following, suggestions for supply chain risk instruments are exemplarily given for the marked fields and are explained in greater detail.

Table 1: Combination of Knowledge Organisation and SCRM

	Knowledge Identification	Knowledge Buildup	Knowledge Transfer	Knowledge Documentation
Risk Identification
Risk Analysis
Risk Assessment	
Risk Handling	
Risk Control

A good example for knowledge identification in the field of risk management is the identification of appropriate criteria and of instruments for risk assessment. A lot of instruments in this area exist, so in most cases there is no need for companies to develop completely new tools. But often there is a lack of transparency about what is already known internally as well as externally and what can be adapted for a specific purpose. An example for a risk assessment tool is a diagram containing two criteria: the likelihood of occurrence for a risk and its impact on the company performance, so that companies or supply chains are able to classify identified risks according to these criteria.

To build-up knowledge on risk analysis it is necessary to link expert experience about causes and consequences of

the identified risks. This knowledge should also be transferred from experienced employees to other employees. Similarly, experienced companies should transfer their knowledge to other companies, so that the whole supply chain can benefit. To avoid employees withholding information knowingly or unknowingly, it is important to create an adequate business culture [25]. To support a continuous transfer of knowledge it seems reasonable to set up so called risk core teams. These teams should consist of highly qualified employees with specific knowledge of risk management from previous projects. Ideally, there is one core team in each company and one inter-organisational team with members from different companies [26]. By this approach, communication channels can be established between companies and it is ensured that intra- and inter-organisational risk management are coordinated.

The last example for the combination of knowledge management and SCRM is visualisation as an instrument of knowledge documentation. Generally suitable to all risk management process steps, probably the most important field of application is risk handling. Visualisation – e.g. of information on business processes, dependencies, risks and results of risk management activities - is relatively simple and inexpensive to implement but can have a large impact on the success of risk handling. It makes information easy to understand, even for unskilled employees. For the visualisation of how to deal with risks in case of occurrence, a guideline can be established that is accessible by all employees on information panels, diagrams, tables etc. On the inter-organisational level, such a guideline should be made available on a web-based platform to all partners. By making knowledge easy to understand, visualisation increases the transparency and reduces the complexity of the SCRM process. As the lack of transparency was identified as one of the main barriers to the realisation of SCRM, visualisation has the potential to raise the motivation of people to engage in the implementation of SCRM.

5. Conclusion

In recent years, companies have experienced the negative aspects of supply chain management. The risk exposure of companies and supply chains has increased dramatically due to trends such as globalisation, the reduction of the supplier base, and reduction of safety stocks. Companies increasingly realise that today it is insufficient to apply some internal risk management activities, but that it is necessary to integrate partners in an inter-organisational supply chain risk management. It was shown in this paper, however, that there is still a number of barriers to the realisation of supply chain risk management. The lack of an integrated framework with strategies and instruments as a

methodological support was identified as a major reason for low degree of implementation.

The application of knowledge management to the field of supply chain risk management was discussed as one field of activity for companies. The approach could only be discussed exemplarily and therefore leave room for future research on this topic.

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