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An Empirical Approach to Supply Chain Risk Management: Development of a Strategic Framework

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Abstract

Nowadays companies face many critical challenges with regards to Supply Chain Management. One of the main challenges arises out of trends associated with lean management. Strongly synchronized interfaces and the reduction of inventory cause a greater dependence of the supply chain partners on each other. This close co-operation between supply chain partners exacerbates the risk exposure of companies in a supply chain.

The Hamburg School of Logistics performed an empirical investigation on risk and risk management activities. In this paper, a framework for supply chain risk management will be developed. Starting from theoretical risk classifications, companies' risk assessment and the description of companies' supply chains, suitable supply chain risk management strategies will be discussed. We will show that there are differences in the way companies from different sectors should approach this challenge. As a conclusion, recommendations will be given.

Keywords: Risk, Supply Chain Risk Management, Vulnerability, Supply Chain Risk Strategies

1 Introduction

Changes in companies' business environment have increased the intensity of competition, in many markets. Competition changes from a competition between companies towards one of entire supply chains especially driven by the globalization and the shortening of product life cycles. Therefore many companies collaborate closely with their suppliers and customers using the concept of Supply Chain Management. This approach, which was first mentioned in 1982 by Oliver and Webber (Oliver and Webber, 1982), is widespread in today's business. Since its occurrence, numerous techniques and strategies have been developed and subsumed under this concept. In general, companies strive to optimize the inter organisational flow of material, information and capital along the network. Today, Supply Chain Management is defined by Christopher 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 (Christopher, 2005). Apart from logistics management other functions have been integrated into Supply Chain Management approaches such as manufacturing operations, product design and information technologies. Companies like DELL, WALMART or Benetton gain their competitive advantages by the application of Supply Chain Management techniques.

However, applying Supply Chain Management approaches within a network also causes difficulties mainly the increasing dependency between companies in supply chains on each other. The main reasons for this development are the reduction of channel inventory as well as the standardization of interfaces. Companies as well as entire supply chain networks become more vulnerable against disruptions. Therefore it is essential for companies in supply chains to agree on a common risk management approach for their network.

The aim of this paper is to stretch a theoretical as well as an empirical framework for supply chain risk management. Firstly, risk and risk management are analysed from the literature

point of view for this purpose. Secondly, an empirical exploration will be introduced and the most important results will be presented. The Hamburg School of Logistics performed this empirical exploration as a preparation for a main study in 2007. Thereby the focus lies on companies' risk assessment as well as on the relevance, on potential barriers, and on methods of an inter organizational risk management approach.

2. Theoretical Framework

In recent years, many companies have observed that beside their "traditional" risks arising from their business activities new risks emerge from sources that are often related to the close collaboration within their supply chain networks (Giunipero and Eltantawy, 2004). As a consequence, their risk portfolio changes. This development is triggered by drivers originating inside and outside their supply chains. The main drivers are related to the trends of globalization and lean supply chains (Jüttner, 2005).

In the literature, the definitions of the term "risk" as well as the instruments that are used for risk measurement strongly depend on the chosen field of research (cp. Christopher and Peck, 2004). Common definitions of risk are based on the volatility of possible return, on the concept of uncertainty caused by information deficits and on the willingness to accept a potential loss if positive returns are expected (Baird and Thomas, 1990). In traditional decision theory, risk is defined as the variation in the distribution of potential results, their probability of occurrence and their subjective value (Arrow, 1965). 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 practical business, 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 (March and Shapira, 1987). With respect to the supply chain networks 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 more than one company in the supply chain negatively (cp. Kersten et al., 2006).* The first part of our definition describes the two dimensions needed for risk assessment: the probability of occurrence and the caused damage. However, in contrast to March and Shapira's general definition of risk management, this definition includes no rule of how those two dimensions have to be combined. The combination of these dimensions strongly depends on a person's individual attitude towards risk. Therefore it is useful for a practical risk appraisal to use a matrix representing both dimensions, probability and damage. For instance, Norrmann and Lindroth (Norrmann and Jansson, 2004) as well as Wildemann (Wildemann, 2006) suggested concepts.

The second part of our definition deals with the difference of supply chain risk and usual business risks. Therefore the range of risk is introduced, which distinguishes between usual risks and supply chain risks. Supply chain risks are only those risks that affect at least two companies of a supply chain. However, it is irrelevant whether a company is affected directly or indirectly by a supply chain risk. If companies pass their own, mostly internal risks on to their supply chain partners, the partners are affected indirectly by these risks, whereby consequential damages occur. This effect is not limited to one level of a supply chain. Even companies which are only affected indirectly emit these risks to further members of their network. Companies are often unable to handle indirect supply chain risks because the origin of these risks are simply out of their visibility horizon. This phenomena which is responsible for the increasing supply chains risk portfolios is also called vulnerability in literature. The level of vulnerability and therewith the extent of the described effect is proportional to the level of the temporal, functional and relational dependencies within that supply chain (Svensson, 2004). Since the mutual dependency of companies within a supply chain is closely linked to their cooperation and since the importance of this cooperation for company's

performance is growing continuously, the vulnerability of the whole supply chain and individual companies will increase further.

Supply chain risks can be typed according to different classifications in literature (Ritchie and Brindley, 2000, Pfohl, 2002, Christopher and Peck, 2004, Spekman and Davis, 2004). For instance, Pfohl distinguishes between endogenous risks emerging in a supply chain and exogenous risks whose origin is located in the environment of the focal network (Pfohl, 2002). However, this taxonomy mainly concentrates on company's internal risks. A common classification was introduced by Christopher and Peck (Christopher and Peck, 2004), who classify supply chain risks in five sources according to their origin (cp. Figure 1). These five sources can be summarized in three groups: company internal risks, supply chain internal risks, and environmental risks (Christopher and Peck, 2004).

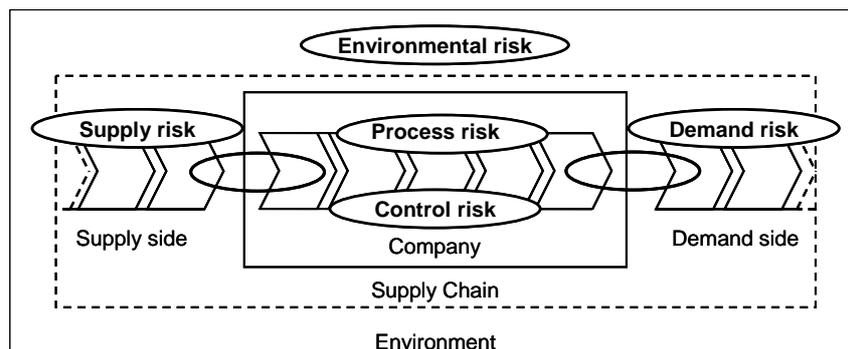


Figure 1: Sources of supply chain risk (Christopher and Peck, 2004)

Two risk sources, process and control risks, are located within the company considered. These sources cover all risks emerging out of production and logistics processes as well as managerial risks, which fulfil the definition of supply chain risks. The second group consists of two other risk sources, supply and demand risks. These sources contain all risks emitted by supply chain partners, thus all indirect supply chain risks. The last group is formed by the environmental risks. These risks represent all potential damage caused by socio-political, macroeconomic or natural disasters (Christopher, 2005).

To handle supply chain risks, an approach for an inter organizational risk management was developed in literature – supply chain risk management. In the following Supply Chain Risk

Management 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 organisational level to reduce supply chain risk (Kersten et al., 2006). For this purpose three basic strategies can be used, risk bearing, risk avoidance and risk transfer.

By applying the strategy of risk bearing to a specific risk, companies try to reduce the potential damage caused by the occurrence of this risk. The minimisation of the probability of occurrence is not the focus of this strategy, the occurrence of a risk is rather accepted. Business Continuity Management is one common concept to limit the effects of an incident. Hiles and Barnes (Hiles and Barnes, 2001) define it as *the development of strategies, plans and actions which provide protection or alternative modes of operation for those activities or business processes which, if they were to be interrupted, might otherwise bring about a seriously damaging or potentially fatal loss to the enterprise*. The basis of business continuity management is the existence of buffers such as inventory, capacity or time buffer. The four elements of business continuity management are summarized in Table 1.

Elements of Business Continuity Management	Description
Crisis management	Overall process to manage the incident
Disaster recovery	Recovery of critical systems, applications, data and networks
Business recovery	Recovery of critical business processes
Contingency planning	Recovery from impact external to the organization

Table 1: Business Continuity Management (Norrman and Jansson, 2004)

Essential for the success of all these elements is that they are initiated immediately after an incident occurs. Therefore, the strategy of risk bearing can be best applied if there are early warning systems installed along the supply chain.

Another approach for risk management is to *avoid* risk. The main target here is to reduce its probability of occurrence. By applying this strategy, companies try to eliminate the causes of

incidents pro actively. The methods used within this strategy are e.g. tools to protect processes and data, audits and the risk-oriented revision of new business contracts and projects. Companies should try to influence the attitude towards active risk management of their suppliers positively, so that potential risks do not arise (Zsidisin and Ellram, 2003). The main premise for applying this strategy is a wide visibility horizon along the supply chain network. Companies are not able to recognize possible risk sources and to handle them proactively, without this transparency.

By following the third strategy of risk handling, companies try to *transfer* risk to other organisations. Typically only the potential impact of a specific risk will be transferred, for instance to an insurance company. The transfer strategy is suitable when a potential damage is materially and the continuance of the firm is not affected.

3. Empirical Exploration

In order to investigate the application of supply chain risk management in management practice, an empirical study will be conducted at the Hamburg School of Logistics in 2007. We performed a smaller exploration to formulate hypotheses concerning supply chain risk and risk management strategies in preparation for this. In our main investigation we plan to mainly differentiate between manufacturing companies and logistics service providers. Although we have only the results of our pre-study so far, we found some interesting aspects we will present in section 4. We used two different surveys for conducting our pre-study, one for manufacturing companies and one for logistics service providers. Each of these two surveys was available as a paper-based and as an online version. Beside directly collected data such as company's size, we used five point Likert scales for estimation questions. The scales encoded from 0 (lowest category) to 4 (highest category). For most analyses the five items were classified into three classes, the first consisting of the two lowest categories, the second

one, being composed of the two highest categories, and the last one sharing the neutral category.

		Risk sources			
		Company	Supply	Demand	Environment
Manufacturing companies	Loss of production		Failure of supplier	Increasing variations in demand	Legal risk
	Quality failure		Decreasing supply quality	Customer insolvency	Risk of liability
	Failure of logistics service provider (internally)		Decreasing supply reliability	Margin	Political risk
	Shortage of employees		Increasing supply lead times	Unpredictable substitute products	Risk of conflict / war
			Rise in prices	Dependency on single customer	Natural disaster
			Stock outage	Failure of logistics service provider (Distribution)	
Logistics service providers	Insufficient capacity		Subcontractor failure	Customer insolvency	Legal risk
	Quality failure		Decreasing quality of services	Margin	Risk of liability
	Shortage of employees		Decreasing supply reliability	Substitution of companies service	Political risk
			Rise in prices	Dependency on single customer	Risk of conflict / war
			Dependency on subcontractors		Natural disaster

Table 2: Assessed Risks

In order to evaluate companies' assessment of supply chain risks, the companies were asked to estimate both, the potential damage and the likelihood of occurrence for typical risks in accordance with the supply chain risk definition presented in section 2. These supply chain risks were classified according to Christopher's and Peck's method (Christopher, 2004) which we introduced in section 2. The classification of the single risk is shown in Table 2. Afterwards we aggregated the separate risk assessments to an average assessment per risk source. We visualize this value using the matrix proposed by Norrmann and Lindroth (Norrmann and Jansson, 2004) as well as by Wildemann (Wildemann, 2006).

We also investigated the relevance of supply chain risk management in practice by the means of a five item scale. Companies were asked to estimate the importance for three points in time, 2000, 2005 and 2010. As mentioned above, the answers were classified into three

classes. We assume in this context that the relevance of the concept can be used as an indicator for its appliance. In case supply chain risk management is applied less than we expected, we also evaluate the relevance of potential barriers for the implication of supply chain risk management. The relevance of these barriers was assessed on a similar scale like the importance of the whole concept. We asked companies to assess the frequency of application for the methods presented in Table 3 to evaluate the most common methods of supply chain risk management. Beyond the application of the individual methods, we assume that it is reasonable to get an impression which strategies are applied the most for risk handling by grouping the results for the single methods (cp. Table 3).

Risk Bearing	Risk Avoiding	Risk Transfer
Continuity Planning	Supplier contract review	Hedging and insurance activities
Advanced early warning systems	Risk oriented evaluation of new commercial operations	
Safeguarding of data and processes	External independent audits	
Safety stock	Self-assessment	

Table 3: Methods of Supply Chain Risk Management

Surveys were sent to 823 companies, namely 594 manufacturing companies and 229 logistics service providers during our pre-study. With an average rate of return of about 10.8%, 50 manufacturing companies and 39 logistics service providers were covered in our sample. In detail, out of the group of manufacturing companies, 22% of the respondents belong to the chemical industry, 17% to the automotive industry, and 15% to the engine building industry sector. 26% of the questioned manufacturing companies consider themselves as an OEM and 30% as a Tier 1 supplier. Our sample mainly contains smaller companies - 67% have less than 1000 employees. The interviewed logistics service providers mostly perform classical services such as warehousing (72%), material handling (67%), and transportation (54%). Although 41% of them performs third party logistics services “often” or “always” while even 18% of the logistics service providers perform fourth party logistics services “often” or “always”. 57% of the investigated logistics service providers have less than 1000 employees .

4. Empirical Results

In the following, we will present the most interesting results of our exploration. Firstly, the risk assessment by manufacturing companies and logistics service providers will be shown. Secondly, the results concerning supply chain risk management are presented.

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 rather unimportant to companies. Risks with ratings varying in both dimensions cannot be classified clearly, since there is a strong dependence on the respective company.

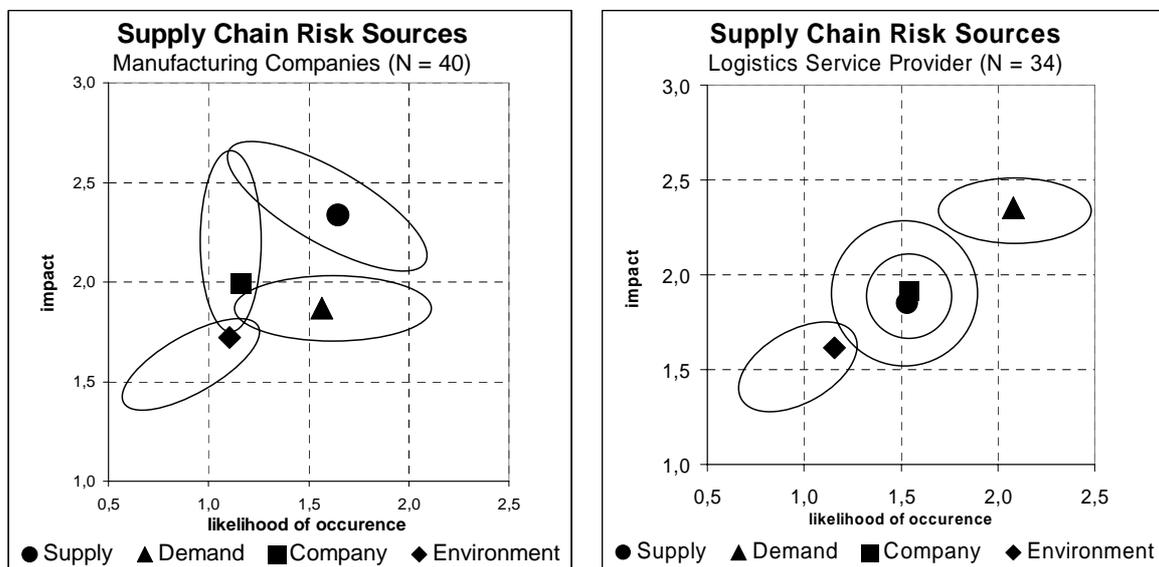


Figure 2 *Assessment of the risk sources within a supply chain by producing companies and logistics service providers*

Beside the fact that manufacturing companies and logistics service providers estimate risk sources differently, there are two main results from this question. First, although manufacturing companies assess supply risk and logistics service providers estimate demand risks as most dangerous, risks arising from the supply chains are most serious for the majority of both groups. Second, environmental risks are rather irrelevant for the respondents. The only exception is the risk of liability, which was assessed as dangerous by the majority of the questioned companies.

To start with the supply chain risk management part, we present the concept's general importance in practice. We asked companies to estimate the importance on a five item scale for three points in time, 2000, 2005 and 2010. In Figure 3 the accumulated proportions of companies in the category “high” or “rather high” are presented. It can be recognized, that the importance of supply chain risk management has been increasing dramatically since the year 2000. The majority of the manufacturing companies particularly expects such a development. A recent investigation by Wildemann (2006) approves these results. In this study, the majority of the investigated companies also expected an increased importance of risk management in the future for all areas considered.

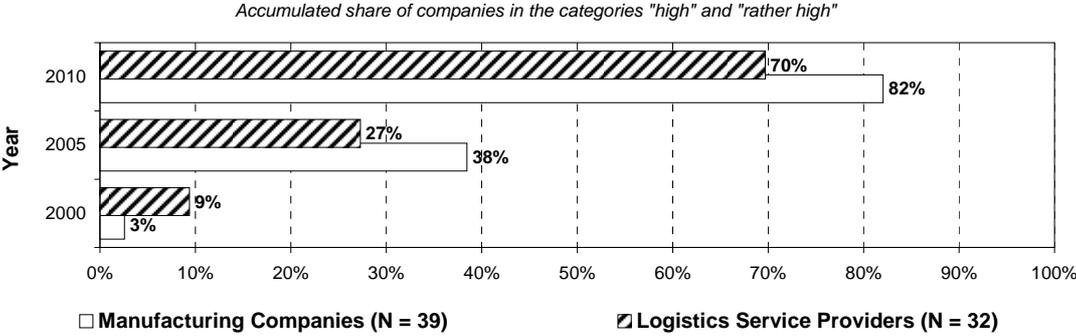


Figure 3: Importance of Supply Chain Risk Management

However despite this development the past (2000) and also the current (2005) importance of supply chain risk management is rather low. In 2000 the approach was not widespread in literature and practice, only some scientists and logistics professionals noticed it. That is why in 2000 the proportion of logistics service providers, which estimated the importance of supply chain risk management high or rather high, is superior to manufacturing companies. Global incidents happened between 2000 and 2005, for instance 09/11 or SARS, so that more executives became aware of the problem (Peck and Jüttner, 2002). As a consequence, the number of companies considering supply chain risk management as relevant is significantly higher than in 2000, although it is still rather low. Only the prediction for 2010 nearly reflects the level we expected for 2005. Here, a majority of companies from both groups estimated supply chain risk management as relevant.

Our results indicate that the application of the supply chain risk management approach in practice is rather low. This seems to be surprising, especially when considering the results of the companies risk assessment shown in Figure 2. However, the large proportion of companies believing today that supply chain risk management will have a certain importance for them in the future indicates that most companies have already recognized the necessity for such an approach. But why is supply chain risk management not as important nowadays as companies risk assessment indicates? Based on our exploration, we assume that there are some barriers in practice which foreclose a more rapid increase of supply chain risk management importance. We further assume that these barriers comprise company internal aspects as well as aspects of the entire supply chain.

On the supply chain or on the inter organisational level, barriers to the implementation of Supply Chain Risk Management are similar to those of the general Supply Chain Management approach. Two closely related barriers, the lack of transparency and the insufficient trust within the network, are mainly responsible for the slow implementation of supply chain risk management in practice. For instance, a holistic perception as well as a broad visibility along the chain are essential for the realisation of both concepts (Svensson, 2004). Due to the lack of transparency, companies are not able to recognize the current sources of their supply and demand side risks in most cases. Svensson (Svensson, 2004) and Jüttner (Jüttner, 2005) assume that the majority of risks is invisible to companies. Currently, the visibility in supply networks still seems to be small and the transparency appears to be low. As our exploration shows, 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 of much more members. Consequently, most companies can only take their own risks and those of their direct partners into account. Additionally, a lack of transparency leads to an insufficient confidence along the chain, as Christopher and Lee have shown by their risk spiral (Christopher and Lee, 2004). Hence, companies build up their

buffer stocks, which lowers transparency even more and may even lead to a further decrease in confidence. Another mechanism is mentioned by Spekman and Davis (Spekman and Davis, 2004). They assume that a lack of confidence leads to companies' fear that their partners may behave opportunistically. Therefore, another potential consequence of such a lack of confidence shows competitive rather than cooperative behaviour in the supply chain. The relevance of these issues, lack of transparency and competitive thinking in cooperations, was investigated in our exploration (cp. Figure 4).

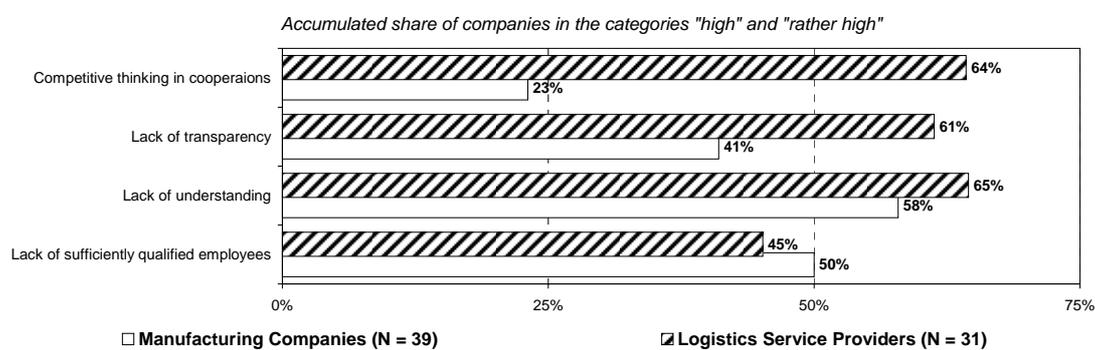


Figure 4: Barriers to the implementation of Supply Chain Risk Management

In this context, an interesting point is that logistics service providers consider these inter organizational aspects as much 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 asymmetry between logistics and manufacturing companies. In general, service providers as agents have better information on their capabilities and on their performance, whereas manufacturing companies as the principals have better knowledge on customers and on their market segment (Kersten and Koch, 2006). 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 a lot of relationships with a lack of trust, this problem is of greater relevance. But also manufacturing companies regard this problem as important.

On the company or intra-organisational level, the lack of understanding and the shortage of qualified employees are investigated as potential barriers of SCRM. Independent from industry affiliation, companies attach great importance to these aspects. The lack of understanding seems to be more important than the insufficient qualified employees, especially for logistics service providers.

However, many companies apply methods related with supply chain risk management despite of these barriers. Companies were asked to assess the frequency of application for these methods by a five item scale. In Figure 5 the scale of companies are presented which “always” or “often” apply a methods. The results are again separated in manufacturing companies and logistics service providers. Concerning the strategy of risk bearing, we concentrate on methods related to the concept of business continuity management (cp. Table 1). Beside the application of the approach itself, companies were asked to assess two of its measures: the safeguarding of data and processes as well as safety stock. Additionally, the use of advanced early warning system was included in our investigation. Both, manufacturing companies and logistics service providers, apply the safeguarding of data and processes most frequently in comparison to all other investigated methods. When looking at the other methods concerning the strategy of risk bearing, differences between manufacturing companies and logistics service providers can be recognized. The scale of manufacturing companies applying the other methods concerning risk bearing is homogenously about 40%. In contrast, logistics service providers assess separate measures in a more different way. Safety stocks are particular only used by a small number of them, which is not remarkable due to their chosen business model. The scale of service providers which apply continuity plans, advanced early warning systems, and the coverage of data and processes is significantly higher in comparison to manufacturing companies. This implicates, that the strategy of risk bearing is applied more frequently in the group of logistics service providers.

Accumulated share of companies in the categories "always" and "often"

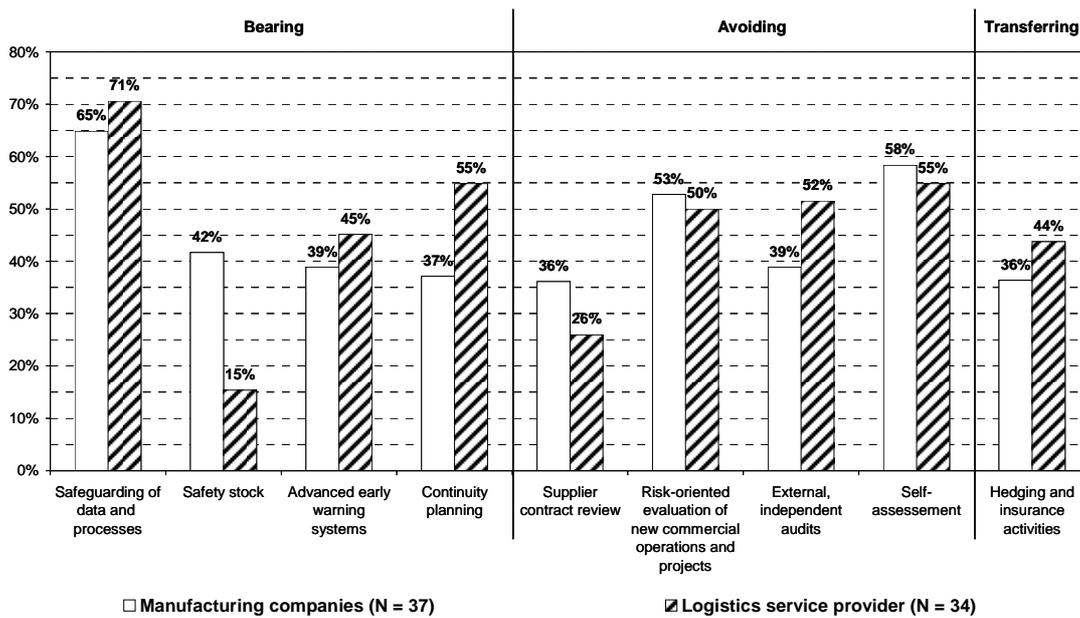


Figure 5: Methods of Supply Chain Risk Management

Concerning the strategy of risk avoiding, we concentrate on methods related to so called behaviour-based management (Zsidisin and Ellram, 2003). As presented in Table 3, we integrate the risk oriented evaluation of new commercial operations and of supplier contracts in our investigation as methods for behaviour change. Additional audits - external as well as trust-based, internal audits - were included as control instruments. In comparison to the risk bearing strategy manufacturing companies and logistics service providers apply risk avoiding somewhat more often (Figure 5). In this context manufacturing companies prefer the risk oriented evaluation of commercial operations and the self-assessment of supply chain participants. In contrast to self assessment, they apply external audits less frequently. However, logistics service providers behave differently in this point. They clearly favour external audits. One possible reason for this is the lack of a physical product they receive from suppliers in their business model. Therefore, a control dimension is missing and building up trust is more complicated.

The third strategy of supply chain risk management, the transfer of risk was not in the focus of our exploration and is therefore only represented with one method (cp. Table 3). Hedging

and insurance activities are integrated, here., The Scale of companies applying this method is rather high, although such transfer is not suitable for every risk.

5. Recommendations

In this section, we will give recommendations for the further application and development of supply chain risk management. First of all, supply chain risks have a great relevance for manufacturing companies as well as for logistics service providers. Risks occurring on the supply and on the demand side are especially dangerous for most companies. Therefore the practical approaches concerning risk management need to be enhanced quickly. As a key factor for such general enhancement, we identified the increase of transparency within the network. This can be reached by the use of a common computer based risk management tool along the chain.

As a methodical improvement of the supply chain risk management approach, we identify the extensive assessment of a companies' overall risk portfolio. Therefore, we recommend the use of a top-down filter approach for validated risk identification. Since the overall number of risks increased, it is nearly impossible for companies to take all potential risks into account. For this reason, the objective is to reduce all possible risks to an amount manageable by a company. All potential supply chain risks are identified and catalogued initially. The identified risks are grouped into categories as those by Christopher and Peck described above in order to guarantee a systematic risk evaluation. Based on this catalogue, the risks are filtered in several stages, so that important company specific risks are deduced. The results of this process step are the extracted risks that are relevant to the individual company and/or the supply chain. An exemplary three-stage process is illustrated in Figure 6.

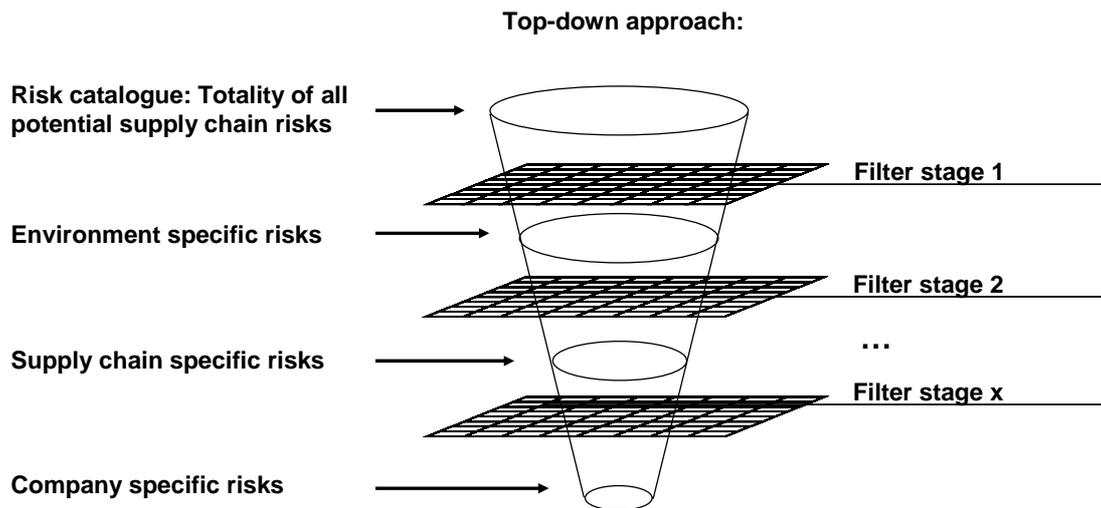


Figure 6: Top-down approach to risk selection

When a company's risk portfolio is identified and matched with its supply chain partners, a risk management strategy needs to be defined. This strategy depends strongly on the risk portfolio a company is faced with. Additionally, we assume that the company's position in its supply chain network as well as the overall competitive strategy a supply chains follows influence this risk management strategy. However, such a correlation has to be carefully tested in our main survey scheduled in 2007.

6. Conclusion and Outlook

In recent years, many companies experienced that the application of Supply Chain Management does not only have positive consequences like reduced costs and increased customer service. For instance, one of the main disadvantages of Supply Chain Management is the growing exposure towards supply chain risk companies are faced with. Risks arising from the supply side as well as from the demand side are most dangerous in today's business environment. The concept of supply chain risk management has been developed in literature and practice to handle this risk. Its importance has been increasing dramatically since the year 2000 and will reach high values in 2010. Nowadays, there are still barriers inhibiting the application of an inter organizational risk management. On the supply chain level, there is a lack of transparency and trust along the network. As a consequence, companies are not able to

recognize many of their supply chain risks before they occur. To enhance risk handling within a supply chain, the transparency along the network has to be improved in general. Methodically, it is necessary to find a common approach for risk identification along the supply chain network. We recommend a top-down approach with different filter stages. Secondly we advise the application of a common risk management strategy inside a supply chain network. Criteria related to the character of risks and manufactured products as well as to the overall supply chain strategy should be considered for selecting an appropriate risk management strategy.

For the enhancement of a holistic inter organizational risk management, the application of a common tool along the entire network would be useful. Therefore, we suggest the development of an IT-based tool, which simultaneously increases transparency along the network, offers strategic support, and structures the risk management process within the supply chain. Thus, the suggested tool should offer methodical support for all stages of the supply chain risk management process. We assume that the first step for such a development should be the phase of risk identification. But the problem is to build up enough trust between the partners within the supply chain network and to create a culture which supports communication about potential upcoming risks.

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