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

Purpose: The present study considers disruption in the buyer-supplier-supplier triad. This triad has a common second-tier supplier as the disruption source, which gives us the tetradic context. The goal is to advance the 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.

Design/Methodology/Approach: Data from 33 triads was collected and analyzed.

Findings: As predicted, co-opetition between two first-tier suppliers increases the first-tier supplier's capability to be resilient to disruptive events emanating from a lower tier source. However, contrary to initial theorization, the first-tier supplier's resilience capability affects the buyer's performance during disruptive events negatively. With increasing buyer–supplier social bonds, this negative relationship can partly be alleviated.

Research implications: Analyzing resilience within a triad to a disruption in the tetradic context reveals unexpected dynamics. Individual supplier's resilience may have a negative impact on the buyer's resilience in certain disruption events.

Practical implications: The buyer can increase collective suppliers' resilience through establishing horizontal links. To prevent becoming a victim of the supplier's resilience in the event of a second-tier disruption, a buyer needs to become a member of the supplier's relational network.

Originality/value: We propose that resilience can rest with the suppliers. This observation has implications for the buyer when selecting and coordinating suppliers. Further, it considers a context beyond a triad by venturing into the tetradic context. We anticipate more studies in tetrads in future and this study can serve as a bridge.

1. 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 their capabilities (Ellis et al., 2012; Pulles et al., 2014). One such capability is the first-tier suppliers' resilience against upstream supply disruptions. Scholars have referred to "resilience" as a firm's capability to respond to disruptions and restore normal operations (Rice and Caniato, 2003). It has traditionally been researched as a capability that rests within the focal firm's boundaries (Ambulkar *et al.*, 2015), with its development in lower-tier suppliers and downstream impacts largely ignored (Kim and Henderson, 2015). Helping first-tier suppliers to develop resilience should underlie the same rules as developing in-house resilience. Resilience can require the participation of supply chain partners (Bakshi and Kleindorfer, 2009) and may be facilitated through reducing information asymmetry in the supply chain (Wakolbinger and Cruz, 2011). From a buying-firm's perspective, large informational benefits may be expected though linking the same tier suppliers that have similar requirements regarding their sourcing markets. The resulting collaboration would have the character of co-opetition as noted in Brandenburger and Nalebuff (1996), in which competition between suppliers continues, but cooperation is also required to deal with joint risks.

Real-life evidence and case-based research have already proposed that buying firms can proactively create coopetition among suppliers to elicit collaborative synergies (Dyer and Nobeoka, 2000; 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 chain provides an interesting case example of how multiple suppliers can together mitigate the impact of disruptive events in supply chains (Nishiguchi and Beaudet, 1998; Dyer and Hatch, 2006). Aisin, a first-tier supplier, experienced a fire that prevented the supply of proportioning valves and would have caused a production disruption at Toyota. However, disruption was averted due to the joint effort of multiple suppliers. This case illustrates that a cooperative relationship between suppliers and the buying firm can help make those suppliers more resilient and mitigate the disruptive impact on the buying firm.

Yet, to benefit as buying firm from the downstream resilience, social exchange theory suggests that buyers would need to develop themselves into preferred customers (Hirschi, 2002; Kaufmann and Carter, 2006). The goal of a buyer regarding its downstream suppliers should thus be to integrate them into its relational networks. Social bonds between a buyer and its suppliers can then influence the suppliers to prioritize allocation of limited resources during disruptions (Sheffi, 2001).

Building on such literature, this paper investigates the role the first-tier suppliers play in a disruptive event emanating from a second-tier supplier. This relational structure is shown in Figure 1. The focus of the study is the triad involving the buyer and its two first-tier suppliers, while the context is the tetrad that includes the buyer-supplier-supplier triad and a common second-tier supplier. We call this context a stylized tetrad.

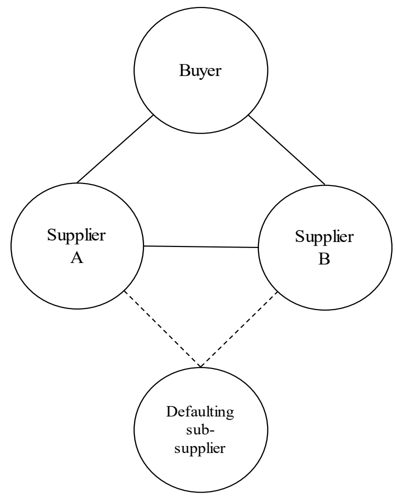

Figure 1 Triadic structure within a stylized tetradic context

This paper aims to explore whether coopetition between first-tier suppliers can help develop their resilience capability and how it affects the buyer's performance outcomes. Three research questions are posed: (1) Does supplier–supplier coopetition lead to the first-tier supplier resilience when facing a disruption from a common second-tier supplier? (2) Does supplier resilience increase the buyer's financial resilience to the disruption? (3) Do increasing social bonds between buyers and suppliers help buyers to benefit from their first-tier supplier's resilience?

We contribute to the literature primarily in two ways. Firstly, the 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. Secondly, this study builds on the triadic perspective within a tetradic context, conceptualizing the supply chain as a network. It provides a more realistic picture and insights on how multiple supply chain actors across three tiers are interdependent and affect each other when a disruption occurs.

2. Theoretical background and hypotheses development

2.1 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 unit of analysis, and evidence of the efficacy of practices has been drawn from this level (Choi and Wu, 2009; Durach et al., 2017). However, researchers have questioned this, arguing that the "smallest" unit of network 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. Multiple suppliers interact within and across tiers to mitigate the undesirable consequences for their customers and themselves.

Social exchange theorists assume companies to be self-interested actors that work with other supply chain partners in such ways that the rewards of cooperation outweigh the costs, with self-interest (i.e., economic gains) and interdependence as central aspects (Cropanzano and Mitchel, 2005; Griffith et al, 2006, Lawler and Thye, 1999). Each of the linked actors in a network offers some form of value to the others and decides whether or not to exchange (Blau, 1986; Cropanzano and Mitchell, 2005). Two same-tier suppliers may behave cooperatively to serve a joint customer to improve products and services yet simultaneously compete with similar production and process capabilities and technical know-how for resources and market share (e.g., Bengtsson and Kock, 2000; Lundgren-Henriksson and Kock, 2016).

In the present stylized tetrad, 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 an interesting tension between cooperation and competition, commonly referred to as supplier–supplier coopetition (SSC). The two suppliers have similar production and process capabilities and technical know-how, which should place them in competition. Yet, with respect to this buyer, the two suppliers do not compete by offering the same parts. Thus, the situation may cultivate 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 a common second-tier supplier, they can draw on their SSC, as they have an incentive to cooperate. They need to balance cooperation and competition with the other supplier to minimize their own losses (Blau, 1986). In turn, building on exchange theoretical assumptions, when suppliers are engaged in a coopetitive relationship, we would assume that they do so because of the expected positive (self-interested) outcomes of this action (Lawler and Thye, 1999). This outcome may be increased organizational resilience to an upstream disruption (Nishiguchi and Beaudet, 1998).

Firm resilience is commonly defined as the multidimensional "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). Such resilience involves several dimensions, that is, to detect, respond, and recover, which reflect the sequential phases of a resilient firm's management of disruptions (Sheffi and Rice Jr., 2005).

To 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 likely fosters developing this capability through frequent interaction and information exchange between the suppliers (Wu et al., 2010), providing a potential asset to reduce informational asymmetry (Bakshi and Kleindorfer, 2009). *To respond* refers to the firm's ability to deal with the disruption quickly so its negative performance impact is minimized (Chowdhury and Quaddus, 2016). SSC may help firms gain knowledge about each other's capabilities and thus respond in a cooperative way when the need arises. Information exchange has been pointed out as an important issue to coordinate supply chain actions (Fiala, 2005). *To 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.

2.2 Suppliers' resilience capability and buyer's financial performance

Surprisingly, despite the significant research on the topics of supply chain disruption and supplier capability-performance efficacy, a buyer-centric research perspective dominates. For example, when addressing supply chain disruptions, Braunscheidel and Suresh (2009) and Wieland and Wallenburg (2013) focused on a buying firm's capability to be agile, which left unaddressed the supplier's role. Others found that the pivotal buying firm's capabilities reduce the probability and impact of disruptions (e.g., Ambulkar et al., 2015; Durach and Machuca, 2018). However, to date, it has not been sufficiently explored how buying firms are affected by their suppliers' capabilities to detect, respond, and recover.

Resilience is usually a dormant capability, manifesting only when a disruption occurs. Researchers have described it as a dynamic capability (e.g., Brusset and Teller, 2017; Dabhilkar et al., 2016) because companies need to make real-time adjustments as disruption strikes. In this study, we propose such dynamic resilience capability may not have to rest within the company but can also be found at its suppliers.

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), which would typically impede performance (Hendricks and Singhal, 2005). Irrespective of the supplier's capability to respond and recover, its capability to *detect* disruptions enables an early recognition of the event in the supply chain, theoretically allowing network partners to take timely actions if informed. Its capability to *respond* should help to avoid the propagation of a disruption to the downstream buying firm if suppliers choose to stop their propagation. Finally, any disruptive event is likely to have some negative implications for the supplier's operational performance (Sheffi and Rice Jr., 2005). The subsequent effect on the buying firm is yet likely to be curtailed by the supplier's capability to restore its capabilities (Hu et al., 2012), i.e. *recover* from a disruptive event.

Hence, we posit that increased supplier capabilities in any of these supplier resilience dimensions, would benefit the buying firm by increasing the buyer's financial resilience to the disruption. In other words, it would prevent the buying firm from experiencing negative financial performance implications i.e., financial resilience (FR). We conceptualize FR as the negative performance implication of the event's impact on the buying firm's return on asset, profits, EBIT and firm valuation. Therefore, we propose:

Hypothesis 2: The negative impact of disruptive events in the supply chain on the buyer's **financial resilience** is curtailed 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.

2.3 Moderating role of buyer–supplier social bonding

In the third set of hypotheses, a moderating role stemming from the exchange theoretical construct of social bonding (SoBo) between the buying firm and its supplying firms is postulated. It refers to those bonds between companies that are mainly trust-based and do not primarily rest on legal agreements or market power. Durach and Machuca (2018) used the term informal governance. Others, like Kaufmann and Carter (2006), spoke of trust, relational satisfaction and the commitment to fulfill relationship specific obligations and expectations. The level of social bonding between companies is commonly understood as the quality of the relationship. The greater the social bonds, the greater the likelihood of conforming to the other party's expectations (Sims, 2002).

In the present context, social bonds develop gradually as supply chain partners better understand each other's idiosyncrasies over time as they repeatedly interact 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 (Altman, 1973). The disruption management literature has often drawn direct links between the relational closeness of a buyer with its suppliers and the buyer's resilience, framing communication practices as an enabler for buyers (Wieland and Wallenburg, 2013). In qualitative studies, social bonds have been proposed as an effective lever when it comes to sourcing resilience capability from a supplying firm (Johnson et al., 2013; Scholten and Schilder, 2015).

Social bonds drive business partners toward using their capabilities to the other's benefit (Cropanzano and Mitchell, 2005). In other words, we postulate that only if social bonds between partners are strong, can the supplier's capability to detect, respond and recover be fully leveraged by the buyer. The supplier's capability to *detect* disruptions can be leveraged by the buyer through social bonds that are reflected in openly addressing potential problems as soon as they arise, allowing for the buyer to react and curtail financial implications (Scholten and Schilder, 2015). The supplier's capability to detect disruptive events early is more likely to be beneficial to the buying firm when social bonds are strong and open exchange of problems is common practice. The supplier's capability to *respond* to disruptive events has been suggested to dampen the downstream rippling effect of the event. With respect to this relationship, the supplier is more likely to prevent the event from propagating to the buying firm if social bonds are strong, as partners with strong social bonds seek to avoid putting their relationship at risk (Johnson et al., 2013). The *recovery* phase from a disruption is typically said not to be a discrete function in which operations are either down or up. It has, instead, been described as a continuous process in which the affected company gradually recovers from the impeding situation (Sheffi and Rice Jr., 2005). During this phase, preferred customers are likely to see a faster restoration of their supply than others. The social bonds between suppliers and buyer are thereby indicative of the potential preference and prioritization the supplier takes during its restoration, as it seeks to maintain good relationships. Therefore, we propose:

Hypothesis 3: Social bonding between a buyer and a supplier positively moderates the relationship between the supplier's capability to

- **Hypothesis 3$_{(a)}$: … detect** disruptive events
- **Hypothesis 3$_{(b)}$: … respond** to disruptive events
- **Hypothesis 3$_{(c)}$: … recover** from disruptive events

…and the buyer's financial resilience.

Figure 2 summarizes the above-developed hypotheses.

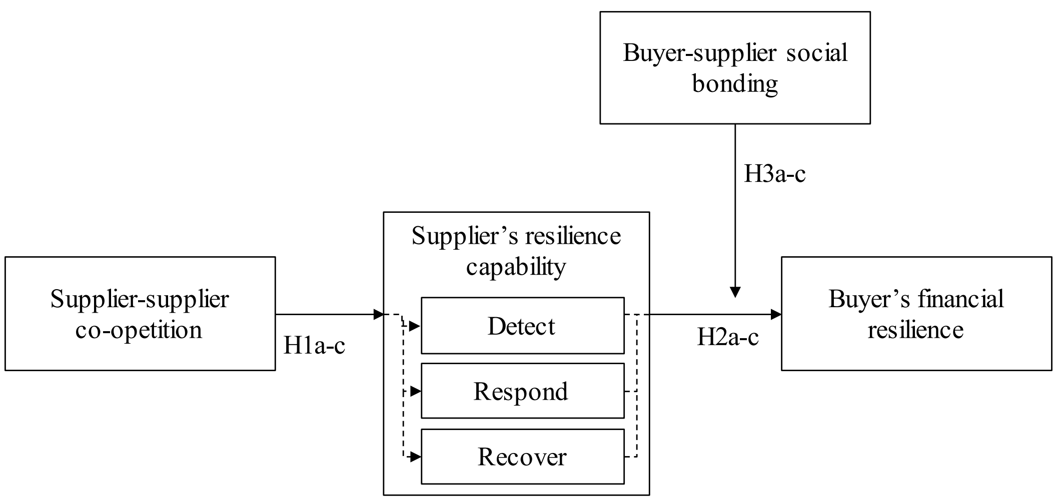

Figure 2 Proposed theoretical model

3. Methodology

3.1 Sample and triadic data collection

The hypotheses are tested by examining the data from buyer–supplier–supplier triads in Austria, Germany, and Switzerland. A random sample of 1,486 manufacturing firms with International Standard Industrial Classification codes 10–31 was identified from the list of participating firms of the 29th–33rd International Supply Chain Conferences held in Berlin, Germany; the biggest European forum for firms from all areas of manufacturing/logistics. The companies were then contacted via mail to request their participation in the project. One hundred and twenty-five companies agreed to participate with a response rate of 8%. Multiple researchers then telephoned each of the 125 companies to identify key informants—managers with responsibility for purchasing/SCM, direct experience in their company's risk management, and at least two years of work experience with the company. The key informants were then asked for the names of two suppliers, using the following criteria: (1) the two suppliers have similar production and process capabilities and technical know-how, (2) they supply non-identical parts that go into the same end product, (3) they are located in Austria, Germany, or Switzerland, (4) they use a common second-tier supplier, and (5) the sourcing relationship with this supplier had to have been ongoing for at least two years. As in Wu and Choi (2010, p. 117), "the first criterion was intended to ensure that the two suppliers being considered are competing suppliers, and the second to provide context for collaboration." The third criterion ensured a similar cultural context. The fourth criterion established our stylized tetrad, and the last criterion ensured a shared history of buyer-supplier relationship when responding to our questionnaires. At this point, 81 buyers had to be dropped from the list, mainly because their supply structure did not fit the tetradic context. The remaining

44 key informants at the buying firms completed two questionnaires—one for each of their two first-tier suppliers. All participants were assured of the confidentiality of their responses and the academic purpose of the project.

Next, all contact people at the suppliers were called to verify their knowledge of their company's links with this buyer and the second supplier. The names of the two suppliers were disclosed in the survey for cross-reference. If both named suppliers agreed to participate, they were sent a link to the survey. Data from 33 complete triads was eventually retrieved by matching 132 complete surveys (one survey per supplier, and two surveys per buyer) (Table 1) with an inclusion rate of buying firms at 2.2%. The low inclusion rates of buying firms along with the purposeful selection of their suppliers must be pointed out as a limitation of the present triadic setting that cannot simply be argued away. It remains a significant challenge to collect matching triadic data. To indicate that self-selection did at least not affect our sample of buying-firms, key firm characteristics (i.e., annual turnover, number of employees, company age, industry sector, and country of headquarters)[1] were compared across (1) responding buying-firms that filled in the survey versus responding firms that responded but could not be included and (2) responding buying-firms that filled in the survey versus those firms that did not respond at all. Welch's t-test was then conducted to compare means of the three first firm characteristics (p-values ranging from 0.120 to 0.818). Chi-square difference test on the last two firm characteristics also prompted no significant differences (p-values 0.163

[1] Secondary data on the firm characteristics "industry sector" and "number of employees" were obtained from the Thomson Reuter's EIKON Database, and company websites.

and 0.627). Based on these outcomes, no evidence for the systematic dropout/inclusion of buying-firms from the original sample was found.

Insert Table 1 about here

3.2 Measures and pre-tests

The scales were taken from previous research (see Appendix A). A questionnaire was developed in English and translated into German, and we applied the back-translation approach as outlined in Sperber et al. (1994). To assess constructs related to the occurrence of disruptive second-tier events, a vignette-based survey approach with a constant variable value vignette (CVVV) was used (Aguinis and Bradley, 2014). This approach has several methodological advantages. First, it is challenging to directly assess firms' capabilities and performance outcomes during disruptive events because these events rarely happen. Second, a variety of potential disruptive situations exist with each event, potentially triggering different firm reactions and outcomes, making it difficult to control for the particularities of the individual event. A CVVV allows for the presentation of a scenario identical across all participants, providing uniformity and strengthening internal validity and measurement reliability.

While the CVVV was taken from a real event where a common second-tier supplier defaulted, a pretest was conducted to evaluate the degree of perceived realism and validity of the vignette (Wason et al., 2002). Thirty-five graduate students with 1–7 years' work experience in

SCM/Logistics (average 2.5 years) were asked to (1) assess whether the scenarios are believable and (2) whether they could imagine themselves in the situation (seven-point Likert scale). Both questions received an average score of 5.6 and 5.7, respectively, exceeding acceptance rates reported in previous vignette studies (Hartmann and Moeller, 2014). Subsequently, the CVVV was accepted and used in the survey. All constructs in the survey are measured on a seven-point Likert scale. Descriptive statistics of our key constructs are reported in Table 2.

Insert Table 2 about here

Supplier–supplier coopetition (SSC): The construct assesses the degree of coopetition within the supplier–supplier relationship. The original measurement items of supplier–supplier coopetition by Wu et al. (2010) were used. To increase face validity, we decided not to include five items from the original 13-item construct in our questionnaire, as these items mainly assess what is “expected” in the relationship in terms of coopetition rather than what is “fact.”

Buyer–supplier social bonding (SoBo): This four-item measure refers to buyer–supplier bonds “that are mainly trust-based and do not primarily rest on legal agreements or market power” (Kaufmann and Carter, 2006, p. 658). The original three-item measure of SoBo from Kaufmann and Carter (2006) was used, and one item from Flynn et al. (1994) was added to assess the parties’ satisfaction with the relationship and to better link the construct to social exchange theory.

Suppliers' resilience capability: This construct assesses the suppliers' capability to detect, respond, and recover from a disruptive supply chain event. The CVVV presents a scenario where the two suppliers are affected by the temporal default of a common sub-supplier. The participating suppliers were asked to indicate their company's perceived capability to detect, respond, and recover from the disruptive event described in the vignette. The multi-item scales from Ambulkar et al. (2015) and Chowdhury and Quaddus (2016) were adapted to assess this construct in its three dimensions. Detection was measured with four items. Response and recovery were measured with three items each.

Buyer's financial resilience (FR): To assess the financial impact a disruptive event might have on the buying firm, the buyer was presented with the identical disruption scenario provided to the supplying firms. FR was then measured using the original three items by Chen and Paulraj (2004), considering the events impact on firm's return on asset, profits and EBIT. A fourth item was added to include an assessment of the event's impact on the firm's overall present value.

Control variables: To test the first reduced form model (i.e., the relationship between SSC and the suppliers' resilience capability), various controls were included. Industry sector was controlled for because industry dynamism may influence the supplier's capability to be resilient to disruptions and may also explain coopetition amongst suppliers (Pettit et al., 2013). Next, various firm characteristics were included, as they may impact the development of firm-level capabilities. Firm size was controlled for using the natural logarithm of the number of employees as a proxy measure (Bode and Macdonald, 2016). We controlled for the buyer's appreciation of SSC (potentially because of its expectance of the outcome) by prompting the buyer regarding how much emphasis is placed on the supplier's capacity for teamwork during supplier selection/evaluation (Wu et al., 2010). The buyer's encouragement of its suppliers to cooperate during production issues was included as a single variable to assess the buyer's involvement in its suppliers' coopetition (Wu et al., 2010). Last, supply chain position was included to account for the potentially increasing negative disruption impacts of being further upstream in the supply chain (Vilko and Hallikas, 2012).

Information regarding industry sector was collected from the company websites Thomson Reuter's EIKON Database. Firm size information was obtained directly from the suppliers and verified with secondary data. Data on the buyer's appreciation of SSC and the buyer's encouragement to cooperate were obtained from the buying firms. Information on the suppliers' supply chain position was obtained from the suppliers.

The following controls were included to estimate coefficients in the second reduced-form model (i.e., relationship between the suppliers' resilience capability and the buyer's FR). The buyer's industry sector was again included as a dummy variable, as the industry itself may explain parts of the firm's FR during disruptive events. Firm size was included, using the logit transformed number of employees of the buying firm. We obtained assessments of the buyer–supplier relational stability to take account of the number of years the said relationship has been considered stable. Assessments were obtained from both the buyer and the suppliers and averaged. We performed a natural logarithmic transformation on this variable to account for its skewed distribution. The importance of the end item under consideration was assessed using a four-item measure from Bode and Macdonald (2016). Last, we used the logarithmically transformed number of backup suppliers for each of the supplied parts as a measure for the buyer's sourcing structure for the regarded parts of the end item. The number of backup suppliers for each part may well explain the impact a disruption along this product's supply chain may have on the buying firm's FR.

3.3 Measurement models

This study employed a multiple-informant research design whenever feasible to reduce the risk of common method bias. For the first reduced-form model, the assessments of SSC were swapped between each supplier–supplier pair at the first tier. Using the SSC assessment of the other supplier in the same regression with the supplier's resilience capability helps to eliminate the risk of social desirability biased regression estimates. This approach was deemed appropriate due to an interrater agreement $r_{WG(J)}$ of 0.83 (Wagner et al., 2010). We ran a confirmatory factor analysis (CFA) to test construct validity with data obtained for each of the 66 suppliers. Following recommendations in Koufteros et al. (2009), a model with three correlated first-order factors (i.e., detect, respond, and recover) without a second-order factor for suppliers' resilience capability shows the most acceptable model fit indices (χ^2= 174.697; χ^2/df=1.398; confirmatory fit index [CFI]=0.959; Tucker–Lewis Index [TLI]=0.949; Bollen's Incremental Fit Index [IFI]= 0.960; root mean squared error of approximation [RMSEA]=0.078), given the small sample size (Marsh et al., 1988). The results overall demonstrate evidence of convergent validity.

To assess discriminant validity, the maximum shared variance (MSV) was computed for each construct and compared against the corresponding average variance extracted (AVE). The AVE of each construct was much higher than its MSV with other constructs (Wang et al., 2016). It was concluded that the measures in this model possess adequate reliability (Table 3).

Insert Table 3 apprx. here

For the second reduced-form model, information retrieved from the buyer was used to assess the buyer's FR, and the averaged assessments of SoBo from buyers and suppliers ($r_{WG(J)}$=0.93) were used to create the "buyer–supplier social bonding" construct. The CFA model with three correlated first-order factors was again determined to show the best model fit indices (χ^2=73.451; χ^2/df=1.035; [CFI]=0.996; [TLI]=0.995; [IFI]=0.996; [RMSEA]=0.023). Thus, the supplier's resilience capability is again observed with three correlated first-order factors. The assessment of discriminant validity as reported in Table 4 raised no major concerns.

Insert Table 4 apprx. here

3.4 Endogeneity and post hoc power tests

We sought to address the potential of endogeneity both in the research design phase and the data analysis phase. To reduce the potential threat of spurious correlations stemming from correlated measurement errors, we used data from different respondents to assess the independent and dependent variables, and used the mean values for the moderator.

To address the problem of omitted variables simultaneously affecting the independent and dependent variables, we sought to include such variables as controls in the estimations. Additionally, in the first reduced form model, the theoretical trajectory of the link is from SSC to supplier's resilience capability, as SSC is measured as on-going, while the supplier's resilience capability come into play after the disruptive event. Based on the literature, firm resilience is also seen as an outcome of the firm's collaboration with its network partners (Revilla and Saenz, 2017; Scholten and Schilder, 2015). We tested this assumption further by means of instrumental variable (IV) estimation (Wooldridge, 2016). The IV regression recognizes the presence of potentially omitted variables. A good instrument for the estimation needs to be exogenous in the equation (exogeneity condition) and strongly correlated with the explanatory variable (relevance condition). In the present setting, an ideal instrument for SSC is the second measure of SSC as obtained from the first-tier supplier (we refer to this as SSC*). Because it is SSC that affects the resilience capability of the supplier, it is natural to assume that SSC* is uncorrelated with the error of the dependent variable. SSC* is also relevant, as it is positively ($p<0.001$) and strongly ($\beta=0.64$) correlated with SSC. We thus used SSC* in a 2-stage-least square (2SLS) estimation (with small sample correction) along with all control variables to instrument SSC and predict the three dimensions of supplier's resilience capability. The IV and OLS estimates were compared subsequent to the IV estimation. The directions as well as the sizes of coefficients were practically not different. We then conducted the Wu-Hausman test for endogeneity of SSC with each dimension of resilience. Tests were supportive of the assumption of exogeneity of SSC, as the null of the tests cannot be accepted (p-values 0.124, 0.761 and 0.830) despite the strong instrument. As 2SLS estimators are less efficient than OLS estimators when the explanatory variable is exogenous, we decided to use OLS regression in our subsequent analyses of the data (Wooldridge 2008).

For the second reduced form model a strong theoretical argument can be made for the absence of simultaneity. As it has been shown, the buyer's FR is an outcome of its suppliers' capabilities to manage the event (Dyer and Hatch, 2006; Lavie, 2006; Pulles et al., 2014). In other words, the suppliers' resilience capability has been submitted as a precursor for the buyer's FR during the event. This literature helps us to establish confidence in the trajectory of our link. In addition, all potentially omitted variables were sought to be included in the model. However, it must be acknowledged that the possibility of omitted variable bias cannot be completely ruled out for the second reduced form model, as we could only identify weak instruments from the data, rendering IV estimation impracticable. That is, while we are confident that omitted variable bias does not majorly bias these estimates, it cannot be ruled out either.

Finally, as discussed, the country, industry selection and the requirement for triads in a certain tetradic context all limited our sample size. This may give rise to the issue of whether undetected phenomena could be attributed to the sample size. Post hoc power tests were therefore conducted both for the first reduced-form model (with models 2a and 2b; Table 5) as well as for the second reduced-form model (with models 4a, 4b and 4c; Table 6) with 15 independent variables and sample sizes of 66 each using Gpower. Power (1-β err prob) was estimated to be at least 0.954 for both reduced-form models, signifying a low chance of a type II error (Beuckelaer and Wagner, 2012).

4. Results

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

Testing of the study hypotheses was based on the 132 surveys that were matched to create 33 triads. To test the effect of supplier–supplier coopetition on suppliers' resilience capability (H1) we used the matched information that was obtained from the surveys of the 66 suppliers, employing seemingly unrelated multiple regression (SUR). SUR allowed combining the three dimensions of suppliers' resilience capability into one model, alleviating potential risks for multiple testing errors stemming from running separate regressions. SUR assumes the dependent variables are theoretically unrelated, but their error terms are not (a reasonable assumption in this study, as all construct dimensions are collected from the same suppliers). The variables were entered block-wise. Confidence intervals of coefficient estimates indicated no multicollinearity issues (O'brien, 2007) (all VIF < 2.25). Table 5 presents the results using standardized regression estimates with t-values in brackets.

Models 1a, 1b, and 1c use the control variables to provide a baseline model. Models 2a, 2b, and 2c include the three dimensions of suppliers' resilience capability. Buyer's encouragement to cooperate shows significance across all models. It is negatively related to the supplier's resilience capability during the disruption. Corroborating findings reported in the triad study of Wu et al. (2010), who found that increasing cooperation between suppliers (pressured by the buying firm) reduces suppliers' overall performance.

$H1_{(a)}$ postulated a positive effect of SSC on the detecting phase of suppliers' resilience capability. The observed coefficient of SSC on the suppliers' detection capability is positive and significant ($\beta=0.261$, $p<0.05$). The R-square change from the baseline model was significant ($\Delta R^2=0.062$, $p < 0.05$), thus supporting $H1_{(a)}$.

$H1_{(b)}$ 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 (ΔR^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. Therefore, this hypothesis is rejected (β=0.165, p=0.172).

Insert Table 5 about here

4.2 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. A model that included all three correlated resilience dimension (see Table 4) simultaneously prompted large confidence intervals and small t-values, providing indication of multicollinearity (O'brien, 2007). As a treatment, each dimension and its interaction terms with SoBo was entered separately and removed before the next dimension and interaction was included. For further examination of multicollinearity and the potential implications of our treatment on the stability of our estimates, see Appendix B.

Table 6 presents the results. Model 1, the baseline model, shows significant improvement relative to the null model; models 2b and 3b are the main effect models ($H2_{(a-c)}$), and models 4 are the moderation models ($H3_{(a-c)}$). We see that the control of "end-item importance" has a negative influence on the buyer's financial resilience across all models, suggesting that the importance of an item to the buyer increases the negative financial implications a supply disruption of that item has on the buyer. This logic of this finding bolsters the accuracy of the directions of the observed coefficients.

H2 proposed the buyer's FR during disruptive events to be supported by the suppliers' capability to detect, respond, and recover from disruptive events. The results indicate all three phases, detection (β=-0.242, $p<0.05$), response (β=-0.227, $p<0.05$), and recovery (β=-0.25, $p<0.05$), have a significant impact on buyer's FR, with all R-square changes from the baseline model being significant ($p<0.05$). However, contrary to $H2_{(a-c)}$, the significant coefficients are negative, indicating the suppliers' resilience capability does not help the buyer to safeguard its FR but rather the contrary.

Insert Table 6 about here

SoBo's moderating effect on the relationship between the three phases of the suppliers' resilience capability and the buyer's FR is assessed and presented in Models 4a, 4b, and 4c (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 FR (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 FR of the buyer.

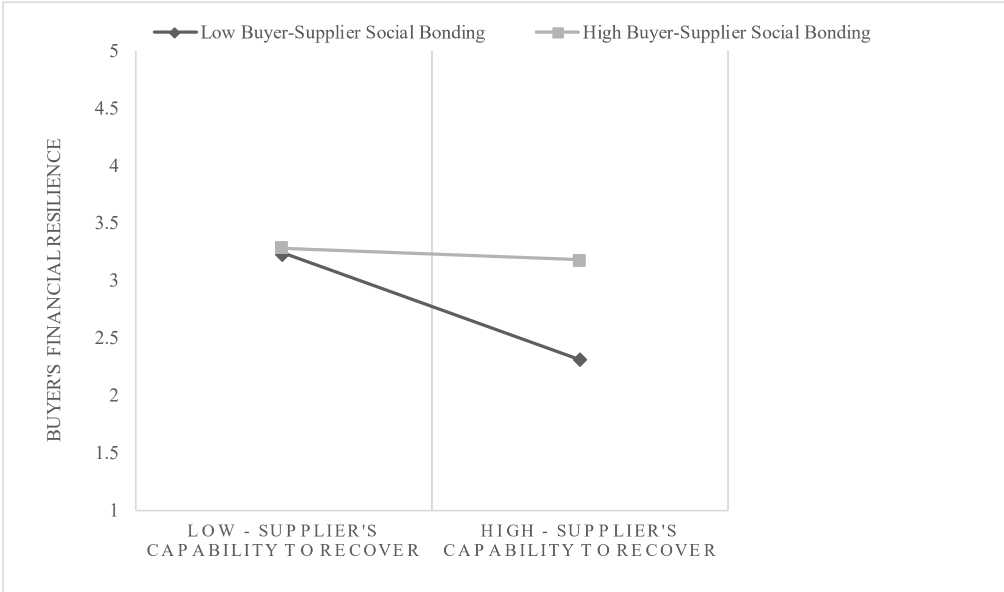

Figure 3 Interaction moderation H3$_{(c)}$

5. Discussion

This paper was set out to provide answer to the following research questions: (1) Does supplier–supplier coopetition lead to first-tier supplier resilience when facing a disruption from a common second-tier supplier? (2) Does supplier resilience increase the buyer's financial resilience to the disruption? And, (3) do increasing social bonds between buyers and suppliers help buyers to benefit from their first-tier supplier's resilience? To explore these complex questions, we isolated the locus of supplier resilience capability from supply disruption, and created a multi-tier, tetradic context in this study. The findings confirm that co-opetition between two first-tier suppliers increases the first-tier supplier's capability to detect and respond to disruptive events coming from a lower tier source. However, the first-tier supplier's resilience capability does not help the buyer safeguard its performance during disruptive events. In fact, it affects negatively. When we apply the theory of social exchange, we see that with increasing buyer–supplier social bonds, the negative relationship between the first-tier supplier's resilience capability and the buyer's financial performance can partly be alleviated.

Theoretical implications

A supplier–supplier coopetitive relationship increases the supplier resilience capability at the first-tier supplier level, in terms of its capability to detect and respond to the depicted disruption scenario. By extension, the supplier–supplier relationship should increase the buyer's resilience. The common theoretical disposition is that the buying firm can draw on the suppliers' resilience as a capability when supply chain disruption strikes. Ironically, however, the results indicate supplier resilience capability negatively affects the buyer, impeding its FR during the disruption. In other words, in contrast to the initial theorization (see H2), when the disruption comes from the second-tier supplier, the supplier resilience capability grounded in the supplier–supplier relationship gets in the way of the buyer's ability to overcome the impending situation.

A partial answer to this puzzling observation may lie in how differently suppliers with low and high resilience capabilities react to the particular disruption scenario. According to the results, supplier resilience capability with respect to its coopetiting supplier at the first-tier level is not helping but keeping the supplier back from doing its job for the buyer. While speculation, we posit that resilient suppliers in this particular disruption scenario may choose to "bridge" the problem, rather than "buffering" the propagation (Bode et al., 2011). Firm reactions have been argued to be strongly linked to the managers' perception of a particular risk. For example, Vanpoucke and Scott (2020) found that buyers respond to events that are perceived to be more likely with buffer- and process-oriented risk mitigation. This suggests that when risks are generally less likely, such as the imminent risk event used in our vignette, suppliers may prepare and respond with bridging, which then passes the problem on to buyers. More to the point, Manhart *et al.* (2020) recently argued that a bridging strategy, as opposed to buffering strategies, has a significant and strong positive effect on a firm's resilience, suggesting that only firms that choose bridging also achieve organizational resilience. Bridging can be facilitated through organizational agility and builds on a firm's external ties (Manhart *et al.*, 2020). This includes integrational practices that allow firms to quickly anticipate supply side risks. Bridging is enabled by close relationships, monitoring, cooperation and exchange information with supply chain partners. If buying firms are not part of this relational and cooperative network, they seem to become the victim of their suppliers' resilience. The goal of a buyer should thus be to become a part of this relational network, in order to benefit from its capabilities. In this regard, in the analysis of H3 the recovery dimension of the supplier resilience capability provides interesting insights. Evidence suggests that buyer–supplier social bonding can help the buyer to hamper the negative relationship between its financial resilience and its supplier's recovery capability. This finding advances social exchange theory in the supply chain context, providing indications that social bonds can influence suppliers' allocation decisions in the event of disruptions.

The present study setting further contributes to our understanding of supply networks as complex adaptive systems. The results again show that supply networks are complex and dynamic, such that a supplier makes allocation decisions that are outside a buyer's direct control (Choi *et al.*, 2001). We thereby provide a direct response to Zhao et al. (2019) who pointed out research with a focus “on the propagation of disruptions and the effect of adaptive behaviors during propagation [is] lacking in the literature” (p. 193).

Additionally, 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, while 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.

The present study contributes and extends three literature stream, First, the triad literature (e.g., Madhavan et al., 2004; Wu et al., 2010) 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 context, 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 (e.g., Cropanzano and Mitchell, 2005; Griffith et al., 2006) is extended by showing the basic forms of interaction of four partners in a supply chain disruption scenario. It is shown that while the horizontal supply chain partners seem to decide to exchange to better detect and respond to a disruption, their mutual support ends when it comes to recovery. In addition, it is shown how social bonding between the buyer and supplier moderates aspects of the supplier resilience capability at the first-tier level and its performance implications. This is also supports the wealth of literature which has shown that cooperation and close social bonds between suppliers (and even competitors) are beneficial to the supply chain (e.g., Cao and Zang, 2011; Dyer and Hatch, 2004).

Finally, the disruption literature is extended (e.g., Ambulkar *et al.*, 2015; Revilla and Saenz, 2017) by theorizing the supplier resilience capability in the supplier–supplier coopetitive relationship context. It was conceptualized that at least part of the buyer's resilience capability would reside in its supply base, in this case supplier–supplier coopetition, incorporating the perspectives of multiple network partners. The network perspective in this paper allowed providing a more holistic and a more realistic perspective on risk management in a supply chain context. The findings support suggestions in the recent study by Sà et al. (2019), where the authors pointed out that the sum of the resilience capabilities of each supply chain member is not equivalent to the whole resilience of the chain. We find that resilience of suppliers does not necessarily aid the resilience of buyers. The dynamics are much more complex; for instance, social bonding affects how the resilience of suppliers affects that of the buyer's. Researchers and practitioners alike have stressed the importance of a network perspective (Choi and Wu, 2009; Durach et al., 2017). This study has followed this premise in its theorization and methodological design.

5.1 Managerial implications

Our study makes a case for the practitioners about the importance of supply network mapping. We had initially theorized that as a buying company they could rely on their first-tier suppliers to work together to help them when a disruption occurs. However, what we have learned is that these suppliers tend to bridge the propagation of the disruption rather than buffer it. They are keener on taking advantage of the coopetitive relationship with the other supplier to increase their own resilience, and they appear to be not as concerned about helping the buyer attain financial resilience. What that means is that the buyer is on its own when it comes to gaining resilience during a disruption. In other words, the buyer is on its own and needs to monitor its supply chain and be aware of a disruption in the upstream of its supply chain as soon as it happens. The only way this can happen is if the buyer has done the supply network mapping and monitors critical suppliers. In our case, the second-tier supplier common to both first-tier suppliers would be that critical supplier with high outdegree centrality—one that assume a high "demand load" (Kim *et al.*, 2011). These critical suppliers can be identified by conducting a network structural analysis (Shao *et al.*, 2018), which is possible only after the buyer has done the mapping of its supply networks.

Ultimately, we have only begun to understand 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 into a network context by providing insights that facilitate our understanding of how suppliers benefit from horizontal collaborations and how buyers should interpret the implications of this.

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 exceptional situations such as a disruption from an upstream supplier. This study has apparently come across one of these downsides. 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, may impede the buyer's FR during the disruptive event, unless the buyer manages to become part of the supplier's relational network.

6. Conclusion

The study has shown that in a triadic setup two first-tier suppliers with common capabilities and joint interests benefit from their coopetitive behavior in that they become more resilient during a disruption emanating from 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.

Part of the explanation for these contradictory findings may arise from a more realistic setup of the present study. To the best of our knowledge, this study is the first to use CVVV in order to reduce the impact of confounding sources of variability in respondents' answers.

In order 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, due to the particular characteristics of the study the sample size, though comparable to other studies (Chen et al., 2007;

Wu et al., 2010), was limited to 33 triads or a total of 66 observations per regression model. Power analyses yet suggest that both models are well within recommended statistical power levels.

Secondly, it could not definitively be proven that endogeneity does not affect the second reduced-form model in this study. However, considering the study setting and analyses, as well as prior theoretical findings, confidence is established in the results. Parts of this limitation could be alleviated by future research relaxing some of the study setup criteria to increase response rates and help in identifying an effective instrument.

Finally, single respondents were used from each firm to make inferences about several of the study's constructs. While these respondents are considered key informants, they ultimately represent a single source of subjective information. Consensus among the informants on inter-organizational constructs (e.g. SSC or SOBO) indicated by $r_{WG(J)}$ scores supported their judgements of the organizational constructs. In addition, comparing our instrumental variable estimates with regression results showed no practical differences, alleviating concerns for measurement error in the explanatory variable.

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Appendix A – Survey Items

Supplier-supplier coopetition (collected from first-tier suppliers)

Source: adapted from Wu *et al.* (2010)

Scale: (1=strongly agree – 7=strongly disagree)

1. [__] and our company advise each other of any potential problems in the supply base.
2. [__] and our company advise each other of any potential problems in meeting the buyer’s needs.
3. Exchange of information between our two companies occurs frequently.
4. Exchange of information between our two companies occurs informally.
5. Problems that arise in the course of our relationship with [__] are treated by our two companies as joint rather than individual responsibilities.

6. Our two companies do not mind owing each other favors.
7. The responsibility for making sure that the relationship works for our two companies is shared jointly.
8. [__] and our company help each other with ideas, problem solving, costs etc.

Suppliers' resilience capability (collected from first-tier suppliers)

CVVV: "At 11:00 pm on a Saturday night in late August, a fire hits the production facilities of a supplier that is common to you and firm [__]. You consider the supplier a key supplier as it supplies critical parts that go into your product for buyer [__]. The fire, caused by a faulty electrical outlet and the lack of safety features at the supplier (i.e., fire detection and suppression systems), spread across the entire plant. Consequently, the supplier will be down for at least five months."

Considering this scenario, where you and firm [__] are affected by the default of a supplier that was used by both of you, please assess your capability to respond to this event:

Source: adapted from Ambulkar et al. (2015) and Chowdhury and Quaddus (2016)

Scale: (1=strongly agree – 7=strongly disagree)

Detect

1. We share risk information with supply chain partners.
2. We continuously monitor developments that might promote this event.
3. We have processes in place to detect this event early.
4. We have a high institutional awareness.

Respond

1. We would be able to respond quickly to this event.
2. We would be able to respond effectively to this event.
3. We could undertake an adequate response to this event.

Recover

Considering your post-event performance:

1. It would be easy for us to absorb the loss.

2. We would easily restore normal material flow.
3. We would be able to recover to our original state easily.

Buyer's financial performance (collected from buyers)

CVVV: "It is 6:00 am on a Monday morning in late August when you receive mail from your two suppliers informing you that one of their common critical sub-suppliers was severely hit by a fire. The sub-supplier is a key sub-supplier, as it delivers critical parts that go into the products that these suppliers supply to you. You are told that the sub-supplier will be down for at least five months."

If such a disruptive event affected this supplier, how would this event, at the second-tier supplier in your supply chain affect your firm in terms of the following performance dimensions (considering your knowledge about the two suppliers' capability to work together).

Source: Chen and Paulraj (2004)

Scale: (1=severe negative impact; 7=no impact)

1. Return on investment
2. Profits as a percent of sales
3. Firm's net income before tax
4. Present value of firm

Social bonding (collected from first-tier suppliers and buyers)

Source: adapted from Kaufmann and Carter (2006)

Scale: (1=strongly agree – 7=strongly disagree)

1. We are satisfied with this relationship.
2. The [buyer/supplier] openly addresses problems when they arise.
3. The [buyer/supplier] treats us fairly and honestly.
4. We do our utmost not to put this supply relationship at risk.

End-item importance (collected from buyers)

Source: Bode and Macdonald (2016)

Scale: (seven-point Likert scale)

- Please characterize the main item purchased from this supplier in terms of the following dimensions:

1. Low profit impact–High profit impact
2. Uncritical to our operations–Critical to our operations
3. Unimportant for us–Important for us
4. Low priority for us–High priority for us

Relational Stability (collected from first-tier suppliers and buyers)

- For how long do you think this relationship has been stable? [years]

Buyer's appreciation of supplier–supplier cooperation (collected from buyers)

Source: Wu et al. (2010)

Scale: (1=strongly agree – 7=strongly disagree)

1. Supplier A and Supplier B's ability to work as a team is an important supplier evaluation/selection criterion.

Buyer's encouragement to cooperate during production issues (collected from buyers)

Source: Wu et al. (2010)

Scale: (1=strongly agree – 7=strongly disagree)

1. We encourage Supplier A and Supplier B to help each other out if they encounter production problems.

Sourcing structure (collected from buyers)

1. How many direct suppliers do you have for this main item?

Supply chain position (collected from buyers)

Source: Bode and Wagner (2015)

If comparing your firm to an automotive supply chain, which of the following would be your supply chain position?

1. OEM/Final product manufacturer" ("far downstream")
2. …
3. …
4. Fourth-tier supplier of raw material" ("far upstream")

Appendix B – Examination of multicollinearity and potential implications

Multicollinear predictors in multiple regression may create a model that is sensitive to slight variation in the data. This can cause erratic changes in the coefficient estimates (Farrar and Glauber, 1967). In the present study, multicollinearity was indicated by significant correlation values above 0.4 (Table 5) between the three dimensions of resilience capability, large confidence intervals, small t-values and, as a rule of thumb, VIF exceeding 3.5 (O'brien, 2007). Dropping collinear variables would be an accepted remedy, yet the approach calls for caution. By dropping variables, we lose information which may result in biased coefficient estimates for the remaining variables. Therefore, we opted for checking the robustness of the study results (Table 6), by calculating a model with suppliers' resilience capability (SupResCap) as a second-order factor (Table 7). As this factor includes all three dimensions of resilience, it is stripped off multicollinearity concerns. This may help to find indications of whether coefficients in Table 6 are biased to a degree that may affect their direction. Results yet remain significant, with negative and similarly strong values.

Insert Table 7 about here

Table 1 Sample information for buying firms (n=33) and supplying firms (n=66)

Buying firms							
Number of Employees	Count		Revenue (in 1,000,000 €)	Count		Industry Sector	Count
≤ 10	0		≤ 10	3		ISIC 10	1
11–50	0		11–50	9		ISIC 11	1
51–250	8		51–250	5		ISIC 17	1
251–500	3		251–500	2		ISIC 20	7
501–2000	15		501–2000	4		ISIC 22	3
2001–5000	2		2001–5000	9		ISIC 24	4
> 5000	5		> 5000	1		ISIC 25	1
						ISIC 28	10
						ISIC 29	5
Supplying firms							
Number of Employees	Count		Revenue (in 1,000,000 €)	Count		Industry Sector	Count
≤ 10	3		≤ 10	11		ISIC 10	2
11–50	15		11–50	17		ISIC 17	6
51–250	15		51–250	8		ISIC 20	5
251–500	3		251–500	7		ISIC 22	1
501–2000	10		501–2000	9		ISIC 24	7
2001–5000	8		2001–5000	3		ISIC 25	7
> 5000	12		> 5000	11		ISIC 26	3
						ISIC 27	13
						ISIC 28	12
						ISIC 31	5
						ISIC 32	5

Table 2 Descriptive statistics of construct measures

	Mean	STD	Min	Max
FR	4.27	1.81	1	7
Detect	4.09	1.49	1.1	6.5
Respond	5.31	1.15	2.1	6.8
Recover	4.66	1.39	1.4	6.8
SSC	2.25	1.63	1.0	6.55

Table 3 Correlation of constructs (first reduced-form model)

	AVE	MSV	Recover	SSC	Respond	Detect

Recover	0.740	0.590	0.860			
SSC	0.769	0.058	0.148	0.877		
Respond	0.811	0.590	0.768***	0.241	0.900	
Detect	0.686	0.391	0.433**	0.232	0.625***	0.828

Notes: Square root of the AVE depicted on the diagonal; construct correlations (two-tailed), *p<0.07 (marginal); **p<0.05; ***p<0.001.

Table 4 Correlation of constructs (second reduced-form model)

	AVE	MSV	Recover	SoBo	Respond	Detect
Recover	0.738	0.588	0.859			
SoBo	0.555	0.063	0.251	0.745		
Respond	0.811	0.588	0.767***	0.126	0.900	
Detect	0.685	0.389	0.431***	0.012	0.624***	0.828

Notes: Square root of the AVE depicted on the diagonal; construct correlations (two-tailed), *p<0.07 (marginal);

**p<0.05; ***p<0.001.

Table 5 First reduced-form models (H1): Seemingly unrelated regressions (n=66; suppliers and their links to the second supplier)

Variables	**Detect ($H1_{(a)}$)**		**Respond ($H1_{(b)}$)**		**Recover ($H1_{(c)}$)**	
	Model 1a	Model 2a	Model 1b	Model 2b	Model 1c	Model 2c
Independent Variables[1]	β (t)	β (t)	β (t)	β (t)	β (t)	β (t)
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	0.076 (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 ($H1_{(a, b, c)}$)		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

[1]industry sectors were included as dummy variables but not reported

Table 6 Second reduced-form models (H2, H3): Multiple moderated regressions (n=66; all links between buyers and suppliers)

Variables	Buyer's FR									
	Model 1 a, b, c	Model 2a	Model 3a	Model 4a	Model 2b	Model 3b	Model 4b	Model 2c	Model 3c	Model 4c
Independent Variables[1]	β (t)	β (t)	β (t)	β (t)	β (t)	β (t)	β (t)	β (t)	β (t)	β (t)
End-Item Importance	-0.457 (-3,343)**	-0,434 (-3,382)**	-0.437 (-3.388)**	-0.451 (3.394)**	-0.465 (- 3.585)***	-0.470 (- 3.635)***	-0.469 (- 3.608)***	-0.480 (- 3.704)***	-0.488 (-3.802)***	-0.434 (- 3.369)***
Buyer–Supplier Relation. Stability	-0.197 (-1.648)	-0.210 (-1.818)	-0.230 (-1.926)*	-2.12 (-1.691)	-0.208 (-1.778)**	-0.243 (-2.021)**	-0.234 (-1.922)*	-0.239 (-2.350)**	-0.287 (-2.356)**	-0.305 (-2.557)**
Buyer's Firm Size	-0.261 (-1.852)*	-0.288 (-2.118)**	-0.262 (-1.847)	-0.264 (1.849)*	-0.267 (-1.942)*	-0.224 (-1.584)	-0.234 (-1.634)	-0.332 (-2.350)**	-0.291 (-2.039)**	-0.313 (-2.238)**
Sourcing Structure	0.033 (0.235)	0.089 (0.653)	0.079 (0.568)	0.065 (0.456)	0.012 (0.09)	-0.005 (-0.035)	0.009 (0.067)	0.035 (0.259)	0.017 (0.127)	0.091 (0.661)
SoBo			0.076 (0.712)	0.067 (0.616)		0.12 (1.184)			0.154 (1.414)	0.228 (2.010)**
Detect ($H2_{(a. b)}$)		-0.250 (-2.248)**	-0.242 (-2.161)**	-0.250 (-2.195)**						
Respond ($H2_{(a. b)}$)					-0.209 (-1.892)*	-0.227 (-2.043)**	-0.226 (-2.021)**			
Recover ($H2_{(a. b)}$)								-0.223 (-2.034)**	-0.245 (-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	9.263 (7.270)***	9.269 (7.553)***	9.194 (7.428)***	9.274 (7.378)***	9.609 (7.644)***	0.9513 (7.581)***	9.463 (7.486)***	10.132 (7.740)***	10.117 (7.803)***	9.760 (7.620)***
R^2	0.487	0.533	0.538	0.540	0.521	0.534	0.538	0.526	0.544	0.574
ΔR^2	0.487***	0.046**	0.005	0.002	0.034*	0.013	0.004	0.038**	0.018	0.030*
ΔF	4.116	5.053	0.507	0.257	3.578	1.402	0.444	4.136	1.998	3.420

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

[1]industry sectors were included as dummy variables but not reported

Table 7 Addition to Table 6–Suppliers' Resilience Capability as a Second-Order Factor: Multiple moderated regressions
(n=66; all links between buyers and suppliers)

Variables	Buyer's FR			
	Model 1	Model 2	Model 3	Model 4
Independent Variables	β (t)	β (t)	β (t)	β (t)
Buyer Industry Sector[1]	-	-	-	-
End-Item Importance	-0.457 (-3.439)**	-0.465 (-3.620)***	-0.470 (-3.673)***	-0.446 (-3.369)***
Buyer–Supplier Relational Stability	-0.197 (1.648)	-0.221 (-1.903)*	-0.258 (-2.156)**	-0.247 (-2.054)**
Buyer's Firm Size	-0.261 (-1.852)*	-0.284 (-2.0825)**	-0.242 (-1.726)	-0.256 (-1.810)
Sourcing Structure	0.33 (0.235)	0.023 (0.167)	0.006 (0.046)	0.025 (0.183)
SoBo			0.130 (1.220)	0.142 (1.318)
SupResCap		-0.238 (-2.164)**	-0.256 (-2.371)**	-0.257 (-2.326)**
SupResCap_x_SoBo				0.092 (0.916)
Intercept	9.263	11.734	11.789	11.745
R^2	0.487	0.530	0.544	0.552
ΔR^2	0.487	0.043	0.14	0.008
ΔF	4.116***	4.685**	1.488	0.839

*p<0.07 (marginal); **p<0.05;***p<0.001
[1]industry sectors were included as dummy variables but not reported