Dealing with supply chain risks
Linking risk management practices and strategies to performance

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Abstract

Purpose – The effects of supply chain risk management (SCRM) on the performance of a supply chain remain unexplored. It is assumed that SCRM helps supply chains to cope with vulnerabilities both proactively by supporting robustness and reactively by supporting agility. Both dimensions are assumed to have an influence on the supply chain's customer value and on business performance. The aim of this research is to provide clarity by empirically testing these hypotheses and scrutinizing the findings by the means of case studies.

Design/methodology/approach – The research is empirical. Survey data were collected from 270 manufacturing companies for hypotheses testing via structural equation modeling. Additionally, qualitative data were collected to explore the nature of non-hypothesized findings.

Findings – It is found that SCRM is important for agility and robustness of a company. Both agility and robustness show to be important in improving performance. While agility has a strong positive effect only on the supply chain's customer value, but not directly on business performance, robustness has a strong positive effect on both performance dimensions. This important finding directs the strategic attention from agility-centered supply chains to ones that are both robust and agile. The case studies provide insights to the fact that robustness can be considered a basic prerequisite to deal with supplier-side risks, while agility is necessary to deal with customer-side risks. The amount of agility and robustness needs to fit to the competitive strategy.

Practical implications – Since volatility has increasingly become a prevalent state of supply chains, companies need to consider robustness to be of primary importance to withstand everyday risks and exceptions.

Originality/value – This is the first study to view the relationship between SCRM, agility/robustness, and performance.

Keywords Strategy, Supply chain, Risk management, Supply chain management, Agility, Robustness, Performance management

Paper type Research paper

1. Introduction

Researching supply chain risks (i.e. the exposure to a premise of which the outcome is uncertain, Rao and Goldsby, 2009), supply chain risk management (SCRM) is one of the

fastest growing areas in logistics research. In a recent supply chain survey among executives, more than two-thirds of the respondents reported increasing risk over the past three years, and nearly as many expect that risk will continue rise (McKinsey, 2010). This observation is consistent with the "era of turbulence" proclaimed by Christopher and Holweg (2011) and a statement by Simchi-Levi (2010): "With the increasing level of volatility, the days of static supply chain strategies are over." For supply chains, this translates into everyday risks such as fluctuating demand and in exceptional risks such as the 2010 Eyjafjallajökull volcano eruption in Iceland or the 2011 Tōhoku earthquake in Japan.

Several authors have proposed models that help to select the appropriate supply chain strategy with respect to internal or external context factors (Fisher, 1997; Lee, 2002; Christopher et al., 2006). While certain context factors can affect the supply chain negatively, choosing appropriate strategies can help to overcome these effects. In this respect, the view is supported that supply chain strategies and SCRM (i.e. the implementation of strategies to manage both everyday and exceptional risks along the supply chain based on continuous risk assessment with the objective of reducing vulnerability and ensuring continuity) can be seen as being a "two-sided coin" (Jüttner, 2005). As it will be demonstrated, both proactive (i.e. robust) and reactive (i.e. agile) supply chain strategies reduce the vulnerability of global supply chains and are in that way necessary. There is, however, a lack of research about how and to what extent a structured SCRM approach that involves the identification, assessment, controlling, and monitoring of possible risks within the supply chain (Hallikas et al., 2004; Kern et al., 2012) fosters improved agility and robustness and, in turn, better performance. Especially the need for corresponding empirical work has been pointed out (Thun and Hoenig, 2011).

While many empirical logistics researchers tend to consider themselves positivists and, thus, utilize quantitative approaches as primary research method, increasingly calls have been made to also use qualitative approaches (Mangan et al., 2004; Frankel et al., 2005). It was decided to exploit these methodological complements by dividing this research in two phases. In a deductive phase, it is built on prior knowledge to hypothesize the relationship between SCRM, supply chain strategies, and performance and then test the hypotheses with survey data. Then, during an inductive phase, managers are confronted with the preliminary findings of the first phase in order to exploratively gain additional knowledge.

While anecdotal evidence points to the fact that SCRM practices allows supply chains to react faster (increased agility) and to withstand adverse events (increased robustness), virtually no empirical research exists that reveals the underlying mechanisms. Our multi-method approach is aimed at filling this gap by testing whether SCRM influences both the agility and robustness of a supply chain. In addition, our research is first in examining the impact of these two general supply chain strategies on different performance dimensions in order to understand the performance implications these strategies have.

The rest of this article is organized as follows: first, the multi-method research design employed for this article is described. Second, a deductive research phase is implemented based on a survey. Third, to gain additional insights, the first phase is followed by an inductive research phase based on case studies. And finally, the results of both phases are jointly discussed.

2. Methodology

Two main research approaches can be distinguished in logistics research: following the deductive approach, hypotheses are first developed and then tested through empirical observation. Following the inductive approach, the researcher develops propositions with a view to explaining empirical observations of the real world (Crowther and Lancaster, 2008).

Quantitative methods count, measure, and analyze objects across a very wide range of observations and are often, though not always, associated with deductive research, whereas qualitative methods are concerned with identifying and perhaps comparing the "qualities" or characteristics of empirical evidence, from easy-to-apprehend external appearances to internal, difficult-to-capture characteristics and are mostly used in inductive research (Huff, 2008). It has also been suggested that quantitative methods are relevant for getting an overview and for considering the broad structure of decisions, whereas qualitative methods are useful for finding out at the micro level about the behavior of the decision maker (Mangan *et al.*, 2004). Näslund (2002) argues that it is necessary to use both quantitative and qualitative methods if we really want to develop and advance logistics research. In particular, the combination, or "triangulation", of quantitative and qualitative methods rests on the premise that the weaknesses of one method will be compensated by the counter-balancing strengths of another method in order to capture a more complete, i.e. holistic and contextual portrayal of the units under study (Jick, 1979; Aastrup and Halldórsson, 2008; Boyer and Swink, 2008).

For our research, first a survey was conducted as a quantitative method and then supplemented by case studies in order to collect additional qualitative data. Surveys have been criticized for over-simplification of reality, but they allow for statistical generalization. This method was used to test the hypothesized effects of SCRM on agility and robustness and further on performance. Interviews as part of case studies have been criticized for their propensity to encourage interviewer and respondent bias, but they represent a targeted method of collecting data and are often insightful (Frankel *et al.*, 2005). Here, this method is used, to build on survey findings presented to the interviewees to reveal new knowledge about agility and robustness in the context of SCRM. Most importantly, the integration of a survey with case studies combines the advantages and minimizes the disadvantage of each method and allows the qualitative refinement of the theory underlying the quantitative survey. Building on research processes proposed by Spens and Kovács (2006), deductive and inductive approaches were combined in this research as is shown in Figure 1.
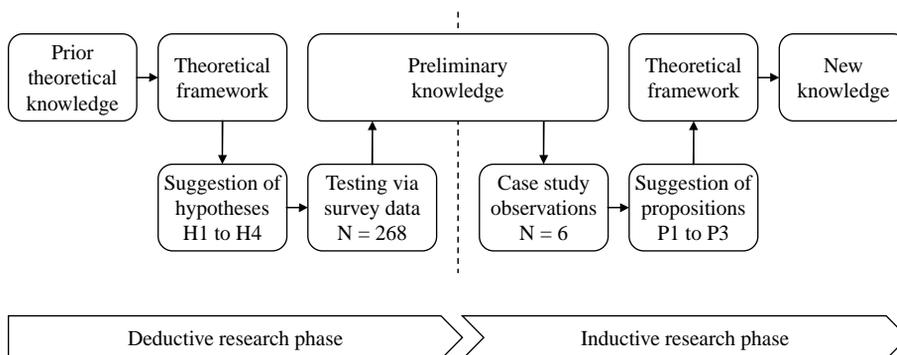

Figure 1.
Utilized multi-method
research design

3. Deductive phase

3.1 Theoretical framework and hypotheses

Supply chains have often been oversimplified as linear and static chains reaching from source to sink including the suppliers' suppliers and the customers' customers. However, a supply chain is a complex web of changes, coupled with the adaptive capability of organizations to respond to such changes (Choi *et al.*, 2001). Strategies to manage supply chains must incorporate these inherent properties. We argue that, due to this very nature of supply chains, both proactive (= preventive) and reactive strategies need to be implemented. Both strategy types have to be invested in *ex ante*, but proactive instruments are cause-related and lead to directly observable effects (e.g. increased buffer stock), whereas reactive instruments are effect-oriented and can only show their impact *ex post* (Thun and Hoenig, 2011).

A strategy to cope with changes reactively is agility. Early literature on agility was often anecdotal and attached dimensions to agility such as "enriching the customer", "cooperating to enhance competitiveness" and "leveraging the impact of people and information" (Goldman *et al.*, 1995). Today, however, agility is mostly understood as the ability of a supply chain to rapidly respond to change by adapting its initial stable configuration. Agility corresponds primarily with being responsive (Christopher *et al.*, 2006), being fast (Prater *et al.*, 2001), and being able to reconfigure the supply chain (Bernardes and Hanna, 2009). While some authors highlight the reactive nature of agility to changes primarily on the demand side (van Hoek *et al.*, 2001), other authors argue that it comprises all kind of changes (Charles *et al.*, 2010). For example, postponement makes the supply chain more agile by delaying the point in which the final personality of the product is to be configured (Swaminathan and Lee, 2003), thereby increasing the speed to respond to demand changes by adapting the final product. In contrast, robustness is a proactive strategy that can be defined as the ability of a supply chain to resist change without adapting its initial stable configuration. A robust supply chain remains effective for all plausible futures (Klibi *et al.*, 2010), it remains in the same situation before and after changes occur (Asbjørnslett, 2008, p. 19), and it is insensitive to noise factors (Mo and Harrison, 2005, p. 243). Thus, a robust supply chain endures rather than responds to changes (Husdal, 2010, p. 14). For example, multiple sources of supply make the supply chain more robust, because the flow of material from supplier B is sustained even if the flow from supplier A is disrupted (Tang, 2006b). In contrast to agile concepts, no adaptation is needed. And while robustness and agility are independent, some supply chain-related measures can increase both dimensions at the same time. Additional examples for implementing agile and robust strategies can be found in Table I.

Recent crises and catastrophes abruptly reminded companies how vulnerable their global supply chains are. Particularly, a number of prominent examples led companies to reconsider a structured risk management approach as an important field of action. Among them are implementations at Cisco (Harrington and O'Connor, 2009), Ericsson (Norrman and Jansson, 2004), and in the fashion retail industry (Khan *et al.*, 2008). No standard definition is available for the term SCRM. By combining definitions by Jüttner *et al.* (2003), who underline the reduction of vulnerability, Tang (2006a), who emphasize continuity, and Manuj and Mentzer (2008), who highlight strategy implementation, with own observations, SCRM is defined as the implementation of strategies to manage both everyday and exceptional risks along the supply chain

Strategy	Implementation	Source
Robustness (proactive)	Multiple sources of supply	Tang (2006b)
	Inventory	Tang (2006b)
	Make-and-buy	Tang (2006b)
	Product design	Khan *et al.* (2008)
	Logistical network design	Meepetchdee and Shah (2007)
Agility (reactive)	Supplier/buyer communication	Norrman and Jansson (2004)
	Business continuity planning	Norrman and Jansson (2004)
	Visibility	Christopher and Peck (2004)
	Assortment planning	Tang (2006b)
	Make-to-order/postponement	Swaminathan and Lee (2003)

Table I.
Examples for agile and
robust measures

based on continuous risk assessment with the objective of reducing vulnerability and ensuring continuity. Thus, SCRM extends traditional risk management approaches by integrating risks of partners upstream and downstream the supply chain.

SCRM can reduce vulnerabilities in both a reactive and a proactive manner: on the one hand, SCRM is reactive, because it helps to monitor changes in the supply chain, customer needs, technology, partner strategies, and competitors and to update the risk assessment correspondingly (Hallikas *et al.*, 2004). Hence, it lays the foundations for fast reactions. Ergun *et al.* (2010) highlight how SCRM processes enable a US restaurant chain to respond to hurricanes. Such major weather event triggers the response systems and lessons learned are documented for future seasons. Further, each functional area of the organization has clear responsibilities and plays a key role in enabling quick recovery. On the other hand, SCRM can also reduce vulnerabilities in a proactive manner: it helps identifying a potential risk and to assess its impact and probability before it can occur. Then, the decision maker can implement actions that prevent the risk or, at least, minimize the impact when occurring. Correspondingly, Blackhurst *et al.* (2008) describe the case of an auto manufacturer who implements a proactive way of managing disruptions by tracking risk ratings and risk indices over time and monitors trends to determine if thresholds and unacceptable levels are reached. In this way, a problem can be predicted and management action taken early on. Based on this reasoning it is hypothesized:

H1a. SCRM has a positive effect on agility.

H1b. SCRM has a positive effect on robustness.

Due to the multifunctional character of supply chain management, the performance of a supply chain can be regarded to encompass the strategic, tactical and operational level of activities toplan, source, make and deliver (Gunasekaran *et al.*, 2004). However, it has often been highlighted that a supply chain is particularly aimed at providing value via products and services in the hands of the consumer (Christopher, 2005, p. 17). Therefore, this research investigates the effects of agility and robustness on the supply chain's customer value. Employing an agile or a robust strategy has implications for the value of the supply chain for the respective customers. In their empirical work, Wagner and Bode (2008) find that both supply- and demand-side risks have a significant negative impact on supply chain performance, which they measure in terms of order fill capacity, delivery dependability, customer satisfaction and delivery speed,

i.e. important aspects of customer value. Charles *et al.* (2010) argue that volatility of demand, imbalance between supply and demand, and disruptions are all factors that affect supply chains negatively and call for a high level of agility. Thus, agility is important to adjust supply chain configuration and processes. Agility allows rapid responses to events and agile supply chains will, therefore, react in a timely manner, before occurring risks can materialize in decreasing the value of the supply chain for its respective customers. A second strategy is to include "safety nets" when selecting supply chain configuration and processes when risks appear on the horizon. In line with this, Meepetchdee and Shah (2007) argue that, besides aiming at efficiency and responsiveness, logistical network designers should also consider robustness as it is an important characteristic of functioning logistical networks. Robustness allows withstanding risks and, therefore, robust supply chains will prevent risks from having negative effects on the supply chain's customer value. When risks occur, supply chain processes and structures are already in place that absorb risks and still allow to satisfying the customer. This leads to the following hypotheses:

H2a. Agility has a positive effect on the supply chain's customer value.

H2b. Robustness has a positive effect on the supply chain's customer value.

A second, important measure of effectiveness is the overall business performance of a company. It may refer to different areas of outcomes, e.g. financial, product-market, and shareholder-return related areas (Richard *et al.*, 2009). Financial investments have to be made to become agile and/or robust. It is of particular interest, if the implementation of agility and/or robustness is beneficial for financial outcomes of a firm. Therefore, this research is concentrated on financial performance aspects when examining the impact of these management strategies on business performance. Jüttner *et al.* (2003) argue that there is a trade-off between the extra costs related to risk management strategies and the total costs of supply. That is, investments in agility and robustness incur additional costs which have to pay out in terms of improved business performance. Hendricks and Singhal (2005) empirically investigate the association between supply chain glitches (e.g. parts shortages) and various performance indicators. They find that firms who experience glitches report on average lower sales growth, higher increases in cost, and higher increases in inventories. This indicates that a proactive management strategy (i.e. robustness) is necessary in order to prevent supply chain glitches from occurring, which, in turn, helps to prevent deteriorating business performance. After risks have occurred, it is also important to be reactive (i.e. agility) to bring the supply chain "out of harm's way" as fast as possible, which, in turn, helps to get business performance under control again. It is thus hypothesized:

H3a. Agility has a positive effect on business performance.

H3b. Robustness has a positive effect on business performance.

Overall business performance is dependent on performance in subordinate business functions. For instance, excellence in logistics is related to higher business performance (Fugate *et al.*, 2010). In line with that, Johnson and Templar (2011) show that improved supply chain management practices have a positive impact on firm performance. An improved supply chain will result in more efficient processes, but it will also help to increase the quality of products and services. Similarly, it has been demonstrated

that quality performance is positively related to financial performance (Kaynak, 2003). If the supply chain's customer value increases due to higher product quality, this will result in satisfied customers and improved reputation, which, in turn, will result in higher sales. Customer value will be high, if the received products are not damaged or wrong and no rework has to be done. But this can also decrease costs for the manufacturer and its supply chain. As increased customer value leads to increased sales and can also lead to reduced costs, it can be concluded:

H4. Business performance is positively influenced by the supply chain's customer value.

3.2 Survey testing

An online survey was conducted in 2010 to test the hypotheses. The initial sample included informants involved in general management and business functions related to SCM from industrial companies (SIC 20-39) based in three countries (Germany, Austria, Switzerland). After excluding mailing errors, the sample contained 1,366 contacts. Only responses with less than 10 percent of missing item values were accepted. The EM algorithm (Dempster *et al.*, 1977) was used for a remainder of 0.6 percent missing item values. In sum, 270 responses were retrieved (response rate: 19.8 percent). Two outliers were removed.

Late-response bias was tested for by comparing the means of all scale items via *t*-tests between the first and last third of responses. No significant differences ($p < 0.05$) were found (Armstrong and Overton, 1977). Also, no indication for a non-response bias was found: following Mentzer and Flint (1997), 56 non-respondents were convinced by phone to answer a brief survey. Variables covering items from original scales were compared via *t*-tests showing no significant differences. In addition, a χ^2 test revealed no significant differences between respondents and non-respondents for demographic figures. The CFA marker technique (Williams *et al.*, 2010) was applied to test for the presence of a common-method variance, but no bias was found.

For measuring business performance and agility existing scale items were slightly adapted. In order to measure the supply chain's customer value, items were selected from existing scales that best capture this specific aspect of supply chain performance. No suitable measurement instruments were identified for robustness and SCRM. Therefore, a systematic instrument development approach proposed by Moore and Benbasat (1991) was applied. To reveal possible overlaps, the instrument development process also included the agility instrument and two related instruments. In total 20 academic and industry participants were grouped into four panels of judges to sort the items of all five constructs into separate categories, based on similarities and differences among items. In each of four rounds another panel of judges was used and after each round inappropriate items were reworded or eliminated. To assess reliability and validity, Cohen's κ (Cohen, 1960) and item placement ratio (Moore and Benbasat, 1991) were calculated. In round four, the average of κ was 0.87; values greater than 0.65 are considered to be acceptable (Jarvenpaa, 1989). Item placement ratio was 0.95 and exceeded the recommended value of 0.70 (Moore and Benbasat, 1991). After four rounds, the final SCRM items hardly differed from the original ones and included items to cover all phases of the SCRM process, whereas the final robustness items, which were based

on statements taken from the literature, were considerably changed during the process. All measurement instruments used can be found in the Appendix.

To test the reliability of the measurement scales, Cronbach's α was calculated for all scales and surpassed the lower bound of 0.7 (Nunnally, 1978). An EFA supported the assumed construct dimensionality. A following CFA provides good model fit ($\chi^2/df = 1.72$; CFI $= 0.96$; GFI $= 0.92$; TLI $= 0.95$; RMSEA $= 0.052$; SRMR $= 0.047$). Composite reliability for all scales surpasses the lower bound of 0.6 (Bagozzi and Yi, 1988). In addition, various aspects of validity of the measurement scales were tested. Both the re-use of well-established scales and high values of κ and item placement ration ensure that high content validity is given. High standardized loadings indicate that convergent validity exists and the Fornell-Larcker criterion (Fornell and Larcker, 1981) was met for all scales, thus, indicating discriminant validity.

Amos was used to test the hypotheses. The results can be found in Figure 2. Again, model fit is good ($\chi^2/df = 1.77$; CFI $= 0.96$; GFI $= 0.91$; TLI $= 0.95$; RMSEA $= 0.053$; SRMR $= 0.057$). SCRM explains 14.9 percent of the variance (R^2) of agility and 17.2 percent of the variance of robustness. About 19.3 and 23.6 percent of the variances of the supply chain's customer value and business performance can be explained by their respective antecedents.

The paths from SCRM to agility and robustness reveal high standardized path coefficients when testing *H1a* and *H1b* empirically. The coefficients for the agility and the robustness links are 0.386 and 0.414, respectively, and highly significant ($p < 0.001$), providing strong support for both *H1a* and *H1b*. Also the links of agility and robustness to the supply chain's customer value are significant at 0.283 ($p < 0.01$) and 0.215 ($p < 0.05$). This corroborates both hypotheses that explain the supply chain's customer value (*H2a*, *H2b*). Surprisingly, the path coefficient for the link between agility and business performance is low and not significant. Therefore, *H3a* that agility influences business performance is rejected. Only an indirect effect via the supply chain's customer value can be concluded. The path from robustness to business performance is positive and significant (0.127; $p < 0.1$), supporting *H3b*. Finally, the standardized coefficient for the path from the supply chain's customer
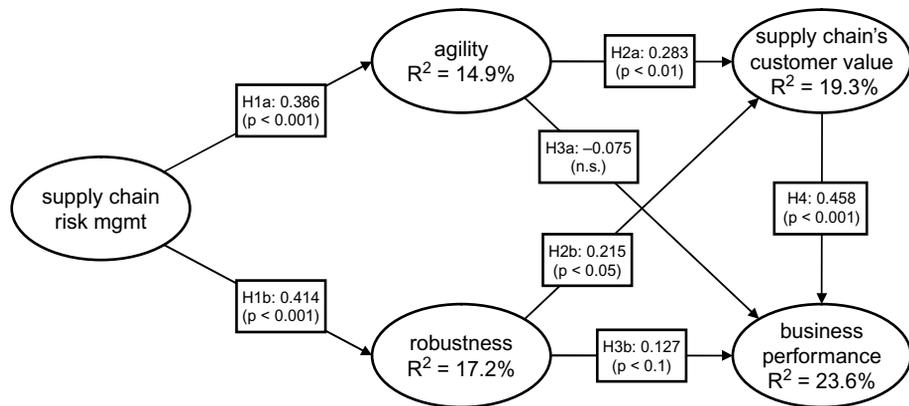

Figure 2.
Empirical results of
hypotheses testing

value to business performance is strong and highly significant (0.458; $p < 0.001$) which corroborates *H4*. In sum, it turns out that all but one hypothesis hold true.

4. Inductive phase

4.1 Case study observations

Preliminary knowledge gained from the survey results were the starting point for the inductive research phase. It was decided to use multiple cases to build on this knowledge to generate further insights on agile and robust strategies employed by companies in their supply chain.

A theoretical sampling approach was followed by choosing cases which were likely to replicate or extend theoretical contributions to SCRM (Eisenhardt, 1989). A number of six cases were sufficient to reach saturation of information, following recommended criteria by Strauss and Corbin (1998). Literal and theoretical replication (Yin, 2009) was achieved in four dimensions which were selected to produce similar or contrary results due to case characteristics:

(1) "Industry" (electronics and vehicle production) was selected based on the importance of both industries in Western Europe.

(2) "Supply chain position" (OEM and first tier).

(3) "Company size" (small, medium, and large) were distinguished to examine their influence on generalizability to the propostions.

(4) "Type of ownership" (privately owned and publicly owned) was chosen because of the possible impact different legislation related to SCRM can have.

Table II summarizes the characteristics of the six cases. Differences and similarities in theses dimensions were strived for. All contacted managers, who all hold positions related to SCM, agreed to take part in the case studies. In average, they have been working in their respective company for 14 years.

Data was collected from three sources. First, six semi-structured interviews were held and recorded with at least one, in some cases two representatives. The interviews were transcribed afterwards. In these interviews, interviewees were confronted with the survey results. Second, annual reports were collected, if available. Third, additional documents were provided by some participants, such as firm presentations and risk management documents.

In order to achieve a high quality of the research design, criteria and further suggestions by Yin (2009) were followed. Reliability, i.e. the possibility to repeat the research with the same findings, was ensured by the use of case study protocols and the development of a case study database. Construct validity, i.e. the identification of correct operational measures, was reached by using multiple sources of evidence and

	Case					
Dimension	1	2	3	4	5	6
Industry	Vehicles	Vehicles	Vehicles	Vehicles	Electronics	Electronics
Supply chain position	OEM	Tier 1	OEM	Tier 1	OEM	OEM
Company size	Large	Medium	Medium	Medium	Medium	Small
Type of ownership	Public	Public	Public	Private	Private	Public

Table II.
Case characteristics

by establishing a chain of evidence to allow a third party to follow all research steps. Due to the explorative character of this research, internal validity is of no concern. External validity, i.e. generalizability beyond the immediate case study, was reached by company selection along the mentioned dimensions. It turned out that replication was possible along these dimensions.

Data from the case study database was analyzed in the following steps: the recorded interviews were repeatedly listened to and the transcribed interview data was repeatedly read. Themes which emerged from the data were used in within-case analyses to combine and cluster the information from all data sources. Most importantly, a cross-case analysis was used to complement the information retrieved from individual cases to find general patterns, which allowed the following propositions.

4.2 Suggestions of propositions

In general, the cases revealed that all companies strive to be both agile and robust in order to utilize the specific advantages of each approach.

One company from the electronics industry states:

> We want to be agile and robust. This should be true for all companies.

This position is supported by a car manufacturer:

> The supply chain is normally very robust, whereas there is also a lot of agility at the same time.

And while companies aim at being agile and robust at the same time, this does not imply being it in the same areas. Our findings reveal that agility tends to be of particular importance on the customer side of a company (i.e. downstream in the supply chain). This observation is consistent with our survey results in that the supply chain's customer value is impacted especially by the agility of firms.

While a proactive strategy via a robust configuration requires risks and their effects to be known *ex ante*, an agile configuration is also able to deal with unforeseen and unforeseeable risks that may originate from the customer side. Here, for example one of the companies from the train industry, who is faced with constant changes in product requirements by the customers, highlights that agility is crucial to deal with fluctuations on the demand side.

Furthermore, the case studies show that robustness is rather required on the supplier side (i.e. upstream in a supply chain). For instance, multiple suppliers are helpful, if the quality of a component is low or a supplier has a high insolvency risk. This finding first of all implies that supplier-related risks tend to be more predictable as otherwise a proactive approach would not be feasible and effective. Additionally, the effects of a supplier-related disruption may be bigger for the companies as this may affect the production related to many customers.

While robustness is regarded as the best approach, it has to be noted that in some cases agility has to be applied as second-best option. A manufacturer of high-performance cars stated that multiple suppliers would be nice to have. However, as it relies upon constantly identifying new suppliers of highly innovative components rather than developing and standardizing such components in-house, mostly no alternative suppliers can be implemented. The consequent dependencies are dealt with via an exceptional ability to rapidly identifying new supplier, i.e. improved agility.

In several of our cases the stability motive as referred to by Bode *et al.* (2011) played an important role and companies strive to have reliable and secure suppliers. On the one hand, in traditional industries, stable supply is important to allow the constant flow of material and highly dependable delivery of functional products to the customers. On the other hand, also in dynamic industries, companies need to be able to rely on their suppliers, even if agility is needed on the customer-side for rapid reactions to changing customer needs. In the case of unreliable or unsecure suppliers, i.e. high supplier-side risks, the stability of the entire chain would be affected. This calls for additional investments in robustness in order to bring the supply chain back to stability.

One further reason for different approaches to supplier- and customer-related risks lies in the fact that a focal company will not be able to only use highly flexible and reactive suppliers and, therefore, need to incorporate robustness on their own. In one case the manager emphasized:

> To sum up, on the one hand, we need to be agile internally, this is a practical constraint related to customer requirements [...]. On the other hand, we cannot force our suppliers to be as agile as we are. Therefore, we need to find a way to decouple the operation modes of our supplier and ours.

The combination of lean and agile supply chain strategies has been coined "leagility". The leagile de-coupling point model described by Mason-Jones *et al.* (2000) and Christopher and Towill (2001) aims at holding inventory in some generic or modular form (lean strategy) and only complete the final assembly or configuration when the precise customer requirement is known (agile strategy). These authors emphasize that managers need to understand how market conditions and the wider operating environment will demand not a single off-the-shelf solution, but hybrid strategies which are context specific. The case findings point us to extend this de-coupling model to an approach where a reactive, agile customer-related strategy is de-coupled from a proactive, robust supplier-related strategy. This finding elaborates on existing strategy-selection models by Fisher (1997) and Lee (2002) by helping managers to select the appropriate supply chain strategy with respect to risk-based context factors.

From our observations, particularly those made in two firms from the electronics industry and two vehicle manufacturers (for *P1* regarding agility) and those made in one firm from the electronics industry and three vehicle manufacturers (for *P2* regarding robustness), it is concluded:

P1. Realizing agility is an effective supply chain approach to deal with customer-related risks.

P2. Realizing robustness is an effective supply chain approach to deal with supplier-related risks.

The cases also showed that agile and robust supply chain strategies are neither mutually exclusive nor applied independent of the broader context. While *ceteris paribus* the *P1* and *P2* hold true, utilization of the two strategies further has to be aligned to the overall competitive strategy of the firm. This is especially important as increasing agility and increasing robustness both requires the allocation of scarce resources. It has carefully to be considered which level of agility and robustness actually fits the competitive strategy, which defines, relative to competitors, which set

of customer needs is sought to be satisfied in which way through products and services (Chopra and Meindl, 2009).

Like other supply chain strategies, agility and robustness determine the nature of procurement, transportation, manufacturing, and distribution, along with follow-up services and a specification of whether these processes will be performed in-house or outsourced (Chopra and Meindl, 2009). This will involve deciding to be neither agile nor robust, either agile or robust, or both agile and robust.

One of the electronics companies, which assess its supply chain to be particularly agile, emphasizes its alignment to overarching objectives:

> Therefore, all efforts to improve processes and develop products flow into these superior targets, insofar that the company delivers reliable and long-lasting products and, simultaneously, rapidly reacts to market changes, demand changes, and disruptions.

The case further highlighted that it is useful to use definite mechanisms to break down the corporate strategy into functional strategies related to supply chain management, for example, purchasing, operations, and logistics management. This was highlighted in our case interviews:

> We employ a [balanced scorecard]. It exists on the corporate level and, below this level, there exists a scorecard for each business function, purchasing for example, which adopts exactly these superior corporate strategies as its starting point in order to derive the functional strategies.

This view is especially supported by one vehicle manufacturer, who links the decision between agility and robustness to product and industry requirements, and another vehicle manufacturer who links means to achieve robustness, such as multiple sourcing, to the overall competitive strategy. Concluding, the last proposition reads as follows:

P3. To be effective, the degree of agility and robustness needs to fit to the overall competitive strategy.

5. Conclusion

Departing from a somewhat heterogeneous literature base on agility and robustness and the expectation that both strategies may be important in improving the supply chain's customer value and business performance, our research provides strong support for this assumption.

Being agile has a strong positive effect on the supply chain's customer value, while its impact on business performance is mediated by the supply chain's customer value and, thus, is indirect only. In contrast, achieving robustness has a strong positive direct effect on both the supply chain's customer value and business performance. This is an important observation, because in the last years both researchers and managers paid a lot of attention to agility, whereas robustness turns out to be the real driver of business performance.

In line with the positive effect agility has on the supply chain's customer value, the exploratory cases revealed that agility is a particularly effective strategy in the case of high customer-side risks. The direct influence of robustness on business performance can be explained by the increasing prevalence of high volatility in supply chains (Christopher and Holweg, 2011). Supply chains need to consider robustness to be able to withstand this ever-occurring volatility risks. The case studies provide insights to

the fact that robustness can be considered a basic prerequisite to deal with supplier-side risks, while agility is necessary to deal with customer-side risks. These findings helps managers to select the appropriate supply chain strategy based on risk-based context factors, which, in turn, can help to shape a supply chain design that not only leads to improved business performance, but also to improved customer value and, consequently, societal benefits.

Our hypotheses that SCRM is important for both agility and robustness of a supply chain are supported. This coincides with the descriptions of managers interviewed as part of our case studies. Thus, the implementation of SCRM, which entails the identification, assessment, and controlling of risks, allows companies to better cope with changes both proactively and reactively. Besides other possible facilitators of agility and robustness, such as cooperation, insurance, and postponement, it turns out that SCRM is a strong driver of realizing these two strategies. This is an important argument for managers who consider the introduction of SCRM. Most importantly, companies, who are searching for a means to improve agility and robustness of their supply chains, find that the introduction of SCRM can be a powerful supplement to more traditional means such as excess capacities and safety stocks.

Further, it is learnt from the cases that choosing and achieving appropriate levels of agility and robustness needs to be aligned to the competitive strategy.

It was aimed to reduce possible research limitation, but it is necessary to point to the following issues. First, all participants were located in German-speaking countries only. Second, except for control variables, no objective data was drawn on. Due to the fact that mainly high-level key informants participated, their judgments can be highly relied on. Third, mainly OEM and first-tier suppliers participated in both the survey and the case studies. Therefore, generalizability may be partially problematic for companies further upstream in the supply chain (although we do not have any indication that this actually is the case). Further, for some of the constructs an even broader operationalization could have been possible. Research propositions yielded from the case study were not tested empirically. This is a possible starting point for further research. In spite of these issues, we are convinced that our findings provide an important extension to the evolving literature on SCRM.

Besides customer value, further research might also investigate the impact of agility and robustness on other broader aspects of supply chain performance and along the supply chain. We also encourage more research to focus specifically on supply chain robustness, due to its importance for both the supply chain's customer value and business performance.

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Appendix
SCRM (newly developed; $\alpha = 0.85$; CR $= 0.85$)
In order to counter disruptions of the material flow along our supply chain (both inbound and outbound), the following measures are taken (1 – strongly disagree; 7 – strongly agree):

(1) Systematic identification of sources for such disruptions.

(2) Assessment of both own risks and risks of important suppliers and customers.

(3) Assigned persons responsible for the management of such risks.

(4) Continuous monitoring of developments that might promote such disruptions.

Supply chain agility (adapted from Swafford et al., *2006;* $\alpha = 0.85$; *CR* $= 0.85$)
Please indicate the speed of reaction with which your company can engage in the following activities should changes occur (1 – slow; 7 – fast):

(1) Adapt manufacturing leadtimes.

(2) Adapt level of customer service.

(3) Adapt delivery reliability.

(4) Adapt responsiveness to changing market needs.

Supply chain robustness (newly developed; $\alpha = 0.87$; *CR* $= 0.87$)
To what extent do these statements apply to your supply chain? (1 – strongly disagree; 7 – strongly agree):

(1) For a long time, our supply chain retains the same stable situation as it had before changes occur (new item based on Asbjørnslett (2008)).

(2) When changes occur, our supply chain grants us much time to consider a reasonable reaction (new item based on own observations).

(3) Without adaptations being necessary, our supply chain performs well over a wide variety of possible scenarios (new item based on Harrison (2005)).

(4) For a long time, our supply chain is able to carry out its functions despite some damage done to it (new item based on Meepetchdee and Shah (2007)).

Supply chain's customer value ($\alpha = 0.76$; *CR* $= 0.76$)
Please indicate the level of your company's performance along the following dimensions compared to that of your competitors (1 – worse than competitors; 7 – better than competitors):

(1) Missing/wrong/damaged/defective products shipped (Kroes and Ghosh, 2010).

(2) Warranty/returns processing costs (Kroes and Ghosh, 2010).

(3) Conformance to customer specifications (adapted from Kroes and Ghosh (2010)).

(4) Customer satisfaction (Chen and Paulraj, 2004).

Business performance (Kroes and Ghosh, 2010; $\alpha = 0.91$; *CR* $= 0.92$)
Please indicate the level of your company's performance along the following dimensions compared to that of your competitors (1 – worse than competitors; 7 – better than competitors):

(1) Profit margin (%).

(2) Return on sales.

(3) Return on total assets (dropped item).

(4) Sales over assets.

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