The Influence of Relational Competencies on Supply Chain Resilience

A Relational View

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Structured Abstract

Purpose

This research explores the resilience domain, which is important in the field of supply chain management; it investigates the effects relational competencies have for resilience and the effect resilience, in turn, has on a supply chain's customer value.

Design/methodology/approach

The research is empirical in nature and employs a confirmatory approach that builds on the relational view as a primary theoretical foundation. It utilizes survey data collected from manufacturing firms from three countries, which is analyzed using structural equation modeling.

Findings

It is found that communicative and cooperative relationships have a positive effect on resilience, while integration does not have a significant effect. It is also found that improved resilience, obtained by investing in agility and robustness, enhances a supply chain's customer value.

Practical implications

Some findings contrast the expectations derived from theory. Particularly, practitioners can learn that integration has a limited role in enhancing resilience.

Originality/value

The study distinguishes between a proactive and reactive dimension of resilience: robustness and agility. The relational view serves as the theoretical basis to explain the effects between three types of relational competencies (communication, cooperation, and integration) and the above-mentioned two dimensions of resilience.

Keywords: relational competencies, supply chain risk management, supply chain resilience, supply chain agility, supply chain robustness

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Introduction

Coping with change – either proactively or reactively – is the essence of management, as Chakravarthy (1982) outlines in his seminal article. With respect to the field of supply chain management (SCM), this has been brought into full view, for example, through the 2010 Eyjafjallajökull volcano eruption in Iceland, the 2011 Tōhoku earthquake in Japan and the 2011 Thailand floods. This is paralleled with the observation by Christopher and Holweg (2011) that managers consistently perceive their business environment as inherently unstable and find supply chains to experience the "age of turbulence." To cope with such turbulences and the changes inherent in today's supply chains, great attention, both in practice and research, has been given to strategies that minimize supply chain risks (Bakshi and Kleindorfer, 2009; Hendricks *et al.*, 2009; Kern *et al.*, 2012; Sodhi *et al.*, 2012).

There is an apparent shortage of empirical research in the area of supply chain risk management (SCRM). Within the literature about SCRM, resilience plays an important role (Sheffi, 2005; Knemeyer *et al.*, 2009), but the resilience term still remains ambiguous and elusive and, at the same time, means to achieve resilience are not yet sufficiently understood. Additionally, even though popular SCRM definitions include the need for a coordinated approach amongst supply chain members (Tang, 2006; Manuj and Mentzer, 2008), the interplay between supply chain relationships and resilience remains unexplored, so far.

In this research, we extend existing literature on relational competencies (e.g., Fabbe-Costes and Jahre, 2007; Gan *et al.*, 2005; Paulraj *et al.*, 2008; Paulraj *et al.*, 2012). As companies build collaborative relationships with other supply chain members in order to achieve competitive advantage, these relationships may also be leveraged to enhance resilience within the supply chain (Christopher and Lee, 2004). Correspondingly, we apply the relational view of Dyer and Singh (1998) to derive how three types of relational competencies (i.e., communication, cooperation and integration) facilitate the resilience of a supply chain. Further, little research exists that distinguishes and jointly investigates different domains of resilience. Here, we follow Wieland and Wallenburg (2012) and distinguish between proactive and reactive strategies to achieve resilience, which can be referred to as robustness and agility, respectively.

The rest of this article is organized as follows. First, a brief review of the current SCM literature on resilience, on two dimensions of resilience (agility and robustness) and on relationships is provided.

The relational view is taken to explain the mechanisms through which relational competencies affect agility and robustness, which have been shown by Wieland and Wallenburg (2012) to be important drivers of the performance within supply chains and the value provided to customers. Then, the methodology is detailed and the model is analyzed. The article ends with a discussion of the results, as well as the theoretical and managerial implications. This discussion is all the more insightful, as some results are contrary to expectations.

Theoretical foundations

Resilience

Välikangas (2010) demonstrates that resilience can be conceptualized, both as the proactive capacity to "[t]ake action before it is a final necessity" and the reactive capacity to "[r]ecover after experiencing a crisis" (p. 19). It includes both the ability to "prevent or resist being affected by an event" and to "return to an acceptable level of performance in an acceptable period of time after being affected by an event" (ISO, 2010). A supply chain can, thus, be resilient if its original stable situation is sustained or if a new stable situation is achieved. In this research, resilience is understood as the ability of a supply chain to cope with change. In order to cope with change and to depart from an unstable state, the nature of interaction with the environment, in general, needs to be either reactive or proactive (Chakravarthy, 1982). A reactive strategy meets environmental change with a corresponding organization action; whereas, a proactive strategy builds on forecasting and prevention (Lengnick-Hall and Beck, 2005). In this respect, we follow Wieland and Wallenburg (2012), who call the first strategy "agility" (Braunscheidel and Suresh, 2009; Swafford *et al.*, 2006) and the second one "robustness" (Husdal, 2010; Meepetchdee and Shah, 2007). Hence, resilience is formed by two dimensions: agility, which is reactive (Braunscheidel and Suresh, 2009), and robustness, which is proactive (Shukla *et al.*, 2011).

Definitions of agility share verbs that point at the reactive ability to answer to change, i.e. "react", "respond", "adapt" or "re-configure." Bernardes and Hanna (2009) suggest that agility focuses on "rapid system reconfiguration in the face of unforeseeable changes" (p. 30) and similarly, Khan K *et al.* (2009) highlight that agile supply chains are capable of responding to marketplace uncertainty and adapting rapidly. This notion corresponds with the notion of agile manufacturing, which "changes operating states in response to uncertain and changing demands placed upon it" (Narasimhan *et al.*, 2006, p. 443). Also, the concept of speed is inherent to agility (Prater *et al.*, 2001). In this research, agility is understood as "the ability of a supply chain to rapidly respond to change by adapting its initial stable configuration" (Wieland and Wallenburg, 2012).

A robust supply chain is able "to carry out its functions despite some damage done to it" (Meepetchdee and Shah, 2007, p. 203). It retains the same stable situation it had before changes occur (Asbjørnslett, 2008), it endures rather than responds (Husdal, 2010), it helps to "withstand shocks" rather than to "adjust to shocks" (Wallace and Choi, 2011) and hence, it is proactive. Moreover, it performs well over a wide variety of possible scenarios (Harrison, 2005) and when system parameters or environmental conditions are undergoing large changes (Yan *et al.*, 2000). Thus, robustness requires the proactive anticipation of change prior to occurrence. In this research, robustness is understood as "the ability of a supply chain to resist change without adapting its initial stable configuration" (Wieland and Wallenburg, 2012).

Relational competencies

Relational competencies influence the patterns of SCM practice and can improve the performance of a supply chain (Paulraj *et al.*, 2012). Particularly, the importance of three relational competencies has been highlighted in prior research: communication, cooperation and integration (Chen *et al.*, 2004; Fabbe-Costes and Jahre, 2007; Omar *et al.*, 2012; Paulraj *et al.*, 2008; Paulraj *et al.*, 2012; Swink *et al.*, 2007).

There has been a "growing trend for organizations to create external linkages based on the sharing of information" (Barratt and Oke, 2007, p. 1217). This is the realm of communication. Communication, which can be viewed as a transmission process, refers to the flow of explicit information (Modi and Mabert, 2007). This includes "the formal as well as informal sharing of meaningful and timely information" (Anderson and Narus, 1990, p. 44). Effective communication between firms can be characterized as genuine, frequent and involving personal contacts (Chen and Paulraj, 2004). However, opportunistic behavior is a common reason why companies fail to achieve high performance. Here, cooperation comes into play. Cooperation refers to the process by which individuals and organizations come together, interact and form psychological connections for mutual gain or benefit (Smith *et al.*, 1995). Cooperation entails the active participation by the actors involved toward sustaining the relationship (Morris and Carter, 2005). Therefore, cooperation goes beyond the flow of information inherent to communicative relationships. To go even further, typically the goal is to create and coordinate processes seamlessly across the supply chain (Flynn *et al.*, 2010; Frohlich and Westbrook, 2001). This is the focus of integration, as integration refers to the process of combining efforts "to integrate supplier and customer information and inputs into internal planning" (Swink *et al.*, 2007, p. 150). Integration supplements the psychological level of a cooperation by a level that is focused on the coordination of systems (e.g., enterprise resource planning) and processes (e.g., inventory management) between partners.

Relational view

By introducing the relational view as a complement to the industry structure view and resource-based view, Dyer and Singh (1998) offer a theory that explains competitive advantage by focusing on dyads and networks of companies as units of analysis. The theory proposes that the greater the partners' investment is in (1) inter-firm knowledge-sharing routines and (2) relation-specific assets, the greater the potential will be for relational rents. Blackhurst *et al.* (2011) generalize from case study data that relational competencies such as defined communication networks, developed supplier relationship management programs and monitoring systems are positively related to resilience. In this research, the relational view is the basis to understand how superior relational competencies can improve resilience in its two dimensions, robustness and agility.

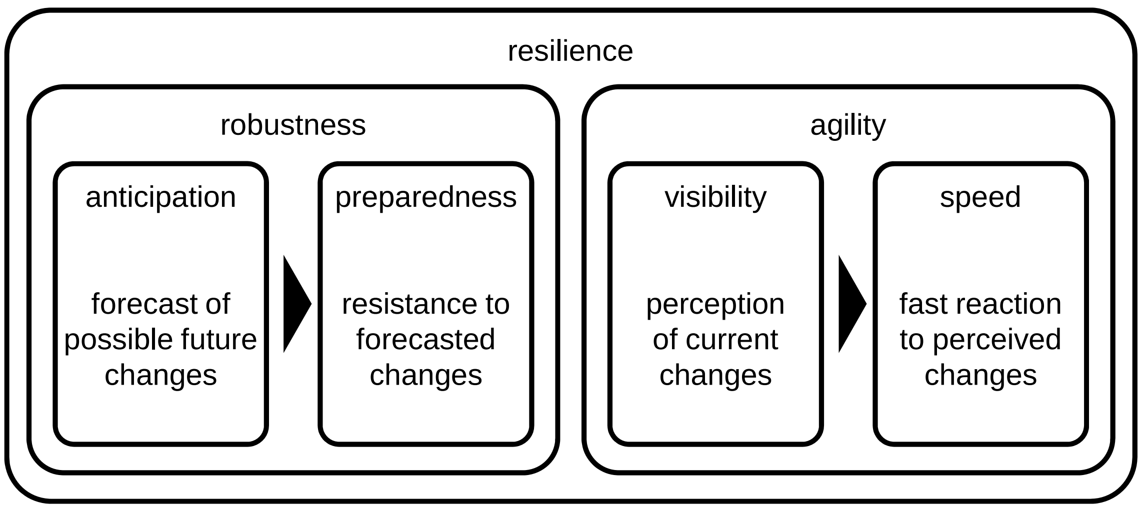

Figure 1. Mechanisms of resilience

The crucial aspects of resilience are anticipation (Hamel and Välikangas, 2003) and visibility (Pettit *et al.*, 2010). Both can be improved by investments in routines to share knowledge about relevant changes in advance or when the change occurs, respectively. Applied to the two resilience dimensions, to become robust, anticipation is needed to gain knowledge about potential changes that might occur in the future (Zsidisin and Wagner, 2010); whereas to become agile, visibility is needed to gain knowledge about actual changes that are currently occurring (Christopher and Peck, 2004). Two additional crucial aspects to achieve resilience are preparedness (Ponomarov and Holcomb, 2009) and speed (Manuj and Mentzer, 2008). They can be improved by investments in relation-specific assets that allow supply chains to cope with change in a proactive or reactive manner, respectively. While robustness needs preparedness in order to maintain a stable situation (Yang *et al.*, 2009), agility needs speed in order to get back to a stable situation (Prater *et al.*, 2001). The aforementioned mechanisms are summarized in Fig. 1.

Hypotheses

Antecedents of agility

In the next sections, effects of relationships on both resilience dimensions are hypothesized, as shown in Fig. 2. To achieve agility, a firm needs visibility for a better identification of changes and speed for a faster response to changes (Christopher and Peck, 2004). Visibility enables managers to know about changes and it is, therefore, the prerequisite to responding to those changes. Then, investments in abilities that accelerate responses are necessary. Both the visibility of changes and the speed to respond to them can be enhanced by relational competencies, as argued in the following sections.

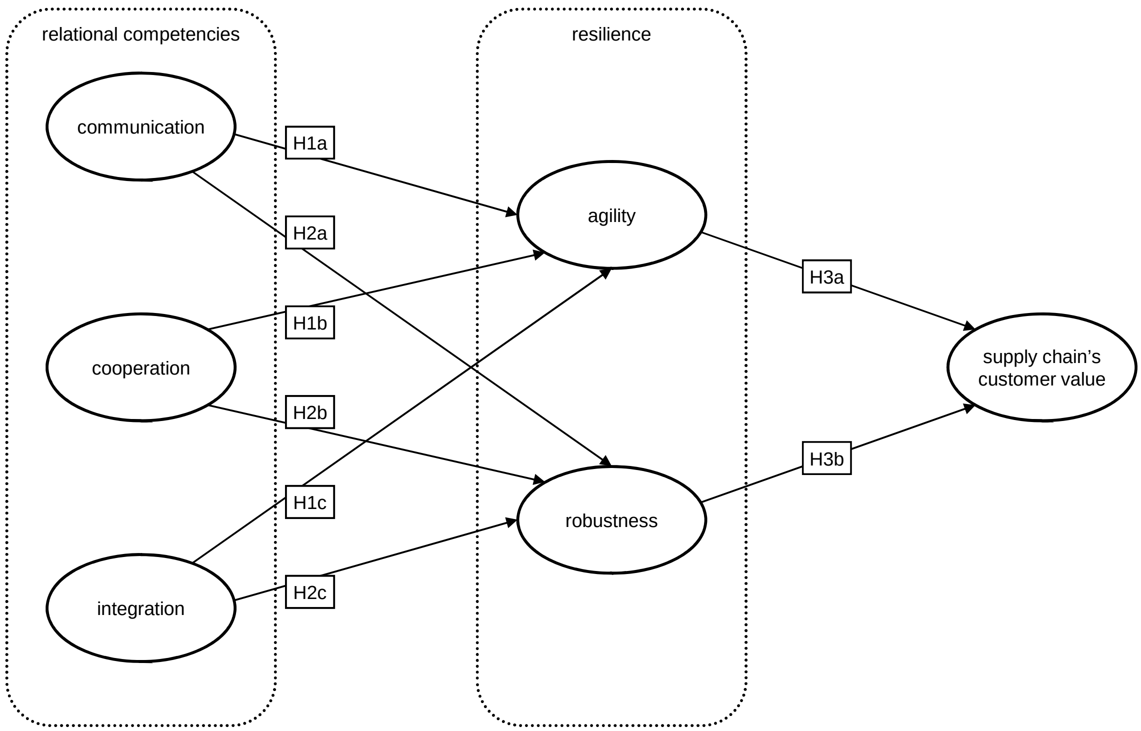

Figure 2. Hypothesized effects

Relationships between supply chain members rely on the availability of information that is visible to the actors along the supply chain (Holweg and Pil, 2008). Particularly, information about current or potential changes along the supply chain can be obtained by communicating with supply chain members. It has indeed been demonstrated that visibility is an outcome of investment in information sharing (Barratt and Oke, 2007). However, firms typically tend to delay the release of information about supply chain disruptions (Hendricks and Singhal, 2005) and other risks. Relations-specific assets that support communication of disruption data enable other supply chain members to quickly find solutions that minimize the effects of the disruption. In a case study from the construction industry, Ritchie and Brindley (2007) observe that communication ensures that any disagreements on quality standards, specifications and price are tackled and resolved early. Communication between supply chain members, therefore, gives firms a head start in responding to change. Consequently, communication between supply chain members improves both visibility and speed. This leads to the first hypothesis:

H1a: Communication has a positive effect on agility.

Investments in the extent of socialization between the supplier and buyer can increase the willingness to make sensitive information visible to partners (Cousins and Menguc, 2006). Cooperative partners are more willing to actively send signals about changes to other supply chain members and to passively endure screenings by them. Screening and signaling enhance visibility and reduce the risks of both adverse selection and moral hazard (Sanders and Boivie, 2004). Investments in cooperation assets also let suppliers and manufacturers act in concert. Partners in such a relationship are tied together and thus, feel committed to help each other by improving both their own and joint processes. It has been observed that good relationships can be an essential enabler to obtain premium service from suppliers (Bruce *et al.*, 2004) and that relationships help to make risk response processes faster, because a company's commitment to its partners drives the continuous improvement in these processes (Ergun *et al.*, 2010). Hence, cooperation between supply chain members has the potential to further improve visibility and speed; thus, it is hypothesized that:

H1b: Cooperation has a positive effect on agility.

Kleindorfer and Saad (2005) stated that there has been a shift towards supply chain wide systems that enable integration, which increases visibility for detecting disruptions and joint problem solving to respond to such events. Whenever short selling seasons make it difficult to match supply and demand, investments in knowledge-sharing routines to interchange sales data between supply chain members enhance the electronic supply chain, giving manufacturers more opportunities to respond to sudden changes in demand (Johnson, 2001). Integrated systems are relation-specific assets that make the interchange of data faster, which in turn, accelerates processes. Therefore, time-based performance of supply chains is significantly affected by deploying an information-intensive IT infrastructure, utilizing process improvement practices and jointly deploying information system infrastructure (Jayaram *et al.*, 2000). Since integration between supply chain members improves both the ability to make changes visible and the speed in responding to them, it is hypothesized:

H1c: Integration has a positive effect on agility.

Antecedents of robustness

It is crucial for manufacturers to learn how to anticipate and prepare for potential disruptions (Yang *et al.*, 2009). In order to reduce risk effects via a robust set-up, supply chain members need to be able to anticipate potential changes in a proactive manner and to implement reliable solutions by building slack into the supply chain that will prepare it against negative effects from these changes in the future (Hendricks *et al.*, 2009; Zsidisin and Wagner, 2010). Therefore, anticipation and preparedness, rather than visibility and speed, are needed for robust supply chains.

The main focus of proactive risk identification is recognizing future uncertainties from the organization's perspective, but firms can benefit from sharing opinions, visions and information (Hallikas *et al.*, 2004). Thus, whenever a firm invests in routines to share information about events that may affect the supply chain, this will improve the partners' ability to anticipate potential changes (Thomas *et al.*, 2009). With respect to preparedness, Yang *et al.* (2009) study a manufacturer who faces a supplier that is privileged with private information about experiencing a disruption. They find that information asymmetry can cause unreliable suppliers to stop using backup production. This is because the manufacturer deviates from symmetric-information risk management policies to curtail large incentive payment by forcing the unreliable supplier to pay a penalty. This penalty is less than the cost of preparedness using backup production. Investments in communication assets will reduce information asymmetry between a manufacturer and its supplier and, hence, increase preparedness. For the above reasons, anticipation and preparedness and, consequently, also robustness are enhanced by a communicative relationship between supply chain members:

H2a: Communication has a positive effect on robustness.

Shared responsibility can be crucial to manage joint supply chains (Jacobs and Subramanian, 2012). Cooperative supply chain members can be more trusted than their non-cooperative counterparts; a cooperative member demonstrates a sense of responsibility towards its supply chain and will, therefore, help its partners in anticipating potential risks. Non-cooperative behavior will impair anticipation. For example, in the case of shared demand forecast information, there is no positive value for suppliers if they distrust these data (Cohen *et al.*, 2003). With respect to preparedness, Bakshi and Kleindorfer (2009) observe that security investments of trading partners are often neither observable nor verifiable and that these partners might renege on their commitments to prepare. Investments in relation-specific assets to enhance cooperative behavior can, therefore, retain responsibility for security investments. A bargaining analysis by these authors establishes the superiority of co-opetition over competition when managing supply chain disruptions. They describe a cooperative contract, which leads to efficient investment in preparedness against risks in contrast to the non-cooperative game, which leads to under-investment. In the aggregate, cooperative partnerships among supply chain members are likely to improve anticipation and preparedness. This leads to the following hypothesis:

H2b: Cooperation has a positive effect on robustness.

It has been argued that integration facilitates anticipation of the partner's needs to better meet the partner's requirements (Flynn *et al.*, 2010). Investments in integrated systems along the supply chain will improve processes that can help supply chain members to anticipate possible challenges. This suggestion is supported by findings from interviews, which reveal that best practices for SCRM include the development of predictive analysis systems and the enhancement of supply chain intelligence by using improved databases (Elkins *et al.*, 2005). Integration can also improve preparedness by lowering the costs of risk-preventing measures: Firms facing the bullwhip effect can reduce the need for order batching by reducing transactions costs (Lee *et al.*, 1997). Investments in integrated order systems help to reduce paperwork and processing requirements in generating an order. This leads to more frequent replenishment in small batches and to less distortion of demand information. Finally, when a transportation disruption occurs, it turns out that, compared to a traditional supply chain, the impacts are less severe for an integrated system based on vendor-managed inventory (Wilson, 2007). Since integration between supply chain members influences both anticipation and preparedness, we hypothesize:

H2c: Integration has a positive effect on robustness.

Resilience and performance

To view the performance effects of agility and robustness, we focus on the supply chain's customer value. This refers to the value of the supply chain for the respective customers and has been shown by Wieland and Wallenburg (2012) to be a dominating performance dimension resulting from resilience. It also refers to different aspects like conformance to customer specifications and customer satisfaction. In concentrating on this dimension, we repeat this analysis and complement the theoretical foundation of the hypotheses by Wieland and Wallenburg (2012) with key aspects of the relational view.

In order to hypothesize the effects of agility on the supply chain's customer value, we again look at visibility and speed. On the one hand, it has been suggested that improved visibility is a way to alleviate the negative impact of the bullwhip effect (Lee *et al.*, 1997) and, more generally, it has been discussed that visibility is crucial for any company within a supply chain (Barratt and Oke, 2007). On the other hand, speed is important in fulfilling the task of the supply chain to serve the customer. Good examples for the latter can be observed in build-to-order supply chains successfully implemented in companies such as Dell, Compaq and BMW (Gunasekaran and Ngai, 2005). Thus, visibility and speed are influential levers to influence the supply chain's customer value positively. If both visibility and speed help to improve the customer value, so does agility:

H3a: Agility has a positive effect on the supply chain's customer value.

Similarly, in order to hypothesize the effects of robustness on the supply chain's customer value, anticipation and preparedness are considered. The importance of anticipating trends that can permanently impair the profitability of a core business has been highlighted (Hamel and Välikangas, 2003). Particularly, the anticipation of future uncertainties is an important SCRM phase expected to have positive performance implications (Hallikas *et al.*, 2004). This is because anticipatory capabilities help firms to gain time to prepare. It has been shown that companies do not quickly recover when disruptions have negative effects (Hendricks and Singhal, 2005) but that prepared companies with more operational slack included in their supply chain experience a less negative stock market reaction to disruptions (Hendricks *et al.*, 2009). Thus, for anticipation and preparedness, it can be assumed that these factors lead to an increase in the supply chain's customer value and the following effect of robustness can be concluded:

H3b: Robustness has a positive effect on the supply chain's customer value.

Research methodology and analysis

Data collection and measurement

To test the developed model, we collected primary data from manufacturing companies in 2010 and applied structural equation modeling for hypotheses testing. The sampling frame consisted of 1,517 potential respondents drawn from two databases and included a good representation of key informants in general management and business functions related to SCM (Table 1). The data includes manufacturing companies (SIC codes 20–39) from small, medium and large companies in Germany, Austria and Switzerland. The contacts received a link via e-mail to a web-based, German-language survey. Incentives and reminder e-mails were used to improve the response rate. A set of 1,366 valid contacts remained after deleting all mailing errors. 270 of the responses were considered usable due to only a few missing values, representing a response rate of 19.8%, which is above response rates observed in other SCRM surveys (e.g., Braunscheidel and Suresh, 2009) and can be considered very satisfactory (Wagner and Kemmerling, 2010). Two outliers were removed based on the Mahalanobis distance, which substantially improved multivariate normality.

Supply chain stage	OEM	63.7%
	first tier	21.9%
	second to n-th tier	14.4%
Annual sales (in €)	… < €50 million	26.3%
	€50 ≤ … < €100 million	15.9%
	€100 ≤ … < €250 million	14.1%
	€250 ≤ … < €1000 million	16.3%
	€1000 ≤ … ≤ €5000 million	11.9%
	… > €5000 million	15.6%
Business function	General management	25.7%

Industry (SIC)	Food, tobacco (20, 21)	5.9%
	Textile, apparel (22, 23)	3.7%
	Wood, lumber, furnitures (24, 25)	2.2%
	Paper, printing, publishing (26, 27)	5.6%
	Chemicals, petroleum (28, 29)	10.4%
	Rubber, plastics (30)	5.6%
	Metal (33, 34)	9.6%
	Machinery, electr. equipment (35, 36)	36.7%
	Transportation equipment (37)	10.4%
	Instruments (38)	7.8%
	Other (31, 32, 39)	2.2%

of respondents	Logistics	31.7%		Position of respondents	CEO	26.1%
	Purchasing	18.5%			Head of department	59.9%
	Production	11.7%			Team leader	8.7%
	Other	12.5%			Team member	5.3%

Table 1. Properties of the respondents

The measurement instruments reflect the unit of analysis: a company and its interfaces with suppliers and customers. The supply chain's customer value, agility and robustness were measured with the scales of Wieland and Wallenburg (2012). An instrument by Chen *et al.* (2004) was adapted to measure communication. Items taken from Morris and Carter (2005) were used to measure cooperation. To measure integration, we focused on four items that reflect coordinated processes and systems; these items were taken from Frohlich and Westbrook (2001). It was ensured that all intellectual aspects of the underlying constructs were measured with the items in order to achieve content validity (Rossiter, 2008). The questionnaire was pre-tested with practitioners and researchers, which led to a restriction to a subset of the initial items and adaptations of the wording of some items. Particularly, initial items were removed whenever they were not regarded to fit the construct definitions well or for statistical reasons. In a few cases, initial items were considered to be formative rather than reflective and, thus, removed. Also, in some cases, the wording was slightly adapted to improve clarity or to better fit the unit of analysis. As the survey was conducted in German, we followed Brislin's (1976, p. 221) advice for back-translation of items. All measurement instruments can be found in the Appendix.

We followed approaches suggested by Armstrong and Overton (1977) to test for a late-response bias, Mentzer and Flint (1997) to test for a non-response bias, and Williams *et al.* (2010) to test for the presence of a common-method variance. No indications of such biases were found.

Measurement model analysis

To assess the measurement model, we first tested reliability via Cronbach's alpha, which was above 0.7 for all constructs (Nunnally, 1978), as displayed in the Appendix. Results of the exploratory factor analysis support the assumption of unidimensional factors. Next, a confirmatory factor analysis was conducted using Amos 20 in order to estimate composite reliability (CR). The model provides good fit (χ^2/df = 1.64; CFI = 0.95; TLI = 0.94; RMSEA = 0.049; SRMR = 0.053). CR has a recommended minimum value of 0.6 (Bagozzi and Yi, 1988), which was well exceeded by all measurement models (the lowest value was 0.76).

	(1)	(2)	(3)	(4)	(5)	(6)
(1) Communication	**0.74**					
(2) Cooperation	0.64	**0.75**				

(3) Integration	0.54	0.33	**0.71**			
(4) Agility	0.38	0.40	0.21	**0.76**		
(5) Robustness	0.35	0.31	0.28	0.54	**0.79**	
(6) Supply chain's customer value	0.43	0.37	0.26	0.38	0.35	**0.67**

The table contains correlations between variables and, on the diagonal, square roots of the average variance extracted.

Table 2. Test for discriminant validity

In order to test the validity of the measurement models, convergent and discriminant validity were taken into account. The recommended minimum value for composite reliability was passed by all constructs and all standardized loadings are sufficiently high. Thus, convergent validity is approved. Discriminant validity was tested for using the Fornell and Larcker (1981) criterion. The criterion is met if the average variance extracted values are larger than the squared correlations with other variables. Therefore, we estimated these values and, indeed, the criterion was met for all constructs. This comparison is presented in Table 2.

Structural model analysis

All hypotheses were tested via structural equation modeling (SEM) using Amos 20 and following the guidelines of Shah and Goldstein (2006). The results are summarized in Fig. 3. The model provides a good fit ($\chi^2/df = 1.69$; CFI = 0.94; TLI = 0.93; RMSEA = 0.051; SRMR = 0.066). Regarding the explanatory power (R^2) of the model, the three relational competencies jointly explain a substantial portion of a company's resilience: 19.7% of the variance of agility and 15.0% of the variance of robustness. The two dimensions of resilience, in turn, explain 18.6% of the variance of supply chain's customer value. To rule out the possibility that the three relational competencies directly impact supply chains' customer value, we also calculated an alternative model containing those paths and all of them were found non-significant. That means that the customer value is only impacted by relational competencies indirectly mediated by agility and robustness.

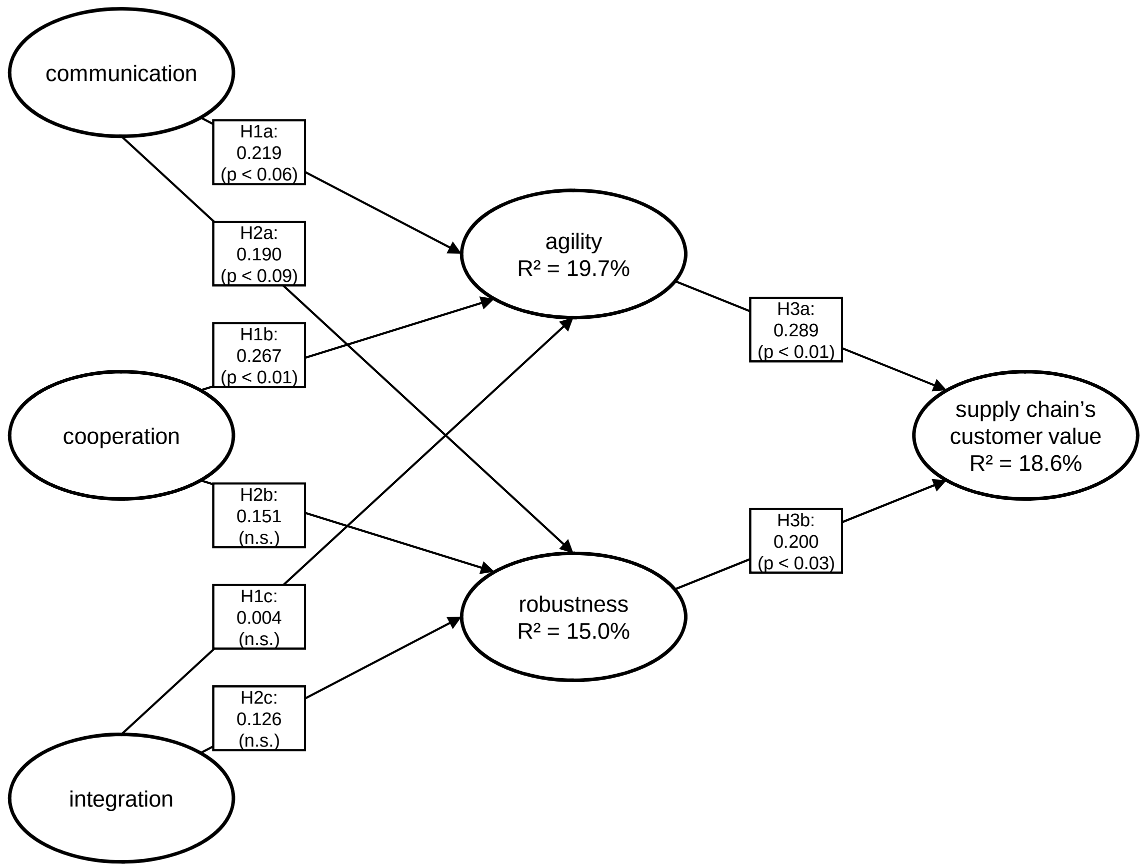

Figure 3. Results of the structural model estimations

When testing hypotheses 1a–c, the standardized path coefficients for the communication-agility link and the cooperation-agility link are +0.219 ($p < 0.06$) and +0.267 ($p < 0.01$), respectively, while the integration-agility link turns out to be non-significant ($\beta = 0.004$). The significant positive effects of communication and cooperation provide support for both H1a and H1b, whereas H1c is rejected. Turning to hypotheses 2a-c regarding the effects on robustness, the standardized coefficient for the communication-robustness path is positive and significant at 0.190 ($p < 0.09$). The corresponding values for the cooperation-robustness ($\beta = 0.151$) and integration-robustness paths ($\beta = 0.126$) are not significant. Therefore, H2a is supported, while H2b and H2c have to be rejected. In H2b and H2c, however, the p values are low, with 0.105 and $p = 0.138$, respectively. In sum, communication influences robustness but cooperation and integration do not. Finally, hypotheses 3a-b regarding the performance effects of the two resilience dimensions are tested. The standardized coefficients for the agility-customer value and robustness-customer value paths are 0.289 ($p < 0.01$) and 0.200 ($p < 0.03$). This reveals that both dimensions, agility and robustness, have a substantial positive effect on the supply chain's customer value supporting H3a and H3b.

Discussion

Our research takes a relational view and has two major implications for the relationships between resilience and the supply chain's customer value, as well as the antecedents of resilience. It was previously supposed in SCM research that supply chain practices need to fit stable business environments; however, meanwhile, there is evidence that supply chains can only perform if they are adjusted to turbulent rather than stable environments (Christopher and Holweg, 2011). As shown by Wieland and Wallenburg (2012), resilience and its two dimensions, agility and robustness, substantially promote the customer value of a supply chain. That is, two strategic paths can contribute to resilience-driven performance improvements. Given that numerous factors contribute to the supply chain's customer value, the variance jointly explained by agility and robustness is noticeably high. This finding underlines the importance of resilience in the turbulent times that today's supply chains are facing.

The second major implication of this research relates to the relational view and the influence that relational competencies have on resilience. Given scarce resources to invest in building relationships, the important question of how tight a relationship should optimally be with respect to resilience is addressed for the first time. Firstly, communication positively influences resilience. Managers must correspondingly be aware that information sharing is a prerequisite for both proactive and reactive resilience. Secondly, if the relationship is based on extensive communication and is cooperative, then agility, at least, can be further improved. Thirdly, it turns out that integration does not yield a significant increase in resilience. It must be concluded that interconnecting systems and processes (i.e., integration) does not provide additional risk-related value in addition to communication and cooperation. This is a surprising finding that contrasts the initial hypotheses and the traditional tone in SCM to constantly strive for integration.

Our results provide a certain contrast to the findings by Paulraj and Chen (2007) that positively link external logistics integration to agility. Also, Braunscheidel and Suresh (2009) find that external integration has a positive effect on agility. However, both studies do not separately consider communication and cooperation. Here, the distinct investigation of three relational competencies offers a more detailed picture. Cooperation, in general, is based on pronounced communication and integration, in turn, requires a certain degree of cooperation. This is reflected in our data by including covariances between integration and communication, and between integration and cooperation in our structural model. The positive effect of integration found by Braunscheidel and Suresh (2009) might, therefore, be based on the communicative and cooperative characteristics inherent in integrative relationships; additional integration is not needed to improve resilience if communication and cooperation are already present. In contrast, a competitive advantage could be gained by not spending scarce resources in highly integrated processes and systems.

A plausible alternative explanation for the non-significant role of integration is that integration, even if it helps to establish knowledge-sharing routines and relation-specific assets, has some negative sides to it. We argue that agility is based on visibility and speed. Yet, tight coupling and integrated processes may impede quick reaction when this reaction, for example, requires the usage of new suppliers. Correspondingly, robustness requires anticipation and preparedness, and while integration, here, helps in certain aspects, it also implies a focus on a limited number of suppliers with whom integration is high. In line with normal accident theory (Perrow, 1984), integration leads to an increase in dependency, as the more integrated supply chains get, the more likely risks in one link affect the other links in the chain (Norrman and Jansson, 2004). This implies that integrated supply chains, themselves, may have a higher risk exposure. This is in line with the results of Manuj and Mentzer (2008), who reveal that integration increases the ability of a member of a supply chain to control processes, systems, methods and decisions; however, integration, at the same time, ties up capital and reduces the flexibility of the supply chain to react to changes. In summary, integration would have the potential to improve resilience but this potential could be neutralized by mutual dependencies, tied-up resources and impaired flexibility.

It has been argued by the resource-dependency theory that interconnectedness creates interdependence and interdependence creates uncertainty (Pfeffer and Salancik, 1978). Particularly, it has been assumed that companies gain power by controlling resources to minimize their dependence and by controlling resources to maximize others' dependence on them (Ulrich and Barney, 1984). However, if a company considers integration as a means of gaining power over supply chain members, this can optimize its resource independence but will generate new dependencies at other places along the supply chain and, thus, also new vulnerability.

The R^2 values of agility or robustness indicate that a substantial part of the variance of resilience is explained by relational competencies. However, resilience-related literature suggests that other antecedents possibly exist that can positively influence resilience. One such important antecedent is shown to be SCRM (Wieland and Wallenburg, 2012). Additionally, we have calculated an alternative model in which the three relational competencies are supplemented with SCRM as a fourth antecedent. It turns out that, in this alternative model, the impact of the three relational competencies on agility and robustness is reduced, whereas SCRM turns out to be the most pronounced resilience driver. As discussed earlier, SCRM implies the need for a coordinated approach amongst supply chain members. Indeed, substantial covariance between SCRM and the three relational competencies was found in the results of the alternative model. That is, SCRM builds on coordination within a relationship that is exploited to generate resilience. The alternative model results also show that, beyond SCRM, additional relational competencies can improve resilience even further. In sum, compared to only viewing SCRM, the three relational competencies offer additional explanatory power. Particularly, relational competencies are valuable supplements to SCRM for driving resilience.

Limitations and future research

In this research, the aim was to minimize possible limitations, although some of them may still remain. Firstly, the data was based on same-respondent replies; hence, it is subjective in nature. However, on average, the respondents – mainly high-level managers – have been working for more than 14 years in their respective companies, which indicates that they are key informants and their assessments can be relied upon. Secondly, the unit of analysis is an industrial company and its external interfaces upstream and downstream in the supply chain. Therefore, statements can be made for vertical relationships but not for internal or horizontal ones. Finally, drawbacks of the cross-sectional nature of the research may still exist, but their minimization was initially assured by carefully hypothesizing the directions of causal effects. The results reveal an ambiguous observation for the impact of cooperation on resilience, as H1b is supported while H2b is rejected. This calls for further examinations of influences that specific aspects of cooperative relationships (e.g., commitment, trust, benevolence or kindness) can have on resilience.

Future research could examine the advantages and disadvantages of integration in the resilience domain. Particularly, integration plays an ambiguous part to potentially increase resilience by correlating with advantageous types of relational competencies, but to potentially decrease resilience by creating dependencies, which is certainly disadvantageous. This disadvantage might also occur for other relational competencies, as in some cases, the paths were significant at the $p < .1$ level only. In contrast, although H2b and H2c had to be rejected, the p values were close to .1. Therefore, there might be some potential for cooperation and integration to increase robustness in specific situations. We have concentrated on integration in terms of coordinated processes and systems. Other aspects of integration may lead to different results. These aspects open several opportunities for future researchers.

In this article, we have not explicitly distinguished between different types of supply chain risk, such as supply-side vs. demand-side risks or everyday vs. exceptional risks. It would be interesting to know whether the source or nature of change matters and whether robustness and agility are equally relevant in all situations. Therefore, future research could look at the role of relational competencies for different sources of supply chain risks. Also, we have not empirically tested the underlying mechanisms of resilience (anticipation, visibility, preparedness and speed). This, again, leads to potential for future research.

Conclusion

The contribution of this research is twofold. On the one hand, it widens our conceptual understanding of resilience; on the other hand, it improves our knowledge about the relational competencies recommended for supply chains in a risky environment. Based on the relational view, these findings provide valuable theoretical supplement to the existing literature on SCRM, resilience and relationships. A literature review was conducted in order to conceptualize resilience. Consistent with Wieland and Wallenburg (2012), resilience can be both proactive and reactive in nature. Most importantly, managers will learn from the results that, in order to positively influence resilience, relationships between supply chain members are beneficial. However, the effect of integration on resilience turned out to be other than expected. In particular, relationships that rely on the close integration of processes and systems between supply chain members do not reduce vulnerabilities to a larger extent than could be achieved by loose types of relationships. This can, in part, be explained by referring to the role of resource dependencies. Therefore, it is all the more important for managers to acquire communicative and cooperative competencies to be applied in relationships, or to implement integration in a way that does not create dependencies. As the system “supply chain” is an intermediate form between the focal company and its environment, the findings of this research underline the importance of a coordinated approach amongst supply chain members to achieve resilience; however, it also shows the limits of such an approach.

Appendix: Measurement models

Communication (Cronbach's α = 0.82; CR = 0.83; adapted from Chen *et al.*, 2004)

To what extent do the statements apply to the relationship of your company with your suppliers and customers? (1: strongly disagree; 7: strongly agree)

1. We provide each other with any information that might help us. (.65)
2. Exchange of information takes place frequently and in a timely manner. (.83)
3. We keep each other informed about events or changes that may affect the other party. (.75)
4. We give each other feedback about our performance. (.70)

Cooperation (Cronbach's α = 0.82; CR = 0.83; adapted from Morris and Carter, 2005)

To what extent do the statements apply to the relationship of your company with your suppliers and customers? (1: strongly disagree; 7: strongly agree)

1. No matter who is at fault, problems are joint responsibilities. (.65)
2. One party will not take unfair advantage of a strong bargaining position. (.75)
3. We are willing to make cooperative changes. (.91)
4. We do not mind owing each other favors. (.68)

Integration (Cronbach's α = 0.80; CR = 0.80; adapted from Frohlich and Westbrook, 2001)

To what extent do the statements apply to the relationship of your company with your suppliers and customers? (1: strongly disagree; 7: strongly agree)

1. We have full access to joint planning systems. (.80)
2. We synchronize our production plans. (.67)
3. We carry out joint electronic data interchange. (.62)
4. We have knowledge of inventory mix/levels. (.77)

Agility (Cronbach's α = 0.85; CR = 0.84; Wieland and Wallenburg, 2012; adapted from Swafford *et al.*, 2006)

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. (.63)
2. Adapt level of customer service. (.82)
3. Adapt delivery reliability. (.85)
4. Adapt responsiveness to changing market needs. (.76)

Robustness (Cronbach's α = 0.87; CR = 0.87; Wieland and Wallenburg, 2012)

To what extent do the 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) (.71)

2. When changes occur, our supply chain grants us much time to consider a reasonable reaction. (new item based on own observations) (.73)

3. Without adaptations being necessary, our supply chain performs well over a wide variety of possible scenarios. (new item based on Harrison, 2005) (.92)

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) (.80)

Supply chain's customer value (Cronbach's $\alpha = 0.76$; CR = 0.76; Wieland and Wallenburg, 2012; adapted from Kroes and Ghosh, 2010)

Please indicate the level of your company's performance along each of the following dimensions compared to that of your competitors. (1: worse than competitors; 7: better than competitors)

1. Missing/wrong/damaged/defective products shipped. (.64)

2. Warranty/returns processing costs. (.73)

3. Conformance to customer specifications. (.70)

4. Customer satisfaction. (.59)

Note: The standardized factor loadings can be found behind each item. All factor loadings were significant at the $p < .001$ level.

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