Supplier–Supplier Relationships and Supply Chain Disruption: First-Tier Supplier Resilience in the Tetradic Context

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Abstract

We consider disruption in the multi-tier context where the disruption derives from a source beyond the first-tier suppliers. To frame the study, we work with a tetrad involving the buyer, its two first-tier suppliers, and a second-tier supplier as the disruption source. The goal is to advance our knowledge on how a first-tier supplier's resilience against lower-tier disruptive events can be developed through horizontally connecting with the other first-tier supplier and how the buyer can benefit from its first-tier suppliers' resilience capability. Data from 33 triads (i.e., buyer–supplier–supplier) and a second-tier supplier common to both first-tier suppliers in Austria, Germany, and Switzerland was collected and analyzed.

Keywords: Risk management, disruption, coopetition

Introduction

First-tier suppliers are increasingly taking over value chain activities from original equipment manufacturers (i.e., buyers), leading to a heightened need for buyers to know how to build and leverage the suppliers' capabilities (Pulles et al., 2014). In the disruption management literature, scholars have referred to "resilience" as a supply chain capability to deal with disruptive events (Ambulkar et al., 2015). Resilience has traditionally been viewed as a capability that rests within the focal firm's boundaries, with its development through external relationships and downstream impacts largely ignored (Kim and Henderson, 2015).

Real-life evidence and case-based research have, however, proposed that buying firms can proactively create coopetition among suppliers to elicit collaborative synergies (Wu and Choi,

2005). In this situation, coopetition can be defined as "the cooperative behavioral actions which two […] suppliers (of a given buyer) engage in" (Wu et al., 2010, p. 116). The Aisin Seiki crisis within Toyota's supply base provides an interesting case example of how multiple suppliers can together mitigate the impact of disruptive events in supply chains (Nishiguchi and Beaudet, 1998). The case illustrates that a cooperative relationship between suppliers can help make those suppliers more resilient and mitigate the disruptive impact on the buying firm.

This paper is motivated by such evidence. It investigates the role first-tier suppliers play in a disruptive event deriving from the second-tier supplier. Building on social exchange theory it is hypothesized that the buyer's financial performance (FP) is safeguarded through its suppliers' resilience capability, which in turn is developed through coopetition amongst the suppliers. Furthermore, the moderation hypothesis suggests an increase in social bonding (i.e., interactions based on reciprocal relationships) between the buyer and supplier increases the impact of supplier resilience capability on buyer FP. It is postulated that increasing social bonds between a buyer and its supplier will increase the supplier's willingness to use its resilience capability to alleviate the potential negative performance impacts for the buyer during disruptions.

We hope to contribute to the literature in two ways with this study. First, the study findings may provide a new perspective regarding supplier selection by proposing resilience as a capability that rests with the supplier and that may be important to consider from a buying-firm perspective. Second, this study builds on the triadic perspective to consider a tetradic context (conceptualizing the supply chain as a network), which provides a more realistic picture and insights on how multiple supply chain actors on three levels are interdependent and affect each other when a disruption stemming from a source upstream to the first-tier suppliers occurs.

Theoretical background and hypotheses development

Supplier–supplier coopetition and suppliers' resilience capability

Traditionally, the focus of supply chain management (SCM) research has been on buyer–supplier links and the cooperative or adversarial nature of this relationship. The dyad has been the traditional unit of analysis, and evidence of the efficacy of supply chain practices has been drawn from this level (Durach et al., 2017). However, researchers have questioned this, arguing that the "smallest" unit of analysis is not the dyad but the triad (Choi and Wu, 2009). In situations of supply chain distress due to a disruptive event (e.g., the Aisin fire), it is important to conceptualize the supply chain as a network.

A more comprehensive research approach to supply networks is needed to truly capture the complexity of this situation. This paper builds on the triadic perception research on buyer–supplier–supplier relationships and outcomes in a particular disruption scenario. Building on social exchange theory the present study setup is developed in such ways that interdependence exists with the first-tier suppliers of a common buyer supplying non-identical parts for the same end-product and using a common second-tier supplier. This setting reveals then an interesting tension between cooperation and competition, commonly referred to as supplier–supplier coopetition (SSC) (e.g., Wu et al., 2010; Wu and Choi, 2005). As the two suppliers do not compete by offering the same parts, the situation may develop an economic interest of the two suppliers to support each other in order to uphold the buyer's production of the end item (i.e., help each other out). If either of the supply parts is not available, the buyer could not continue with its operation, implying negative consequences for both suppliers. With a disruptive event at the common second-tier supplier, they

have an incentive to cooperate with each other and therefore need to balance cooperation and competition with the other supplier to maximize their own profits (Blau, 1986)..

Firm resilience is commonly defined as the "capability of the firm to be alert, to adapt to, and quickly respond to changes brought by a supply chain disruption" (Ambulkar et al.,2015, p. 112). These resilience dimensions, that is, to detect, respond, and recover, also reflect the sequential phases of a resilient firm's management of disruptions.

Detect refers to the ability to recognize a disruptive event in the supply chain. According to Speier et al. (2011, p. 725), "the real challenge of detection is to ascertain that an incident has occurred prior to it doing any harm." SSC fosters developing this capability through frequent interaction and information exchange between the suppliers (Wu et al., 2010). *Respond* refers to the firm's ability to deal with the disruption quickly so its negative performance impact is reduced (Chowdhury and Quaddus, 2016). SSC helps firms gain knowledge about each other's capabilities and thus respond in a cooperative environment when the need arises. *Recover* refers to the "ability to return to normal operational state rapidly" (Pettit et al., 2013, p. 49). In SSC, two suppliers can pool resources in a creative way; thus, SSC can be a driver for the successful recovery from disruption. Based on these arguments, we propose the following:

Hypothesis 1: Supplier–supplier coopetition has a positive effect on the supplier's capability to:

- **Hypothesis $1_{(a)}$: … detect** disruptive events.
- **Hypothesis $1_{(b)}$: … respond** to disruptive events.
- **Hypothesis $1_{(c)}$: … recover** from disruptive events.

Suppliers' resilience capability and buyer's financial performance

In the second set of hypotheses, it is proposed that the first-tier supplier's resilience capability safeguards the buyer's FP during disruptions. In this study, the buyer's FP is defined as the financial effect caused by a disruptive event in its upstream supply chain (i.e., second-tier supplier).

Resilience is usually a dormant capability, manifesting only when a disruption occurs. In this study we propose that resilience capability may not have to rest within the company but can also be found at its suppliers. Having supply chain partners that are resilient to disruptive events reduces the event severity by dampening its rippling effects (Craighead et al., 2007).

A supplier's capability to identify and respond to upstream disruptions and its capability to return to normalcy post-disruption is likely to affect the severity of the event for the buying firm (Bode and Macdonald, 2016). The supplier's resilience capability therefore helps avoid and curtail the propagation of a disruption to the buying firm. The first-tier suppliers' ability to work together to detect, respond to, and recover from disruptive events will be advantageous to the buying firm in terms of mitigating and even preventing the disruptive events from impacting the buyer's FP. Therefore, we propose:

Hypothesis 2: The buyer's **financial performance** during disruptive events is safeguarded by the suppliers' capability to …

- **Hypothesis $2_{(a)}$: … detect** disruptive events.
- **Hypothesis $2_{(b)}$: … respond** to disruptive events.
- **Hypothesis $2_{(c)}$: … recover** from disruptive events.

Moderating role of buyer–supplier social bonding

In the third set of hypotheses, a moderating role stemming from social bonding between the buying firm and its supplying firms is postulated. In social bonds social between supply chain partners develop gradually as they better understand each other's idiosyncrasies over time (Williamson, 2008) as they repeatedly interact (Gulati, 1995) and live through difficult situations (Scholten and Schilder, 2015). This pattern drives reciprocity, where the two parties' actions reinforce each other and a positive move by one is reciprocated by the other. The disruption management literature has often drawn direct links between the relational closeness of a buyer with its supply base and a buyer's supply resilience (Ambulkar et al., 2015). If a supplier and the buyer establish social bonds, the supplier is less likely to deviate from norms (i.e., conform in accordance to expectations), and thus the buyer is more likely to benefit from the supplier's resilience capability. In other words, social bonds (SoBo) between the buyer and supplier may result in a supportive relationship in difficult times. Subsequently, it is proposed:

Hypothesis 3$_{(a,b,c)}$: Social bonding between a buyer and a supplier positively moderates the relationship between the supplier's resilience (with dimensions (a) detect, (b) respond, and (c) recover) to disruptive events and the buyer's financial performance during these events.

Figure 2 summarizes the above-developed hypotheses.

Methodology

Sample and triadic data collection

To enact the tetradic context of the present study, 1,486 manufacturing companies in Germany, Austria, and Switzerland were randomly chosen as buyers from a list of participants of a big German supply chain conference. They were contacted and asked to offer the names of two suppliers that fit in the tetradic study setting. Two main conditions were imposed for the selection of first-tier suppliers: 1) they currently supply complementary parts that go into the same final product using a joint source of supply and 2) they have an on-going coopetitive relationship. Subsequently, 125 buying companies responded in the positive. Of these, 33 matching responses from buyer–supplier–supplier triads with the required tetradic setting were identified and surveyed (i.e., 99 completed surveys). Each supplier was asked about their coopetitive relationship with the other supplier; the name of this supplier was articulated to them. We then presented each first-tier supplier with a disruption scenario stemming from the second-tier supplier they share in common. All participants were assured of the confidentiality of their responses and the academic purpose of the project. Data from 33 complete triads was eventually retrieved (Tables 1 and 2). Non-response (or non-inclusion) bias was checked for by comparing key firm characteristics (i.e., annual turnover, number of employees, industry sector, company age, and country of headquarters) with no evidence for the systematic dropout/exclusion of firms from the original sample was found.

Measures and pre-tests

Study surveys were exclusively based on scales from previous research. A questionnaire was developed in English and translated using the back-translation approach.

To assess constructs related to the occurrence of disruptive second-tier events, that is, suppliers' resilience capability and buyer's FP, a vignette-based survey approach with a constant variable value vignette (CVVV) was used. Vignettes are short descriptions of situations containing precise references to what are thought to be important factors in the respondent's decision-making

processes (Aguinis and Bradley, 2014). Both, the translated survey items as well as the vignettes where tested in multiple rounds or pre-test involving 35 students and 20 researchers.

Measurement models and Endogeneity

This study employed a multiple-informant research design to account for the multi-sided nature of our study and to reduce the risk of common method bias. Employing a non-experimental design may yet raise some endogeneity problems. We sought to address the potential of endogeneity both in the research design phase and the data analysis phase. Data for the independent and dependent variables were collected from different respondents to reduce common method bias. The assessments of SSC were swapped between the supplier pairs. SSC was collected from the suppliers, while the FP variable was collected from the buyer, and the mean values of the buyer and supplier scores of SoBo were calculated. Thus, the potential threat of spurious correlations stemming from correlated measurement errors relating to the independent and dependent variables was reduced. The problem of simultaneity is addressed through arguing that theoretically, the trajectory of the link is from SSC to supplier's resilience capability and not vice versa, as SSC is measured as "on-going", while the supplier's resilience capability refers to the situation of the particular disruptive event; establishing some confidence in the trajectory of the link. However, it must be acknowledged that the possibility of omitted variable bias cannot be completely ruled out. For both models, we carefully sought to identify all factors thought to be related to the independent variables and to give rise to the dependent variables.

Results

The direct effect of supplier–supplier coopetition on suppliers' resilience capability

Seemingly unrelated multiple regression (SUR) was applied on data obtained from the 66 suppliers to test the direct effect of SSC on the supplier's resilience capability (H1). Models 1a, 1b, and 1c use multiple control variables to provide a baseline model. Models 2a, 2b, and 2c include the three dimensions of suppliers' resilience capability. The coefficient of SSC on the suppliers' detection capability ($H1_{(a)}$) is positive and significant ($\beta=0.261$, $p<0.05$). $H1_{(b)}$ proposed a similar positive effect of SSC on the response phase. The results in Table 5 show again a positive and significant coefficient value ($\beta=0.234$, $p<0.05$), with significant R-square change from the baseline model ($\Delta R^2=0.085$, $p < 0.05$), indicating SSC is also positively related with the suppliers' response capability. Finally, in $H1_{(c)}$ a similar relationship was postulated between SSC and suppliers' recovery capability. However, the results are insignificant.

Table 5: *Standardized coefficient estimates (t-value): Seemingly unrelated regressions*

Variables	**Detect ($H1_{(a)}$)**		**Respond ($H1_{(b)}$)**		**Recover ($H1_{(c)}$)**	
	Model 1a	Model 2a	Model 1b	Model 2b	Model 1a	Model 2b
Independent Variable	β (t)	β (t)	β (t)	β (t)	β (t)	β (t)
Supplier Industry Sector	-	-	-	-	-	-
Supply Chain Position	-0.094 (-0.424)	0.044 (0.201)	0.191 (0.947)	0.315 (1.594)	0.295 (1.174)	0.383 (1.48)
Supplier's Firm Size	0.0763 (1.040)	0.112 (1.584)	-0.021 (-0.330)	0.010 (0.163)	-0.131 (-1.591)	-0.109 (-1.301)
Buyer's appreciation of SSC	0.131 (1.376)	0.068 (0.729)	-0.006 (-0.071)	-0.062 (-0.736)	0.083 (0.774)	0.043 (0.394)

Buyer's encouragement to cooperate	-0.591 (-4.694)***	-0.618 (-5.147)***	-0.268 (-2.345)**	-0.291 (-2.675)**	-0.268 (-1.886)*	-0.285 (-2.013)**
SSC		0.261 (2.589)**		0.234 (2.558)**		0.165 (1.385)
Intercept	4.676	3.464	5.414	4.325	5.088	4.323
R^2	0.459	0.522	0.249	0.334	0.211	0.240
ΔR^2	0.459***	0.063**	0.249	0.085**	0.211	0.028
ΔF	3.402	6.703	1.330	6.547	1.074	1.920
*p<0.07 (marginal); **p<0.05;***p<0.001						

The direct effect of the suppliers' resilience capability on the buyer's performance and the moderating role of buyer–supplier social bonding

Multiple moderated regressions on the 66 buyer–supplier pairs were carried out to test H2 and H3. Because of high multicollinearity amongst the independent variables (i.e., the three dimensions of resilience capability), each dimension and its interaction terms with SoBo was entered separately and removed before the next phase and interaction was included. Table 6 presents the results. Model 1, the baseline model, shows significant improvement relative to the null model; models 2a, 3a, and 4a are the main effect models ($H2_{(a-c)}$), and models 2b, 3b, and 4b are the moderation models ($H3_{(a-c)}$). The results indicate all three phases, detection (β=0.234, $p<0.05$), response (β=0.234, $p<0.05$), and recovery (β=0.234, $p<0.05$), have a significant impact on buyer's FP, with all R-square changes from the baseline model being significant ($p<0.05$), supporting H2. However, contrary to $H2_{(a-c)}$, the significant coefficients are negative, indicating the suppliers' resilience capability does not help the buyer to safeguard its FP but rather the contrary.

Table 6: *Standardized coefficient estimates (t-value): Multiple moderated regressions*

Variables	**Buyer's FP**						
	Model 1	Model 2a	Model 2b	Model 3a	Model 3b	Model 4a	Model 4b
Buyer Industry Sector	-	-	-	-	-	-	
Buyer–Supplier Relational Stability	-0.223 (-1.807)	-0.230 (-1.926)*	-0.212 (-1.691)	-0.243 (-2.021)**	-0.234 (-1.922)*	-0.287 (-2.356)**	-0.305 (-2.557)**
Buyer's Firm Size	-0.228 (-1.561)	-0.262 (-1.847)	-0.264 (-1.846)	-0.224 (-1.584)	-0.234 (-1.634)	-0.291 (-2.039)**	-0.313 (-2.238)**
End-Item Importance	-0.460 (-3.455)**	-0.437 (-3.388)**	-0.451 (-3.494)**	-0.470 (-3.635)***	-0.469 (-3.608)***	-0.488 (-3.802)***	-0.434 (-3.369)**
Sourcing Structure	0.021 (.150)	0.079 (0.568)	0.065 (0.456)	-0.005 (-0.035)	0.009 (0.067)	0.017 (0.127)	0.091 (0.661)
SoBo	0.098 (0.885)	0.076 (0.712)	0.067 (0.541)	0.128 (1.184)	0.133 (1.222)	0.154 (1.414)	0.228 (2.010)**
Independent Variable							

Detect ($H2_{(a, b)}$)		-0.242 (-2.161)**	-0.250 (-2.195)**				
Respond ($H2_{(a, b)}$)				-0.227 (-2.043)**	-0.226 (-2.021)**		
Recover ($H2_{(a, b)}$)						-0.258 (-2.316)**	-0.258 (-2.374)**
Detect X SoBo ($H3_{(a)}$)			0.055 (0.507)				
Respond X SoBo ($H3_{(b)}$)					0.068 (0.666)		
Recover X SoBo ($H3_{(c)}$)							0.203 (1.849)*
Intercept	9.166	9.194	9.274	9.513	9.463	10.117	9.760
R^2	0.495	0.538	0.540	0.534	0.538	0.544	0.574
ΔR^2 (change to model 1 or the preceding model)	0.495***	0.043**	0.002	0.534**	0.004	0.049**	0.030*
ΔF (change to model 1 or the preceding model)	3.844	4.672	0.257	4.176	0.444	5.364	3.420

*p<0.07 (marginal); **p<0.05;***p<0.001

SoBo's moderating effect on the relationship between the three phases of the suppliers' resilience capability and the buyer's FP is assessed and presented in Models 2b, 3b, and 4b (Table 6). A marginally significant moderating effect of SoBo was detected for the relationship between the suppliers' resilience capability to recover from this disruption and the buyer's FP (β=0.203, p<0.07). Figure 3 further clarifies this observation. SoBo between buyer and supplier dampens the negative relationship between a supplier's capability to recover from a disruptive event and the FP of the buyer.

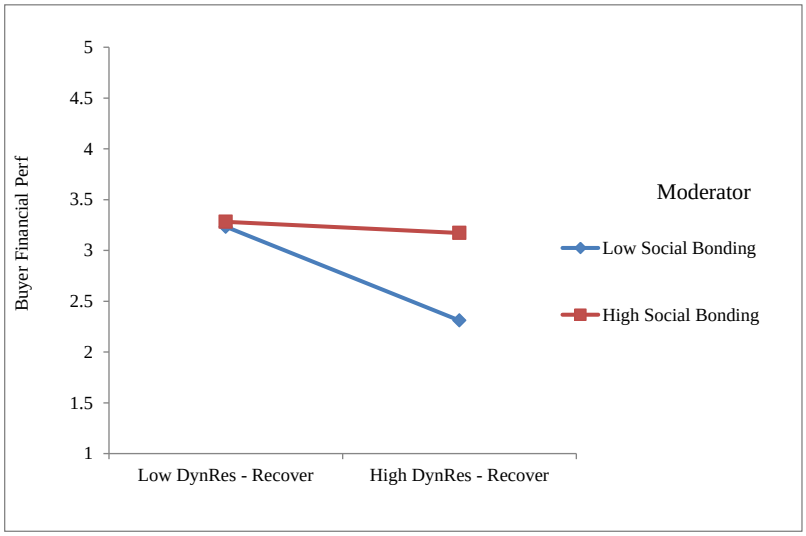

Fig. 3. Interaction moderation $H3_{(c)}$

Discussion

The results indicate a supplier–supplier coopetitive relationship increases the total supplier resilience capability at the first-tier supplier level. By extension, one should be able to argue the supplier–supplier relationship increases the buyer's resilience. The buying firm can draw on the suppliers' resilience as a capability in times of upstream supply chain disruptions. Ironically, however, the results indicate supplier resilience capability negatively affects the buyer, impeding its FP during the disruption. In other words, in contrast to the initial theorization (see H2), when the disruption comes from the second-tier supplier, the buyer indicates that the supplier resilience capability grounded in the supplier–supplier relationship gets in the way of its ability to overcome the impending situation. It is believed that partial answers to this puzzling observation lie in how the different phases of supplier resilience capability play out in terms of how they are affected by the supplier–supplier coopetition and also how they affect the buyer's FP during the disruption event.

It is found that maintaining supplier–supplier relationships requires an investment by supplying firms in the form of coopetition. Such investment affects the phases of supplier resilience differently. According to the analysis, the supplier–supplier coopetitive relationship has a significant impact on the detect and respond phases of the supplier resilience capability, whilst its impact on the recovery phase is insignificant. That means when two first-tier suppliers work together facing disruption from their common second-tier supplier, they are rewarded for their investment by being more able to detect and respond to the particular disruption, although they are on their own during recovery.

All three phases of supplier resilience capability negatively affect the buyer's FP during the event. When a disruption occurs, the buyer is compelled to address it as quickly as possible to regain normalcy. According to the results, the buyer thinks supplier resilience capability with respect to its coopetiting supplier at the first-tier level is not helping but hurting its ability to do its job. The buyer seems to be suggesting the resilient first-tier suppliers are "bridging" the problem rather than "buffering" the propagation (Bode et al., 2011). All phases show a relatively equal negative impact on the buyer FP. However, as opposed to the results in H1, in the analysis of H3 the recovery dimension of the supplier resilience capability provides interesting insights. The recovery dimension is the only phase of the supplier resilience capability that is significantly moderated by the buyer–supplier social bonding. In other words, only in the recovery phase of the disruption event can the buyer use social bonding as the lever.

Theoretical implications

To isolate the locus of supplier resilience capability from supply disruption, a multi-tier context was created in this study. This introduction of a second-tier supplier that is common to two suppliers in a triad introduced interesting and unexpected dynamics and findings.

First, the buyer–supplier–supplier triad literature is extended by creating a tetradic context within which the triad is embedded. This is the first study that uses the tetrad as a research design, taking a modest first step toward investigating how the triad behaves in disruptive situations brought by a fourth supply chain partner in the second tier. Second, the social exchange literature is extended by showing the basic forms of interaction of four partners in a supply chain disruption scenario. Finally, the disruption literature is extended by theorizing the supplier resilience capability in the supplier–supplier coopetitive relationship context.

The network perspective in this paper allowed providing a more holistic and a more realistic perspective on risk management in a supply chain context. Researchers and practitioners alike have stressed the importance of a network perspective (Durach et al., 2017). This study has followed this premise in its setup and methodological design. The multi-tier disruption context is extended with more fine-grained insights about the resilience construct by looking at its detect, respond, and recover phases separately. It shows that depending on the phase, relational links with other suppliers or other buyers become more relevant.

Managerial implications

It has not yet been fully recognized how to manage the propagation of disruptions in supply chains. The discipline is still searching for supply chain strategies that embody a significantly higher degree of resilience for supply chain partners. The present study contributes to this quest for knowledge, extending our analysis beyond buyer-centric risk management efforts.

Pulling two suppliers together by a buyer can bring many benefits to the firm, such as getting the suppliers engaged in joint product development and innovation. Suppliers can share transportation or production capacity. These efforts are likely effective in a stable environment but could have a downside in some exceptional situations. This study has apparently come across one of these downsides in cases of upstream supply chain disruptions. Suppliers' resilience capabilities seem to work against the buyers in the context of a disruption caused by a defaulting second-tier supplier common to both suppliers. It is therefore proposed that when buyers get two suppliers together in a coopetitive relationship they should be mindful about the potential downsides. Linking suppliers that have common capabilities and interests in terms of supplying for the same end product benefits the suppliers' capability to detect and respond to disruptions brought by a common sub-supplier. The suppliers' capability to detect, respond, and recover, however, impedes the buyer's FP during the disruptive event. However, the social bonds with these suppliers help in the recovery and safeguard the buyer.

Conclusion

The study has shown that in a tetradic setup two first-tier suppliers with common capabilities, joint interests, and a common supplier benefit from their coopetitive behavior in that they become more resilient during a disruption at a common second-tier supplier. However, the buyer in this triadic setting does not benefit from their suppliers' increased resilience, although when the buyer manages to generate reciprocity through better supplier relationships, they are able to work against their suppliers' self-interested actions, thus fostering a resilience approach that also brings rewards to the buyer.

Overall, the study results provide guidance for supply chain managers, helping to better understand the potential downsides of linking their supply base. To truly assess such complexity, as our research questions propose, the limitations of our research must be taken into consideration when interpreting our results. First, this study is limited in that only 33 triads embedded in the required tetradic setting could be identified and analyzed. Nonetheless, the perplexing results of this study highlight the need for future supply chain research to adopt more representative study setups. Dyads can hardly reflect the dynamics supply chains managers must deal with every day.

Second, it could not definitively be proven that endogeneity does not affect this study. However, considering the study setting and analyses, confidence is established in the results. Finally, single respondents were used from each firm to make inferences about this study's key constructs

(although secondary data was used for some of the controls). While these respondents are considered key informants within their firms with potentially the best vantage point for viewing the required aspects of the organization, they ultimately represent a single source of subjective information. Future research may therefore benefit in finding more reliable data measures for some of the theoretical constructs, for example, by substituting secondary data or constructs that can be adequately assessed by multiple informants within a company.

Nonetheless, despite these limitations we believe our research has made significant contributions to theory and management from a cooperative risk standpoint by taking a network perspective.

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