

Chapter 17: Dominant Risks and Risk Management Practices in Supply Chains

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17.1 Introduction

Supply chains are inherently susceptible to risky events. Earlier articles in supply chain management by Kraljic (1983) and Treleven, and Schweickhart (1988) stressed the importance to consider the risks arising from interconnected flows of material, information and funds in inter-organizational networks. However, during the last several years, the interest in this topic has significantly gained momentum. A large body of recent literature reports on events that disrupted supply chains and on their negative impact on businesses. These reports are paralleled by numerous articles from researchers and practitioners proposing best practices, guidelines, and concepts for risk management strategies that aim to ultimately create resilient supply chains. But what actually fuelled this recent attention to supply chain risks and their management? There are arguably at least two significant factors.

First, there is substantiated evidence that *the frequency of catastrophic events* such as natural hazards is increasing (Coleman 2006). Elkins et al. (2005) state that there has been an increase both, in the potential for disruptions and in their magnitude. And according to Munich Re's (2007) annual report on natural hazards, the comparison of the last 10 years with the 1960s reveals a significant increase in the number of natural hazards. The series of memorable crises and catastrophes that occurred in the past years underscores this development. Natural disasters such as hurricane Katrina devastating New Orleans in 2005, terrorist acts such as the World Trade Center attack from September 11, 2001, and epidemics like SARS in South-East Asia in 2003 are violent reminders that we live in an unpredictable and increasingly unstable world.

Second, *the vulnerability of modern supply chains* seems to have increased. Almost all industries have witnessed a remarkable change in their business environment, in particular due to increased competitive pressure and the globalization of markets. This resulted in a massive pressure to make intra-firm business processes and inter-firm supply chains either more efficient or responsive. Many firms reacted to this development by outsourcing or off shoring large portions of their manufacturing activities, sourcing in low-cost countries, lowering inventories, or collaborating more intensively with other supply chain actors (Christopher and Peck 2004; Fisher 1997; Hult et al. 2004). However, these developments ultimately led to an increased inter-firm dependence and, generally speaking, to an amplification of the vulnerability of supply chains to the impact of business disruptions (e.g., Gilbert and Gibs 2000; Kleindorfer and van Wassenhove 2004; Sarathy 2006). Certainly, modern supply chain management initiatives are powerful concepts for making operations leaner and more efficient in a stable environment but make supply chains more fragile (Zsidisin et al. 2005a). This argumentation is supported by findings from organizational scientists. There is evidence that increasingly complex and technology-oriented processes in organizations make errors almost inevitable (Lin et al. 2006).

Several researchers emphasize that as a consequence of this development which is characterized by a relatively unstable state of the world and an increased susceptibility of supply chains to disruptions, companies are compelled to tackle supply chain risks just as seriously as they tackle other business risks (Elkins et al. 2005).

Although risks are inherent in supply chains, their impact as well as their appropriate management have been receiving increasing attention, current knowledge is still limited and most articles on supply chain risks are anecdotal or case study-based (Hendricks and Singhal 2005a). Results from large-scale empirical research are scarce and mostly of descriptive nature (Jüttner 2005; Peck and Jüttner 2002; Zsidisin and Ellram 2003). This contribution tackles this lack of evidence and presents the results of a large-scale empirical study ($n = 760$) conducted in Germany among executives in supply chain management, logistics, and purchasing. The goal of this survey was to reveal (1) the *dominant and most prevalent types of supply chain disruptions* that have affected firms operating in Germany during the last years, (2) *how* these disruptions affected the surveyed firms, and (3) *what supply chain risk management practices* (measures and activities) the firms are currently pursuing to deal with supply chain risks.

The rest of this chapter is organized as follows: In Sect. 2, we firstly depict our understanding of the terms risk, risk source, as well as disruption, and secondly present the applied classification of supply chain risks and supply chain risk management practices. Section 3 presents the findings of the empirical study. Finally, Sect. 4 discusses the results, and presents implications for managerial practice.

17.2 Nomenclature and Conceptual Framework

Recently, several researchers have advanced the conceptual clarity of the nomenclature used in the domain of supply chain risk management – yet, there is still no commonly agreed nomenclature. Due to this reason, the purpose of this section is to outline a consistent nomenclature which represents the basis for the survey in the third section.

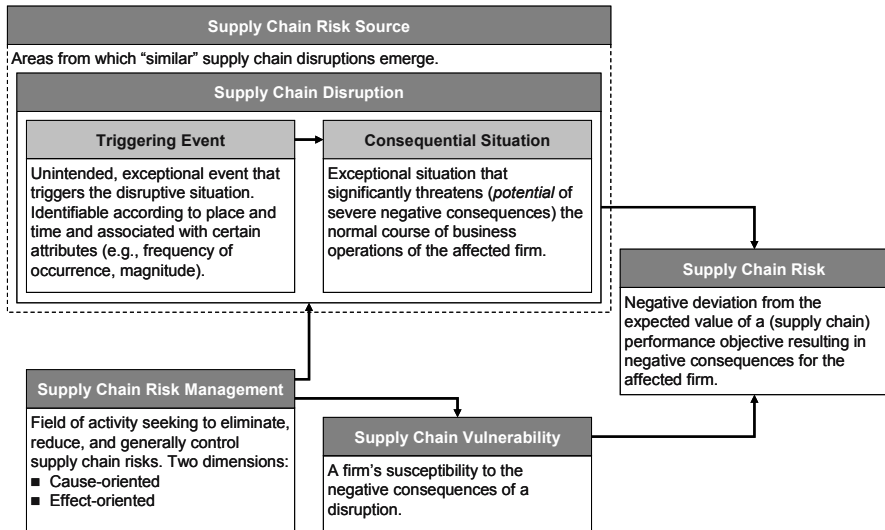


Fig. 17.1 Nomenclature and conceptual framework

In essence, we distinguish four interrelated terms: Supply chain risk, supply chain disruption, supply chain risk source, and supply chain vulnerability. In the following, these terms will be briefly derived from the pertinent literature and discussed. Figure 17.1 illustrates how these concepts are connected with each other.

17.2.1 Supply Chain Risk

In the field of supply chain management, several publications have addressed the question of how to define supply chain risk. Two different approaches can be distinguished: (1) risk as both danger and opportunity and (2) risk as purely danger.

The first approach is in line with common practice in many fields of business research such as finance. Here, the fluctuations around the expected value (mean) of a performance measure are used as proxy for risk, where risk is equated with variance and covers both a “downside” and an “upside” potential. Following these considerations and in analogy to the general definition of March and Shapira

(1987, p. 1404) – risk is the “variation in the distribution of possible outcomes, their likelihoods, and their subjective values” – Jüttner et al. (2003, p. 200) define supply chain risk as a “variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective value.”

In contrast, in most dictionaries as well as in the field of insurance, risk is viewed as the chance of injury, damage, or loss (Webster 1983). The notion that risk inherits primarily negative consequences corresponds to the common human perception. For instance, March and Shapira (1987) empirically examine how managers perceive risk and react to it. They find that the majority tend to overrate the “downside” potential of risk. Several scholars in the supply chain management and supply management field have adopted this view. Harland et al. (2003, p. 52), for instance, discuss several definitions and conclude that supply chain risk is associated with the “chance of danger, damage, loss, injury or any other undesired consequences.”

Considering the impact of recent disruptions on supply chains, we find that the latter notion of risk as being purely negative corresponds best to supply chain business reality. In addition, businesses usually consider their goals (e.g., turnover or production volume) not so much as a target point but as lower limits of half-open ranges, e.g., to achieve *at least* a certain turnover. Hence, a goal deviation only occurs when falling below these thresholds. In insurance research, such a situation is called loss or damage (Knight 1921). Here, we follow this notion and understand risk as being the negative deviation from the expected value of a certain performance measure, resulting in negative consequences for the focal firm. Hence, risk is equated with the detrimental consequences of a supply chain disruption – the realized harm or loss.

17.2.2 Supply Chain Disruption and Supply Chain Risk Sources

A supply chain disruption is a quite vaguely defined concept. This holds also true for related concepts such as incident, accident, glitch, failure, hazard, crisis, or disturbance. Here, we define a supply chain disruption as the combination of (1) an unintended, anomalous event that materializes somewhere in the supply chain or the supply chain environment and (2) a consequential situation which significantly threatens the normal course of business operations of the affected firms in the supply chain. For the affected firms, it is an exceptional and anomalous situation in comparison to every-day business. There has been intensive research by organizational scientists on events that adversely affect organizations, how organizational crises emerge from those events, and how organizations react to them (Pearson and Clair 1998). Several helpful insights can be derived from this research and transferred to the supply chain risk context. For instance, similarly to the triggering event of an organizational crisis, the triggering event of a supply chain disruption is “identifiable according to place, time, and agents” (Shrivastava et al. 1988, p. 288). The disruption is associated with a certain probability of occurrence and characterized by its severity as well as direct and indirect effects (Kleindorfer and Saad 2005). Since the resulting detriment is usually a function of

time, supply chain disruptions involve time pressure, implying that decisions for mitigation must be made swiftly (Hermann 1963).

Supply chain disruptions can materialize from various areas internal and external to a supply chain. Consequently, their nature can be highly divergent. For instance, the financial default of a supplier and a natural disaster destroying production capacity are situations with completely different attributes and therefore entail different effects on the supply chain. Addressing this issue and attempting to differentiate supply chain risks from other business risks, many scholars have proposed classifications in the form of typologies and/or taxonomies of risks (e.g., Chopra and Sodhi 2004; Christopher and Peck 2004; Hallikas et al. 2004; Jüttner 2005; Jüttner et al. 2003; Spekman and Davis 2004; Svensson 2000). The derived categories of supply chain disruptions are often labelled “supply chain risk sources.” As such, Svensson (2000) named two categories (quantitative and qualitative), Jüttner (2005) delineated three categories (supply, demand, and environmental), and Chopra and Sodhi (2004) proposed nine categories (disruptions, delays, systems, forecast, intellectual property, procurement, receivables, inventory, and capacity). In the following, for brevity, we will call a negative deviation from the expected value of a performance measure for instance a “supply side risk” if the deviation results from a supply side (supply chain) disruption.

For our purpose, we will divide supply chain risk sources into five distinct classes: Demand side risk, supply side risk, regulatory, legal and bureaucratic risk, infrastructure risk, and catastrophic risk. While the first two risk source categories deal with supply-demand coordination risks that are internal to the supply chain, the latter three focus on risk sources that are not necessarily internal to the chain.

17.2.2.1 Demand Side Risks

Demand side risks result from disruptions emerging from downstream supply chain operations (Jüttner 2005). This includes disruptions in the physical distribution of products to the end-customer with particular issues being transportation operations (e.g., a truck driver strike) (McKinnon 2006) and the distribution network (e.g., a fire in a warehouse). Further, demand side risks can originate from the uncertainty surrounding the random demands of the customers (Nagurney et al. 2005). Disruptions occur here from a mismatch between a company’s projections and actual demand as well as from poor supply chain coordination. The consequences from these disruptions include costly shortages, obsolescence, and inefficient capacity utilization.

An important issue in this context, affecting forecast quality and therefore demand side disruptions is the *bullwhip effect*, which is characterized by an amplification of demand volatility in the upstream direction of the supply chain. Lee et al. (1997) analyzed this phenomenon and identified delayed and distorted information, sales promotions, order batching, price fluctuations and rationing or shortage gaming as major causes. Other factors intensifying the bullwhip effect are over-reactions, unnecessary interventions, second guessing, and mistrust (Christopher and Lee 2004). Demand volatility still presents a major risk source for many firms. Spekman and Davis (2004) cite the example of Cisco Systems Inc. that

wrote off US\$ 2.5 billion in inventory in 2001 due to a lack of communication among its downstream supply chain partners.

17.2.2.2 Supply Side Risks

Purchasing organizations are exposed to numerous risks associated with their suppliers and their supply network. Supply side risks reside in purchasing, supplier activities and supplier relationships. These include supplier business risks, production capacity constraints on the supply market, quality problems, technological changes, and product design changes (Zsidisin et al. 2000).

Supplier business risks relate to the various events that affect the continuity of the supplier and result in the temporary or permanent perturbation or termination of the buyer-supplier relationship. This concerns particularly the threat of financial instability of suppliers and the consequences of supplier default, insolvency, or bankruptcy (Wagner and Johnson 2004). The financial default of a supplier, such as a supplier going out of business, is a particular but common supply chain disruption that can have severe consequences for the buying firm. Sheffi and Rice (2005) cite the example of the automobile manufacturer Land Rover that found itself in serious trouble after its only supplier of chassis frames, UPF-Thomson, suddenly and unexpectedly folded in 2001. Another type of disruption occurs when a supplier is vertically integrated by a direct competitor of the customer firm, forcing the termination of the relationship (Chopra and Sodhi 2004). In cooperative settings, opportunistic behaviour from suppliers has also been reported in literature as a source of supply risk (Wagner and Hoegl 2007). Particularly organizational lock-in is a threat where a purchasing organization is so dependent on a certain supplier that it has only a limited room for maneuvering.

Capacity constraints or shortages as well as poor logistics performance (delivery reliability) derive from unsolved problems in the supplier's production and operations management (Lee and Billington 1993). The bullwhip effect cited in the previous paragraph plays a role here as well and has to be tackled by the suppliers. Furthermore, poor quality in the purchased products or services is a significant risk and can have a cascading effect through the supply chain to the final customer (Zsidisin et al. 2000).

Finally, the inability of suppliers to adapt to technological or product design changes may have detrimental effects on the customer's costs and competitiveness (Zsidisin and Ellram 2003). With the increased importance and reliance on outsourcing, the cited risks are amplified (Giunipero and Eltantawy 2004).

17.2.2.3 Regulatory, Legal, and Bureaucratic Risk

In many countries, authorities (administration, legislation, regulatory agencies) are an important factor of uncertainty to the setup and operation of supply chains. Regulatory, legal, and bureaucratic risks refer to the legal enforceability and execution of supply chain-relevant laws and policies (e.g., trade and transportation laws) as well as the degree and frequency of changes in these laws and policies. This includes the ability to obtain approvals necessary for supply chain design

activities and supply chain operation. Symptomatic for this risk source is that it is not internal to the individual supply chain or firm.

With the exception of government initiatives for security facilitation such as the Customs-Trade Partnership Against Terrorism (C-TPAT) or Authorized Economic Operators (AEO) certifications (Sarathy 2006; Zsidisin et al. 2005b), little attention has been paid to risks stemming from changing legal stipulations and conditions. Hendricks and Singhal (2003, 2005a, b) mentioned supply chain disruptions associated with actions or decisions of authorities. Administrative barriers (e.g., customs, trade regulations) may restrict the design and influence the operative performance of supply chains. Legal changes are often sudden and very difficult to anticipate. Examples are the newly introduced road pricing schemes for freight vehicles in various European countries which substantially affect transportation costs, as well as the environmental legislation with its requisites for product traceability and the setup of reverse logistics systems. In order to meet such environmental requisites, firms frequently get involved in more complex supply chains and incur higher supply chain costs.

17.2.2.4 Infrastructure Risks

The risk source “infrastructure” includes those disruptions that materialize from the infrastructure that a firm maintains for its operations. It includes socio-technical accidents such as equipment malfunctions, machine breakdowns, disruptions in the supply of electricity or water, IT failures or breakdown, as well as local human-centred issues (vandalism, sabotage, labour strikes, industrial accidents) (Chopra and Sodhi 2004; Spekman and Davis 2004).

IT related problems are highly relevant to supply chain management since a large portion of SCM functions builds on information processing and sharing. Organizations have become increasingly technology-dependent and, consequently, vulnerable to IT problems or breakdown (Chopra and Sodhi 2004). Causes of those events can be malicious intent by individuals or groups (cyber-attacks, virus attacks) as well as software bugs and hardware failures (Warren and Hutchinson 2000). Moreover, modern Enterprise Resource Planning (ERP) systems force firms to open their internal processes and databases both to their suppliers and customers which increases the exposure to IT related threats.

17.2.2.5 Catastrophic Risks

This class subsumes pervasive events that, when they materialize, have a severe impact in terms of magnitude in the area of their occurrence. This refers to natural hazards (force majeure), socio-political instability, civil unrest, economic disruptions and terrorist attacks (Kleindorfer and Saad 2005; Martha and Subbkrishna 2002).

In many regions of the world, natural hazards such as tsunamis, droughts, earthquakes, hurricanes, and floods are a constant threat to societies in general and to firms in particular (Helferich and Cook 2002). The negative consequences on supply chains are obvious since production facilities and transportation are highly vulnerable to natural disasters. Due to the globalization of markets and a surge in

globe-spanning supply chain operations, local catastrophes have increasingly indirect global repercussions. Terrorism is a special topic which has been discussed extensively in a supply chain context. In the current state of the world, terrorism is a threat to global supply chains that has to be considered (Sheffi 2005). These attacks can impact supply chains either directly or indirectly. In addition, there are indirect consequences of terrorism that are not caused by an attack itself but by the reaction of governments and markets. For example Ford, Toyota and DaimlerChrysler experienced massive disruptions to the flow of materials into their North-American assembly plants within a few days after the terrorist attack of 9/11 (Sheffi 2001) due to border shut-downs.

17.2.3 Supply Chain Vulnerability and Its Drivers

While a supply chain disruption is the trigger that leads to the occurrence of risk, it is not the sole determinant of the final loss. It seems consequential that also the susceptibility of the supply chain to the harm of this situation is of significant relevance. This leads to the concept of supply chain vulnerability. The basic premise is that supply chain characteristics are antecedents of supply chain vulnerability and impact both the probability of occurrence as well as the severity of supply chain disruptions.

Although the literature offers numerous approaches to the construct “supply chain vulnerability,” Peck (2005) still appraises its conceptual basis as immature. Christopher and Peck (2004, p. 3) define supply chain vulnerability as “an exposure to serious disturbance.” Svensson (2000, 2002) published several contributions that shed light on the construct. He distinguishes between atomistic vulnerability (of a part of the supply chain) and holistic vulnerability (across the entire supply chain). In the literature on natural hazards and crisis management, vulnerability has been defined as a person’s (or a group’s) capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard (Blaikie et al. 1994). In the context of maritime supply chains, Barnes and Oloruntoba (2005, p. 519) describe vulnerability as “a susceptibility or predisposition to ... loss because of existing organizational or functional practices or conditions.”

In this contribution, this latter definition is applied and the atomistic perspective (supply chain vulnerability on the individual firm-level) is taken. We follow the notion that supply chain vulnerability is a function of certain supply chain characteristics and that the loss a firm incurs is a result of its supply chain vulnerability to a given supply chain disruption (Wagner and Bode 2006b).

Several publications argue that certain supply chain characteristics increase or decrease the vulnerability of the supply chain. Craighead et al. (2007) derive the propositions that supply chain density, supply chain complexity, and node criticality increase the severity of supply chain disruptions. Wagner and Bode (2006a) show empirically that customer dependence, supplier dependence, as well as single sourcing and global sourcing can amplify a firm’s vulnerability to supply chain disruptions. Normal Accident Theory (NAT) can be a theoretic underpinning for research on supply chain vulnerability. This theory links the occurrence and

impact of accidents (disruptions) to the structure of the organization and its technology (Perrow 1984, 1999). Two organizational attributes are argued to be relevant for both the probability of occurrence and the severity of adverse events: (1) (interactive) complexity of the system and (2) tight coupling of the elements in the system. In general, complex organizational systems – such as supply chains – are characterized by a large number of (varied) elements that interact in a non-simple way (Choi and Krause 2006). A system is tightly coupled if the components are interrelated in such a manner that there are few possible substitutions, time-dependent processes, and minimal slack or buffers (Perrow 1984). Given that this theory holds true for supply chains, more complex and tighter coupled supply chains are likely more prone to disruptions (Christopher and Lee 2001).

17.2.4 Supply Chain Risk Management

In general, enterprise risk management can be defined as the “field of activity seeking to eliminate, reduce and generally control pure risks” (Waring and Glendon 1998, p. 3). While the terminology can differ from author to author, a systematic risk management process usually comprises the stages of (1) risk identification, (2) risk analysis (including risk assessment and classification), (3) risk management in the narrow sense, e.g., risk treatment, and (4) risk monitoring. The overall objective of this process is to determine, implement, and monitor an optimal mix of measures to avoid, defer, reduce, or transfer all relevant risks. The determined mix is considered to be optimal if the remaining amount of risk is in line with the firm’s risk preference and corporate strategy. This generic risk management process was transferred and adapted to the supply chain context by various authors (e.g., Hallikas et al. 2004; Ritchie and Brindley 2007).

However, for the purpose of this study, we are interested in specific practices of risk handling, e.g., the third stage of the outlined process. There is a large body of literature proposing measures and activities of supply chain risk management (e.g., Chopra and Sodhi 2004; Christopher and Peck 2004; Elkins et al. 2005; Johnson 2001; Lee and Wolfe 2003; Martha and Subbakrishna 2002; Rice and Caniato 2003; Zsidisin et al. 2005a). The proposed practices can be differentiated or classified according to various criteria. Tang (2006), for instance, identified four areas where supply chain risk management activities can take place: supply management, demand management, product management, and information management. Kleindorfer and van Wassenhove (2004) cite two groups of supply chain risk management activities: supply-demand coordination activities and activities for managing disruption risks.

Here, we decided to apply a different approach and to distinguish (1) *cause-oriented practices* and (2) *effect-oriented practices* of supply chain risk management.

17.2.4.1 Cause-Oriented Supply Chain Risk Management Practices

“If anything can go wrong, it will” says Murphy’s Law. If this holds true, a good risk management approach is to *avoid* activities that are risky and “can go wrong.”

Cause-oriented risk management practices attempt to do this, e.g., to reduce the probability of the occurrence of a disruption by aiming at its causes. Risk avoidance is possible for many types of disruptions. For instance, switching from a financially instable supplier to more stable one reduces the risk of a sudden supplier default. Or the relocation of manufacturing operations from geographic regions with a high exposure to natural hazards to safer regions reduces the probability to be directly affected by such events.

Another set of activities and measures in this context are *preventive* in nature such as preparative safety and security initiatives. Risk prevention can be used to get a grip on issues such as vandalism, sabotage, fire, and some sorts of industrial accidents. Rice and Caniato (2003) distinguish physical security (e.g., access controls), information security (e.g., education and training of employees for IS security), and freight security (e.g., C-TPAT). Zsidisin and Ellram (2003) emphasize that companies can reduce the probability of occurrence of various risks by influencing the risk awareness of their suppliers and by driving a risk culture into the supply base. Sheffi (2005) even argues that competitors should collaborate to control common risks. He names the example of TAPA (Technology Asset Protection Association) which was founded in 1997 by Intel and other high-technology firms with the objective to set standards for freight security.

Approaches that result in improved supply chain transparency and information exchange also support the effort of reducing the probability of occurrence of disruptions.

17.2.4.2 Effect-Oriented Supply Chain Risk Management Practices

In case of effect-oriented risk management practices, a firm decides to bear certain risks but at the same time makes attempts to limit or mitigate the negative consequences of a disruption. Thus, these measures aim at minimizing the level of damage in case of a risk event occurrence. In general, this can be achieved by seeking redundancy for activities or facilities which are particularly exposed to risk. Many of the risk handling activities proposed in the literature are rather effect-oriented than cause-oriented. In particular, buffering strategies are very prominent which aim to increase a company's tolerance to external resource shortage over a limited period of time. A usual approach in practice is to anticipate risk scenarios and to build slack (inventory, flexibility, or time buffers) into the supply chain in a way that the damage to the supply chain and the involved firms is limited in case of a materializing disruption. In this context, one often encounters the terms "resilience" (Sheffi 2005) as well as "robustness" (Christopher and Peck 2004, p. 2).

In the area of supply management and purchasing, the design of the supplier portfolio is a major target for effect-oriented measures – in particular, the decision of single sourcing versus multiple sourcing. The common ex-ante strategy to safeguard against the consequences of a sudden shortfall in supply – such as a supplier default – is the diversification of the supply base (Anupindi and Akella 1993; Treleven and Schweikhart 1988). The rationale is to install redundancy by

developing contingency supply sources in order to decrease the vulnerability to supply-side disruptions (Sheffi and Rice 2005). The buying firm can diversify order quantities and hedge against the sudden demise of a single supplier by having multiple competing suppliers (Tomlin 2006).

Apart from improved forecasting of customer demands, a lot of risk mitigation potential resides in the design of products as well as in the layout of the manufacturing processes. Products can be modularized and components standardized so that the firm becomes more tolerant against the uncertainties on both supply and customer markets. In production and manufacturing, capacity buffers, stockpiling and flexibility are common measures.

Another important aspect is the creation of financial risk reserves which has to be considered to be an effect-oriented risk management measure. The risk bearing firm can build up financial reserves individually or it can try to transfer the risk to an insurance company that builds a collective reserve. Insurance companies offer many products pertaining to supply chain risks such as transportation insurances, inventory-related insurances (e.g., fire), or insurances against natural hazards (e.g., flooding). A rather new technique is the so-called Alternative Risk Transfer (ART) which offers a possibility to provide coverage for very specific risks or for risks where there is no insurance product available, catastrophe risks, for instance. Such catastrophe risks (e.g., gulf coast hurricanes) can be placed with investors by issuing corresponding catastrophe bonds or structuring derivative products (Lewis 2007). Contrary to traditional insurance the risk is transferred to the capital markets (Lane 2003). Finally, “business continuity plans” (Gilbert and Gips 2000) or “recovery plans” have to be cited as important tools to ex-ante optimize the “firefighting” after a disruption.

17.3 Questionnaire Development and Data Collection

The questionnaire for this study consisted of two sections: One referring to supply chain risks and one referring to supply risk management practices. We conducted several qualitative interviews as well as a thorough literature review to determine the initial item pool. After reviewing this pool with several researchers and supply chain management executives, some items were dropped or reworded. The remaining items were incorporated into a questionnaire and pretested. In the first section of the final questionnaire, the respondents were presented a list of relevant types of supply chain disruptions. Among these were aspects like supplier quality problems, supplier defaults, or terror attacks. For each disruption type, the respondents were asked to score on a five-point Likert-scale how their business unit had been negatively affected during the last 3 years in total by each of this specific issue. The scale ranged from “not at all” to “to a very large extent.” The second part of the questionnaire consisted of a list of supply chain risk management measures. The respondents were asked to score the level of implementation of each risk management practices in their business unit on a five-point Likert-scale ranging again from “not at all” to “to a very large extent.”

Based on this questionnaire, data were collected through a cross-sectional survey administered in Germany in 2005 to a sample of 4,946 top-level executives in logistics and supply chain management. The mailing and two follow-ups generated 760 usable responses, yielding a relatively high response rate of about 15.4%, considering the time constraints of top-level executives (Tomaskovic-Devey et al. 1994). Non-response bias was assessed on the notion that later respondents would be more like non-respondents (Armstrong and Overton 1977). For all questionnaire items, the responses of later respondents were compared to those of earlier. This comparison indicated absence of non-response bias.

Table 17.1 Sample characteristics

| | Percent of total sample |
|--------------------------------|-------------------------|
| <i>1. Sector and industry</i> | 71.7 |
| <i>Industry sector</i> | 11.2 |
| Automotive | 10.1 |
| Electro/Electronics | 9.5 |
| Machinery | 8.4 |
| Chemicals and pharmaceutical | 6.6 |
| Information technology | 6.2 |
| Materials and metal production | 5.5 |
| Food | 4.2 |
| Paper, pulp, and printing | 3.0 |
| Construction | 2.5 |
| Consumer goods | 2.1 |
| Aerospace and defence | 1.3 |
| Medical devices | 0.9 |
| Other industry | 11.2 |
| <i>Service sector</i> | 19.5 |
| Logistics services | 17.1 |
| Other services | 2.4 |
| <i>Trade sector</i> | 8.8 |
| <i>2. Sales (in US\$)</i> | |
| Less than 10 million | 14.9 |
| 10 million–under 50 million | 23.9 |
| 50 million–under 100 million | 16.3 |
| 100 million–under 250 million | 14.7 |
| 250 million–under 500 million | 8.7 |
| 500 million–under 1 billion | 6.7 |
| 1 billion–under 10 billion | 7.2 |
| 10 billion and more | 5.0 |
| n.a. | 2.5 |
| <i>3. Number of employees</i> | |
| Less than 100 | 21.4 |
| 100–499 | 42.2 |
| 500–999 | 11.6 |
| 1,000–4,999 | 15.3 |
| 5,000–9,999 | 2.8 |
| 10,000 and more | 3.7 |
| n.a. | 3.0 |

We did not focus on a specific industry sector because we attempted to obtain a more general idea of supply chain risks in Germany. In particular, we wanted to include manufacturing and process industries.

The sample covered a broad range of sectors and firm sizes, e.g., industrial (71.7% of the sample), service (19.5%) and trade (8.8%) firms. The firms' annual sales ranged from less than US\$ 10 million to US\$ 90 billion (mean US\$ 60.3 million), and the number of employees from less than 100 to 430,000 (mean 2,913), thus yielding a heterogeneous sample. Given the range and size of the firms studied and the diversity of industries, there was no *prima facie* reason to expect any systematic bias in the results. Most of the respondents held management positions in logistics and supply chain management (37.5%), or were in higher-level senior management positions (e.g., Executive VP, Senior VP) or owners of the business (23.8%). On average, the respondents have worked in this position for 7.0 years and have been with the firm for 10.9 years. A more detailed breakdown of the sample can be found in Table 17.1.

Additionally, we collected data pertaining to the types of supply chains the respondents were involved in (domestic vs. global and simple vs. complex). In particular, the respondents had to indicate (1) if their firms rely on global supplier networks, and (2) if they consider their supply chains to have a high degree of complexity. The means for these two items were on or close to the scale mean of three (3.00 and 3.18) and the standard deviations were around one (1.37 and 1.01). This shows that on average the respondents reported on a fairly homogeneous set of supply chains.

17.4 Results and Discussion

Based on the obtained sample of 760 top-level executives in logistics and supply chain management, the results of this study (1) present a detailed overview on the importance of specific supply chain risks and (2) shed light on the use and implementation of supply chain risk management practices in Germany.

17.4.1 Supply Chain Risks

Table 17.2 presents the investigated supply chain risks, their mean values, and standard deviations (SD).

The numbers reveal that demand side and supply side risk sources represent the dominant and most prevalent supply chain risks. In particular, the issues of volatile customer demand, information distortion in the supply chain, price fluctuation on the supply markets, as well as quality problems with sourced material have significantly affected the surveyed firms during the last 3 years.

Table 17.2 Supply chain risks and their prevalence

| | Mean | SD |
|--|------|------|
| <i>1. Demand side</i> | 3.03 | |
| <i>Unanticipated or very volatile customer demand</i> | 3.43 | 1.10 |
| Insufficient or distorted information from customers about orders | 3.08 | 1.14 |
| Bad payment behaviour or payment defaults of customers | 2.57 | 1.10 |
| <i>2. Supply side</i> | 2.55 | |
| Price fluctuations on the supply markets | 2.94 | 1.14 |
| Supplier quality problems | 2.80 | 1.03 |
| Capacity fluctuations or shortages on the supply markets | 2.68 | 1.08 |
| Poor logistics performance of suppliers (e.g., delivery dependability) | 2.68 | 1.09 |
| Poor logistics performance of logistics service providers | 2.16 | 0.93 |
| Sudden supplier defaults | 2.03 | 1.03 |
| <i>3. Regulatory, legal and bureaucratic</i> | 2.29 | |
| Introduction of road pricing schemes | 2.47 | 1.23 |
| Changes in the political environment (e.g., new environmental laws) | 2.31 | 1.12 |
| Administrative barriers to the setup and operation of supply chains | 2.08 | 1.03 |
| <i>4. Infrastructure</i> | 1.73 | |
| Downtime of own production capacity due to technical reasons | 1.83 | 0.93 |
| Perturbation or breakdown of internal IT systems | 1.80 | 0.87 |
| <i>Perturbation or breakdown of external IT systems</i> | 1.71 | 0.88 |
| Downtime of own production due to local disruptions (e.g., fire, strike) | 1.56 | 0.84 |
| <i>5. Catastrophic</i> | 1.55 | |
| Terror attacks (e.g., London 2005) | 1.61 | 0.92 |
| Political instability, war, civil unrest or other socio-political crises | 1.59 | 0.89 |
| Natural disasters (e.g., earthquake, flooding) | 1.51 | 0.84 |
| Diseases or epidemics (e.g., SARS) | 1.47 | 0.87 |

Scale: "Please indicate how your business unit has been negatively affected during the last 3 years by each of the following supply chain risks" (1: not at all – 5: to a very large extent).

Interestingly, bureaucratic risks, legal and regulatory risks and particularly catastrophic risks hardly affect firms operating in Germany. Not only are the mean values of these risks low but also the standard deviations indicate very little variation around the means. Of course, Germany has been a very "calm" place for these types of risks during the last years. Similar to most other Western European countries, it has a very low exposure to natural hazards and can be considered a very stable business environment. However, although all respondents were based in Germany and worked for firms sustaining operations in Germany, the supply chains reported in this survey were not dominantly domestic. The sample also included supply chains that extend the national borders. Due to such global supply chains, events can occur in other regions of the world and still have an effect on the surveyed firms. For this reason, the result that catastrophic events did hardly affect the surveyed firms is quite astonishing – and seems somewhat conflicting with the intensive recent interest concerning catastrophic risks. However, there is a well-accepted psychological reasoning for the misjudgement of the impact of supply chain disruptions. Research conducted by psychologists shows that people, instead of using statistics, rely on a limited number of heuristics to predict the

impact of risks. These heuristics sometimes result in reasonable judgments and sometimes in serious errors (Kahneman and Tversky 1973). One such heuristic is called the “availability heuristic” (Slovic et al. 1982). Human beings make judgments based on what they can remember, rather than on complete data. These individuals can easily remember the pictures of terror attacks or natural disasters. The attention and awareness that these events receive is much higher than they should according to their probability (Stauffer 2003).

17.4.2 Supply Chain Risk Management

Table 17.3 shows the investigated supply chain risk management practices, the corresponding mean values, and standard deviations.

Table 17.3 Supply chain risk management practices

| | Mean | SD |
|---|------|------|
| <i>1. Cause-oriented</i> | 3.38 | |
| <i>We use only materials and products to which we know exactly their origin.</i> | 4.04 | 1.12 |
| <i>If possible, we do not sustain own operations in risky geographic regions.</i> | 3.44 | 1.54 |
| <i>We do not source from suppliers that produce in risky geographic regions.</i> | 3.36 | 1.41 |
| <i>We distribute our products only to markets that we know very well.</i> | 3.31 | 1.25 |
| <i>In collaboration with our customers and suppliers we are working on transparent supply chains and open information exchange.</i> | 3.14 | 1.20 |
| <i>We monitor regularly our suppliers with regard to potential supply chain risks.</i> | 3.01 | 1.15 |
| <i>2. Effect-oriented</i> | 2.82 | |
| <i>In our contracts with suppliers we usually try to transfer as much risk as possible to the suppliers.</i> | 3.18 | 1.01 |
| <i>Often, we use flexible contracts or options with our suppliers.</i> | 2.99 | 1.18 |
| <i>Our firm has elaborated business continuity or contingency plans addressing relevant supply chain risks.</i> | 2.73 | 1.33 |
| <i>We use late product differentiation to mitigate demand side risks.</i> | 2.71 | 1.20 |
| <i>We hold additional inventory and capacity buffers to mitigate the consequences of potential supply chain disruptions.</i> | 2.68 | 1.25 |
| <i>If possible, we insure against supply chain related risks.</i> | 2.61 | 1.21 |

Scale: “Please indicate to what extent your business unit has implemented the following supply chain risk management practices” (1: not at all – 5: to a very large extent).

The results reveal that the surveyed firms dominantly pursue cause-oriented activities of risk prevention and avoidance. It seems that most companies are rather risk averse and try to avoid problems wherever possible instead of waiting for a disruption and mitigating its consequences. In particular, the results highlight that there is an emphasis on avoiding risky geographic regions both from a purchasing as well as distribution perspective.

With one single exception, all means are below 3. This is an indication that supply chain risk management practices have not yet fully arrived in business practice. This finding is in line with results from other empirical studies in other countries that indicate that there is a lack of diffusion and implementation of supply chain risk management ideas and measures (Jüttner 2005).

Interestingly, the option to mitigate the consequences of disruptions by the effect-oriented approach “insurance” plays only a very minor role in practice.

17.5 Managerial Implications and Conclusions

The objective of this research was to examine the relevance of various supply chain risks and to provide a current picture of the implementation of supply chain risk management ideas in practice. Building on a thorough examination of the various supply chain risk taxonomies and risk management practices proposed in the pertinent literature as well as on interviews with practitioners, we developed a questionnaire and empirically investigated both aspects on a large-scale basis.

The data indicates that demand side and supply side issues are the most dominant risks for the surveyed firms. Primarily, this bolsters the notion that supply and demand coordination is the central issue in supply chain management (Kleindorfer and van Wassenhove 2004).

However, the results qualify the current interest on the subject, in particular with regard to infrastructure risks and catastrophic risk. Contrary to the general public perception, the prominent catastrophic risks are not a dominant factor for firms operating in Germany. Although the world witnessed a series of large-scale catastrophic events during the time of investigation, the surveyed firms did not experience significant losses from these disruptions. In contrast, the every-day issues of supply side and demand side risks – which are arguably the “bread-and-butter” issues of supply chain management – are the most prevalent supply chain risks.

Certainly, these results do not question the concept of supply chain risk management as a whole. However, they advocate managers to primarily turn their attention on supply side and demand side risk sources and on excelling in the “classic” supply chain management activities such as demand forecasting, supplier relationship management, cooperative information sharing with customers and suppliers, as well as quality management. As supply chain risk management is not for free, managers are compelled to seek an efficient allocation of risk management resources and a reasonable cost-benefit trade-off. Companies in Germany should be cautious about spending significant resources on the management of catastrophic risks.

With regard to supply chain risk management practices, our findings support the results of previous empirical studies which revealed a lack of implementation. Jüttner (2005) conducted a similar study in the UK (2005) and found that “practitioners have little guidance on their supply chain risk management approaches” (p. 139). Despite the numerous helpful articles on supply chain risk management

in practitioner journals (e.g., Chopra and Sodhi 2004; Swaminathan and Tomlin 2007; Zsidisin et al. 2005a), there is obviously a need to put more emphasis on supply chain risk management education and to include these aspects into general supply chain management courses.

Finally, a remark has to be made on the generalizability of the result. Since the data was collected in Germany, the results can – if at all – only be generalized to firms based in countries with very similar geographic, political, and economic characteristics as Germany. Therefore, a replication of this survey in other countries with presumably different risk profiles (e.g., Japan or the United States) would be an important next step towards a better understanding of the dominant risks and risk management practices in supply chains.

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