Barriers to multi-tier supply chain risk management

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Abstract

Purpose – Multi-tier supply chain risk management (MSCRM) is an evolving and dynamic field, as any defaults or glitches in supply chains can potentially harm the efficiency and competitiveness of the entire supply chain. This study aims to investigate barriers to MSCRM in the automotive and civil aircraft industries.

Design/methodology/approach – This study adopts an inductive case study research design. The case analysis includes two parts. First, the within-case analysis develops case profiles and identifies critical categories. Second, the cross-case analysis compares MSCRM patterns across the cases.

Findings – This study argues that narrow information sharing and communication covering only the immediate supply chain partners obstruct the efficiency of MSCRM. Similarly, high dependency on strategic alliances with suppliers hinders efficient MSCRM. Additionally, relying on information and communication technologies (ICT) increases companies’ exposure to risks and poses another barrier to efficient MSCRM.

Research limitations/implications – Further research should be pursued to expand generalizability and test the validity of the findings using other forms of data collection and methodologies, such as large-scale surveys, experiments or secondary data across different sectors and typical supply networks.

Practical implications – This study provides empirical evidence on the obstacles faced by companies during the process of MSCRM. These findings can guide practitioners in developing initiatives to overcome these challenges.

Originality/value – This study is among the first to investigate the barriers to MSCRM in the automotive and civil aircraft industries using in-depth case studies across three tiers of the supply chain.

Keywords Supply risk management, Multi-tier supply chain management, Barriers, Case studies, Automotive industry, Civil aircraft industry

Paper type Research paper

1. Introduction

In an unpredictable and rapidly changing world, no single company or its supply chain is a risk-free island (Håkansson and Snehota, 1989). The recent outbreak of the COVID-19 and the resulting number of supply chain disruptions worldwide has illustrated the vulnerability of today’s disaggregated and globalized value creation. Much of the literature to date on supply risk (Kraljic, 1983; Ellram, 1991; Smeltzer and Siferd, 1998; Zsidisin et al., 2000, 2004; Zsidisin, 2003; Zsidisin and Smith, 2005) and supply chain risk (Juettner et al., 2003; Christopher and Lee, 2004; Kleindorfer and Saad, 2005; Tang, 2006; Manuj and Mentzer, 2008a, 2008b; Tang and Musa, 2011) has improved our understanding of the underlying phenomena. However, our practical knowledge of multi-tier supply chain risk and its managerial counterpart multi-tier supply chain risk management (MSCRM) is still in its infancy and needs substantive investigation (Juettner, 2005; Rao and Goldsby, 2009; Sodhi et al., 2012; Wang et al., 2016a, b). Several past studies have examined supply chain risk in a dyadic relationship. Critics have argued that studies based on dyadic relationships do not capture the multiple, discrete and interdependent interactions that simultaneously exist along the supply chain (Borgatti and Li, 2009; Choi and Wu, 2009a, b; Rowley, 1997; Kull and Closs, 2008). Examining risks beyond

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the immediate dyadic buyer-supplier level but on the multi-tier inter-organizational level is a cornerstone for understanding supply chain risk at numerous inter- and intra-organizational levels (Zsidisin, 2003; Sawik, 2019).

Given this identified research gap, in the present study, we investigate the supply chain risk and supply chain risk management of the three-tier supply system in the automotive and the civil aircraft industries. We chose the automotive and aircraft industries because they are interlocked business domains with a multi-tier supply system (MSS). We focused on the triadic relationship because of two significant reasons. First, as the context of a supply chain is very complex, it gets tough and expensive to gain access and to measure supply chain dynamics and the risk exposure of a supplier’s supplier (Halinen et al., 1999; Harland et al., 2003). Second, a triad is considered the smallest unit of a network which makes it a suitable approach multi-tier supply chains (Choi and Wu, 2009a; Mena et al., 2013).

The purpose of this study is to gain insights into three research questions: (1) What is multi-tier supply chain risk? (2) How is multi-tier supply chain risk managed in the automotive and the civil aircraft industries? (3) What are the barriers to multi-tier supply chain risk management? The remainder of this study is structured as follows: First, a literature review is conducted to outline the research gap and manifest our motivation to conduct this study. Suggested by an inductive approach, the literature review is not used to define themes and hypotheses (Mena et al., 2013). Second, the methodology of the study is explained, which includes the case selection, data collection and data analysis. Next, the results of the analysis and the resulting propositions are elaborated on. Conclusions, limitations and avenues for future research are presented in the final section.

2. Literature review
Since the beginning of the 2000s, studies focused on supply chain risk as a linear series of interconnected companies at the level of the dyad (Zsidisin et al., 2000; Svensson, 2004; Giunipero et al., 2006; Tomlin and Wang, 2010). A dyadic buyer-supplier relationship within a supply chain is made up of a buyer, a supplier and the link that connects them (Choi and Wu, 2009a). While relationships are the building blocks of chains and networks, two links do not make a chain (Harland, 1996a). The supply chain is more like a tree with a multitude of branches and a complex root system that all work together to transform raw material to products delivered to customers (Christopher and Peck, 2004; Mentzer et al., 2001). Risk is inherent in every link within a company’s supply chain and may create a rippling effect on any other tier in its supply chain (Lee et al., 1997; Norrman and Jansson, 2004). Although a supply risk might start with a single direct supplier, the risk can be adequately addressed only in a broader relationship context. The company must, therefore, identify not only the direct risks to its operations but also the devastating rippling effects caused by disasters or minor business glitches at every significant link along the end-to-end supply chain (Norrman and Jansson, 2004; Rao and Goldsby, 2009). For example, Honda articulates that its second- and third-tier suppliers do not merely make parts, but they are making a Honda (Choi and Krause, 2006). However, MSCRM is often simplified as the immediate supplier risk management with narrow arcs of integration of the multi-tier suppliers (Frohlich and Westbrook, 2001; Wang et al., 2013; Ang et al., 2016). As the dyadic approach simplifies the industrial context by eschewing the realistic environment such as multi-tier supply chains with multiple products, it compromises the external validity of the results and does not capture the intrinsic complexity and interconnectedness of a supply chain (Rowley, 1997; Sahin and Robinson, 2002; Choi and Wu, 2009a, b).

To better investigate the complex supply chain relationships and the discrete nature of supply chain risks (Kull and Closs, 2008), some researchers adopted a network perspective (e.g. Christopher, 1992; Harland, 1996b; Harland et al., 2003; Hallikas et al., 2004; Nagurney
and Matsypura, 2005; Choi and Krause, 2006). These authors espouse the values of looking beyond the immediate supplier and considering a supply chain as a complex network with multiple tiers (e.g. Sawik, 2019; Hartmann and Moeller, 2014). A supply network is the network of companies that exist upstream to any one company in the value system (Porter, 1985). A supply network consists of nodes and links. A node is an agent that can make decisions and maximize its gain within the parameters in which it operates. Links connect the nodes in the logistics system. Some researchers argued that supply network designs leaning toward increased efficiency and responsiveness without considering the consequences of fragility and the risk implications of these strategies have resulted in supply networks becoming more vulnerable to disruption and risks (Svensson, 2002; Harland et al., 2003; Christopher and Peck, 2004; Nahmias, 2005; Tang, 2006; Wagner and Bode, 2006). Other researchers provided conceptual frameworks for helping to identify, assess and manage risks in supply networks (e.g. Harland et al., 2003; Wang et al., 2013; Ang et al., 2016; Hofmann et al., 2018). Despite an abundance of studies on supply network risks and their valuable contributions, we still lack a clear understanding of the barriers of MSCRM. Table 1 summarizes the studies addressing supply chain risks adopting the dyadic or the multi-tier perspectives.

3. Research method

Our motivation for using a multiple case study design was driven by the benefits of the case study method in the field of supply chain research (Koulikoff-Souviron and Harrison, 2005; Seuring, 2005, 2008) and the shortage of empirical research into the risks prevalent in supply chains (Sodhi et al., 2012). The central unit of analysis in this study is the multi-tier supply chain risk. The relationships among companies in each MSS are embedded units of analysis within each case study. The reason for focusing on a triadic relationship, i.e. buyer, first-tier supplier and second-tier supplier is that we intend to investigate the MSS in this depth.

Several reasons drove us to select cases in the automotive and the civil aircraft industries. First, both industries are interlocked business domains facing similar political, economic, social and technological influences. Second, both industries are capital intensive, complex, dynamic and subject to short innovation cycles. Third, supplier value creation is organized based on the tier structure. Next, the external sourcing volume in both industries is an integral part of the total cost, which is mostly the result of their heavy reliance on external suppliers in the production of systems and supply of components. Finally, as previous studies have shed light on MSCRM in the automotive industry (Wang et al., 2016a, b) and identified gaps of the supply chain risk management from a holistic perspective (Wang et al., 2013), we are interested in understanding the obstacles of MSCRM from cross-industry perspective.

Sources of data used in this study included interviews and company archives. Selecting informants who can provide meaningful data on multiple incidents is critical for qualitative research (Manuj and Mentzer, 2008b). To ensure the informants are suitable, we pre-screened the initial participants on the participant’s experience with the phenomenon, job profiles, articulation skills and willingness to participate in the research (Manuj and Mentzer, 2008b) through telephone, face-to-face or e-mail interviews. As a result, we chose twenty-eight senior managers working in supplier management, risk management, purchase, logistics and finance from nine companies in both industries. Since the number of employees in the German automotive industry is approximately eight times greater than that of the civil aircraft industry (VDA, 2018; Keller, 2019), we purposefully chose more interviewees from the automotive industry.

Structured interviews with these informants lasted up to two hours. We began with open-ended questions followed by focused and direct questions (Strauss and Corbin, 1998). To maintain data integrity, we had independent experts check three revisions of the interview
<table>
<thead>
<tr>
<th>Citations</th>
<th>Major findings</th>
<th>Factors affecting supply chain risk management</th>
<th>Method</th>
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</table>
| Dyadic perspective Zsidisin et al. (2000) | Investigates how purchasing organizations assess supply risk and the actions these firms take to handle that perceived risk | (1) Risk awareness  
(2) Risk management expertise  
(3) Role of responsibility  
(4) Buyer dependency on suppliers | Case study |
(2) Mutual relationship dependency in buyer-seller relationships                                                | Survey |
| Watson (2004)                   | Argues that buyers must enter collaborative relationships with their suppliers to minimize risk and uncertainty                                  | (1) Power asymmetry between buyers and suppliers                                                               | Case study |
| Giunipero and Eltantawy (2004)  | Categories situational factors that may influence the level of investment in risk management systems                                             | (1) Degree of product technology  
(2) Need for security  
(3) Importance of supplier  
(4) Buyers' prior experience | Conceptual |
| Zsidisin and Smith (2005)       | Investigates the role of early supplier involvement in managing supply risk                                                                      | (1) Outcome uncertainty  
(2) Task programmability  
(3) Goal congruency  
(4) Moral hazard | Case study |
| Aydin et al. (2010)             | Analyzes the challenges and opportunities in supply risk management in decentralized networks                                                  | (1) Misalignment of incentives  
(2) Competing suppliers and buyers  
(3) Asymmetric information | Conceptual |
| Multi-tier perspective Choi and Krause (2006) | Develops a theory of supply base management considering supply risk, supplier responsiveness and supplier innovation                           | (1) Number of suppliers  
(2) Differentiation of suppliers  
(3) Inter-relationships among suppliers | Theorizing |
| Kull and Closs (2008)           | Argues that increased inventory in a tiered supply chain can sometimes increase supply risk rather than decrease it                             | (1) Inventory strategy  
(2) Inter-organizational dynamics | Simulation |
| Hartmann and Moeller (2014)     | Examines chain liability in multi-tier supply chains                                                                                           | (1) Environmental dimensions  
(2) Supply chain structure | Survey experiment |

Table 1. Relevant journal papers adopting a dyadic or a multi-tier perspective
guidelines (McCracken, 1988). Appendix 1 presents the interview guidelines. To ensure data validity, all the interviews were conducted by two interviewers. As two of the interviews were conducted by more than one informant, we effectively had twenty-four interviews in total. Eighteen out of twenty-four interviews were tape-recorded with the interviewees’ prior agreement, then transcribed within 24 h and sent to the informant for verification. The other ten interview protocols were generated from real-time notes taken by a second interview facilitator, then compared and sent to the informant for verification. To maintain appropriate anonymity, we omitted the names of contributing individuals and the corresponding companies and illustrated only the reference to the industry and the tiered system. Table 2 outlines the demographic information of the case.

We analyzed the data following qualitative data analysis techniques (Miles and Huberman, 1984; Strauss and Corbin, 1998; Yin, 2009; Urquhart, 2001). We employed the commercial qualitative data analysis software MAXQDA for systematically coding the data (Elliott, 2018). Following the inductive approach (Eisenhardt, 1989), we performed a two-level coding process (Punch, 2014; Lichtman, 2013). At the first level, we generated forty-three descriptive codes (i.e. concepts) such as operational risk and software solutions to summarize segments of the raw data. We then looked for overlap and redundant codes and reduced the number to twenty concepts. At the second level, we grouped these concepts and derived six inferential codes (i.e. categories) such as MSCRM strategy and resources of MSCRM. These categories were used as headings in Tables 3 and 4 of the interview findings. For the inter-rater reliability, the two interview facilitators coded the same documents independently and compared the coding results to allow for multiple facets of the phenomenon to be revealed (Elliott, 2018). In case of a disagreement in coding, we first analyzed the reasons for that disagreement. If no consensus was realized, an external researcher was invited to recode the part disagreed upon as a way to reach a joint conclusion. (Luker, 2008).

4. Findings
4.1 Within-case analysis of the automotive industry
In this part, we present the results of the within-case analysis for the two case studies in the automotive and the civil aircraft industries, respectively. Each studied case consisted of a three-tier supply chain. We use A, B and C to represent the assembler, the first-tier supplier and the second-tier supplier in the automotive industry and a, b and c for the same purpose in the civil aircraft industry.
For the automotive assembler A1, “keeping innovation in motion and making accurate forecasts” to meet the changing customer demand seems to be the biggest challenge. From the perspective of the first-tier suppliers B1, B2 and B3, operating issues due to on-time delivery, lead time and accountability of the second-tier suppliers are the major bottlenecks. To sum up, the risks which are internal to the supply network but external to the company seem to affect the assembler and the first-tier suppliers the most. The second-tier supplier C1 produces ubiquitous products and its production capacity is redundant in the supply chain. C1 faces high competition regarding price and delivery time.

A1 has implemented advanced information exchange and communication systems at the operational level. The data revealed that A1 and its first-tier suppliers share information and frequently communicate either personally or via email or telephone. However, A1 does not engage in direct information sharing and communication with its second-tier suppliers in most of the reported cases. There are only a few exceptions. For instance, A1 and one of its second-tier suppliers, a manufacturer of the semiconductor, exchange supply chain information directly.

*Interviewee A1:* In some cases, it is vitally important to talk directly to this second-tier supplier, as we cannot easily find an alternative supply for this customer-tailored high-tech part.

*Interviewee A1:* Most of our supply chain problems happen between the first-tier and the second-tier suppliers. We lack better visibility of the multi-tier supply chain.

*Interviewee A1:* We delegate the control of the second tiers to our first tiers; otherwise, the supply system will be too complicated for us. We do not intend to take over the direct monitoring of the second tiers. Building strategic partnerships with first tiers may be insufficient. However, can the additional cost to widen the focus be compensated by its benefit?

B1, B2 and B3 primarily monitor their direct suppliers. B1, B2 and B3 hold back information about their suppliers if sharing such information with their original equipment manufacturer (OEM) could “potentially weaken their competitiveness or negotiation power”. For C1, the supply chain visibility is poor.
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<td>(1) Operational risk</td>
<td>(1) Demand fluctuation</td>
<td>(1) Market and demand risk</td>
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<td>(2) Supplier quality risk</td>
<td>(2) Market risks</td>
<td>(2) Operational risk</td>
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<td>(3) Counterparty risks</td>
<td>(3) Lack of information transparency along the chain</td>
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<td>(4) Risk due to inadequate supply chain visibility</td>
<td>(4) Counterparty risk of direct suppliers</td>
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<td>(6) Supply chain sustainability risk</td>
<td>(6) Supplier cluster management</td>
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<td>MSCRM strategy</td>
<td>(1) Proactive strategy</td>
<td>(1) Risk-sharing with assemblers and direct suppliers</td>
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<td></td>
<td>(2) A strategic alliance</td>
<td>(2) Monitoring of first tiers and indirect supervision of the sub-tiers</td>
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<td>(3) Early supplier involvement</td>
<td>(3) Contingency planning</td>
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<td>(4) Vertical integration</td>
<td>(4) Regular monitoring of critical first tiers</td>
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<tr>
<td>MSCRM coverage and depth</td>
<td>(1) A competitive and contractual relationship with first tiers</td>
<td>(1) Early warning indication on quality and delivery of suppliers</td>
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<td></td>
<td>(2) Quality and delivery monitoring of the vital first tiers and very few strategic second tiers</td>
<td>(2) Regular monitoring of critical first tiers</td>
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<td>(3) Auditing of the selected first tiers</td>
<td>(3) Long-term agreements with critical raw material suppliers</td>
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<td>MSCRM process</td>
<td>(1) Contingency planning</td>
<td>(1) Early warning indication on quality and delivery of suppliers</td>
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<td></td>
<td>(2) Early warning indication on problems of quality and delivery of first tiers</td>
<td>(2) Regular monitoring of critical first tiers</td>
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<td>(3) Auditing of the selected first tiers</td>
<td>(3) Long-term agreements with critical raw material suppliers</td>
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<td>MSCRM systems and tools</td>
<td>(1) High dependence on inter-enterprise ICT</td>
<td>(1) High reliance on ICT such as Opture®</td>
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<td></td>
<td>(2) Key Performance Indicators</td>
<td>(2) External credit information (e.g. Creditreform)</td>
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<td></td>
<td>(3) Lack of tools to manage multi-tier supply network transparency</td>
<td>(3) External finance and country risk information (Coface®)</td>
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<tr>
<td>Resources of MSCRM</td>
<td>(1) Special task force for risk management</td>
<td>(1) A high commitment from the management board</td>
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<td></td>
<td>(2) Emphasis more on teamwork and less on risk ownership of the individual</td>
<td>(2) Emphasis on-site visit and timely communication</td>
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<td>(3) Knowledge sharing</td>
<td>(3) Knowledge sharing</td>
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Table 3. Major interview findings in the automotive industry
<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Civil aircraft principal company a1</th>
<th>First-tier supplier b₁, b₂</th>
<th>Second-tier supplier c₁</th>
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</thead>
<tbody>
<tr>
<td>Source of multi-tier supply chain risk</td>
<td>(1) Market and liquidity risk</td>
<td>(1) Business-to-business customer risk</td>
<td>(1) Demand and price risk</td>
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<td>(2) Risk interrelations due to outsourcing and single sourcing</td>
<td>(2) Counterparty risk of the suppliers</td>
<td>(2) Operating risk</td>
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<td>(3) Sharing of risks by using incentive contracts and long-term supply agreements</td>
<td>(3) Supplier integration through improved confidence and continuous coordination</td>
<td>(3) Risk interrelations such as customer satisfaction</td>
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<td></td>
<td>(4) Strategic partnerships such as alliances and joint R&amp;D (with both first and second tiers)</td>
<td>(5) Focus on the strategic level of cooperation and the long-term relationship</td>
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<td>(6) Reactive tools such as contingency plans and disaster management</td>
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<td>(2) Reactive tools such as resource utilization and risk scenario analysis</td>
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<td>MSCRM strategy</td>
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<td></td>
<td>(1) Gaining experience on managing second and third tiers</td>
<td>(1) Focus mainly on direct suppliers and selected sub-tier suppliers if required by the principal company</td>
<td>(1) Covering only first tier</td>
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<td></td>
<td>(2) Building win-win relationship with suppliers</td>
<td>(2) Sharing the result of risk evaluation with direct suppliers</td>
<td>(2) Competitive relationship with suppliers</td>
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<td>(3) Lack of a higher level of network visibility</td>
<td>(3) Price risk transfer to direct suppliers</td>
<td>(3) Sharing minimal supply risk information with suppliers</td>
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<td>(4) Supplier risk scorecard</td>
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<td>(5) Lack of sufficient re-evaluation of the residual risk</td>
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<td>MSCRM coverage and depth</td>
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<td></td>
<td>(1) Acquiring or building strategic partnership with suppliers</td>
<td>(1) Supplier risk scorecard</td>
<td>(1) Supplier segmentation</td>
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<td>(2) Early supplier involvement in product development</td>
<td>(2) Lack of sufficient re-evaluation of the residual risk</td>
<td>(2) Regular performance review of key suppliers</td>
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<td>(3) Early warning indication</td>
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<td>(3) Supplier risk scorecard</td>
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<td>(4) Sharing risks and profits with suppliers</td>
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<td>(4) Lack of reassessment of the residual risk</td>
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<td>MSCRM process</td>
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<td>(1) Enterprise Risk Management (ERM)</td>
<td>(1) ERM</td>
<td>(1) JDA software planning</td>
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<td>(2) Lack of more efficient appliances to manage multi-tier supply transparency and risk</td>
<td>(2) Risk-monitoring dashboard</td>
<td>(2) Internal database of best practices</td>
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<td>(3) Missing models of supply network risk quantification</td>
<td>(3) KPIs</td>
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<td>Resources of MSCRM</td>
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<td>(1) Based on the high commitment of executives</td>
<td>(1) Concept of risk ownership and the role responsibility</td>
<td>(1) Constrained resources</td>
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<td>(2) Emphasis on leadership and individual’s experience</td>
<td>(2) Focus on effective communication with suppliers</td>
<td>(2) Lack of cross-functional risk communication</td>
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<td>(3) Knowledge sharing</td>
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<td>(3) Risk culture building in progress</td>
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Interviewee B1: When the Typhoon hit one of our direct suppliers, this app alerted us of the possible delivery delay even earlier than the supplier did. However, we cannot monitor the risk beyond the direct suppliers.

Interviewee B2: About two weeks later, we felt the ripple effects of the tsunami and the nuclear fallout in the Fukushima area. One of the suppliers could not deliver a minor semiconductor part because it was produced by their supplier located in Fukushima area. We had no data to what extent our critical suppliers were affected by the Fukushima disaster or how the delivery stoppages of semiconductors and other electronic parts would affect the production.

Interviewee B3: There has been a supply chain visibility program initiated by one of the OEMs. This OEM wants to gain knowledge about our suppliers. We have the resources to do so. However, there is a danger to our profit margin [when sharing critical information]. What if this client bypasses us and buys parts directly from our suppliers?

Interviewee C1: There is only a limited quantity of information transferred from OEMs to us. We receive orders from our direct customers.

Interviewee C1: They [first-tier suppliers of the OEM] expect high quality and just-in-time delivery. This expectation is a big challenge for us, as our company is forecast-driven. Sometimes we had to make decisions based on inferior information.

The interviewees reported that, in the last decade, their companies have engaged in a growing number of alliances with the supply chain partners to gain supply chain visibility, integrity and growth. However, the managers’ experiences in this regard are quite mixed.

Interviewee A1: We have built different types of contractual and strategic relationships with the first tiers. However, to “partner” with the right supplier at the right time is not an easy task. It is a matter of insightful industry experience and support from the board.

Interviewee B1: We were somehow coerced to get engaged in a joint research and development (R&D) project with the OEM a bit more than one year ago. It does not seem to be an equal partnership. The OEM held some crucial information and did not genuinely share it with us. Besides, we do not feel that we are fully integrate into the decision-making process.

Interviewee B2: To sustain the strategic alliance with this big account [automotive OEM], we invest a lot on R&D to diversify our product portfolios and to better fit into the integration program of the customer. It is a win-win at the end of the day.

Interviewee B3: You need to be realistic about what you can get from a strategic partnership. It is not a guarantee of better visibility or more transparent information flow. Unfortunately, many of our managers take things for granted!

Interviewee C1: Recently, one of our big accounts initiated a product development alliance with us. Quite contrary to our expectation, this did not bring more collaborative interaction among engineers from both companies. It is merely a strategic decision made by high-level management.

Over the past three years, all five interviewed companies in the automotive sector have either upgraded their existing information and communication technologies (ICT) or installed new ICT to align processes and share resources with their trading partners. Such technologies include enterprise resource planning (ERP) systems and electronic data interchange. Although equipped with advanced ICT, interviewees commonly feel challenged communicating with different inter- and intra-organizational stakeholders due to the growing complexity of the communication network. It is a common concern among the interviewees that “ICT alone does not ensure the provision of the right information at the right time to the right person.”

Interviewee A1: Setting up the advanced IT systems is only one half of the story; the other half is about building standards and process documentation at the company and the supply chain level.
Interviewee B1: Sometimes, we are challenged by the overload of information in our IT system, especially when the ambiguous information presents conflicting data points. What do you do? You ignore it!

Interviewee B2: The internal flow of risk-related information poses a significant challenge in our daily business. We organize our firm and teams in hierarchies and line roles but working together for projects is different because projects go across silos.

Interviewee B3: We started a pilot ERP project of SAP Business Suite 4 SAP HANA in one of our plants. It is an app-based software package. The user interface is intuitive and user-friendly, but we encountered many technical issues regarding the system compatibility, data exchange with our supply chain partner’s system, and the data security. In the end, we had to postpone the rollout plan for the other plants.

Interviewee C1: Sometimes, the information about potential risks only stays within a single plant or a business division. There is a lack of an integrated risk communication scheme across different internal locations and entities in our company.

In Table 3, we summarized and grouped the interview results into six areas, which we queried based on our interview guideline: (1) Source of multi-tier supply chain risk, (2) MSCRM strategy, (3) MSCRM coverage and depth, (4) MSCRM process, (5) MSCRM systems and tools and (6) resources of MSCRM, such as leadership, communication and the corporate culture of risk management.

4.2 Within-case analysis of the civil aircraft industry

Concerning the distribution of multi-tier supply chain risk for the interviewed companies in the civil aircraft industry, data revealed that the risk of losses in situations arising from price fluctuation is one of the major concerns. Operational risks, such as the supply disruption of the raw material suppliers, quality failure of the semi-finished product, manufacturing failure of the finished product and the inability of the suppliers to meet the contractual obligations, are other significant concerns. Besides the market and operating risks, liquidity and interrelated risks due to outsourcing and single-sourcing are also significant management concerns in the civil aircraft industry.

Interviewee a1: We are under growing pressure to monitor and cope with the backlog of the confirmed orders. It is a nightmare if suppliers cannot meet our demands.

Interviewee b1: The currency shifts, political unrest, cultural differences, piracy, natural disasters, and the uncertainty of demand, make the job of matching supply with demand nowadays more complex than ever.

Interviewee b2: The market [of the aircraft spare part supply] is a battlefield. Competition, government regulation, quality tracking, changing customer requirements, and emerging technologies such as artificial intelligence and robotics; we must face all these.

Like the automotive industry, the four-step MSCRM procedure is the standard practice in the civil aircraft industry. Besides, we found that recurrent risk events with straightforward and tangible consequences seem to attract more managers’ attention than those low-likelihood risks with severe but non-quantifiable impacts. Data revealed that there are three significant reasons to explain this phenomenon. First, because of the frequent occurrence of such risks, managers “feel empowered to cope with them.” One of the interviewees used “risk comfort zone” to describe such risks. Second, managers have the perception that reducing disruptive risks (high-impact but low-likelihood) will “reduce the efficiency from the view of cost-saving.” To avoid further costs, managers tend to choose to do nothing to prepare for the “acts of God.” Lastly, the performance appraisal system for the manager has a direct impact on the manager’s risk-priority setting. Managers are driven to fulfill their work missions by
solving “the most urgent and vital supply chain risks;” there is thus less capacity or resources available for investing in safeguarding against those hidden risks or risks with non-quantifiable impacts.

*Interviewee b1*: We are busy handling the day-to-day risks, such as the supply delay or the shortage of the parts. Our plans mainly focus on protecting against these recurrent risks in the supply chain.

*Interviewee c1*: I have experienced this sort of business risk many times in my career. Handling such risks is a routine job for me.

Compared to the automotive assembler, A1, which shares information and communicates primarily with its first-tier suppliers, the civil aircraft principal company a1 was more inclined to monitor both its first- and second-tiers directly or indirectly. Depending on the criticality of the part to a1’s business, a1 examines the processes of its second-tiers who’s potential failure could significantly affect the whole supply chain. In some cases, a1 works together with its first-tier alliance partners to “solve the problems of the second tiers, design joint supplier selection, and certification programs, and implement alliance development strategies”.

*Interviewee a1*: We have learned the lesson that it can be costly to assess risks either for all or none of our sub-tier suppliers. The result of our internal cost-benefit analysis directs us to decide which second-tier suppliers should be our target of direct monitor.

*Interviewee b1*: Our medium-term alignment of information is also about to integrate different information systems among the supply chain partners.

*Interviewee b2*: The client requires us to acquire parts from a list of second tiers, which are already pre-selected by our client under precisely defined conditions.

The interviewed companies reported that they had realized some benefits by building strategic alliances with their supply chain partners. However, they also show their concerns about the relationship.

*Interviewee a1*: A newly launched project aims at the cost reduction of the parts. This project requires alliance suppliers to open their books to us. Easier said than done. The project team is still working on building a high level of mutual trust.

*Interviewee b1*: One of our strategic suppliers, for example, is not motivated to work with us on the joint R&D project. There is a lack of incentive to put it in short. So, I see limited value in this alliance relationship.

*Interviewee b2*: As the managerial and operational costs continue increasing, the total expenses of maintaining the partnership with the supplier also increase. For example, the consignment stock increases the inventory cost.

*Interviewee c1*: It is a well-established alliance partnership with the buyer. It has worked out for many years. However, this buyer becomes more potent on the market than before. Moreover, we feel that we lose bargaining power. The price they offered recently is not fair, in my opinion.

Interviewees from all three tiers expressed similar concerns about their organization’s dependency on the ICT to manage supply risks. For example, to increase the traceability of parts and transparency of data flow, several multinational companies in our interviews rolled out ERP templates among their subsidiaries across the national borders. An ERP roll-out template is typically centrally developed based on the business process of a handful of reference locations. Without taking system compatibility of the supply chain partners into account, “a standardized template often leads to business failure.” As documented in the company’s internal report, “We should question our conventional approach: information technology (IT) makes the change first, and then the business process tries to adapt to it. The
business should demand IT to make changes to meet business needs. The business needs should stay in the center of the game.”

Interviewee a1: People think technology is the master key to deal with the supply chain risks. Typically, we apply IT systems in one pilot plant, and then roll them out in the rest of the plants. If they fail, then it is the system, not the management that fails. However, what determines success is leadership.

Interviewee a1: The recent cyberattack in one of our Asian plants made us aware that we rely too heavily on the IT system. It was a very chaotic situation as there was no contingency plan at hand to run the warehouse during the unscheduled system downtime.

Interviewee b1: System compatibility seems to be a prominent topic. However, people often overlook adequately configuring and testing all relevant IT device and software’s. For example, can the RF scanner, the USB scanner, and the slip printer read and process the data, such as labels from the suppliers and customers, without compatibility problems?

Interviewee b2: In recent years, we have experienced rapid advances in information technologies. However, these technologies sometimes result in a confusing assortment of alternative IT approaches for supporting our supplier management.

Interviewee c1: Although there is a newly installed company-wide communication software, information sharing is still fragmented, and occurs only within limited business units, especially those between managers and the technical experts.

In Table 4, we summarized and grouped the interview results in the civil aircraft industry.

5. Cross-case analysis and propositions
During cross-case analysis, we compare the patterns of MSCRM across cases in both industries (Miles and Huberman, 1994; Eisenhardt and Graebner, 2007; Yin, 2009; Mena et al., 2013). Following the results, we derive three common barriers to MSCRM by focusing on causal-process observation. We incorporate external studies that are relevant to these emerging propositions, following the inductive tradition (Eisenhardt, 1989).

5.1 Information sharing and communication as MSCRM barrier
In both cases of the present study, supply chain visibility in the upstream and the downstream varies, as there is a different amount of information shared between entities along the supply chains. We developed three models to illustrate the mechanism of information sharing and communication in the reported cases: the arrow model, the bridge model and the triangle model, as shown in Figure 1. The concrete and dotted lines refer to the direct and indirect information flows, respectively. The arrow represents the direction of the information flow. In the arrow model, there is information sharing and communication between the buyer and its first tier and between the first tier and the second tier. However, the direct information flow between the buyer and its second tier is missing. Thus, for the arrow model, information sharing and communication in the MSS is narrow and stays at the dyadic level. In the bridge model, the buyer shares information with its second tiers indirectly, mainly via its first tiers. For instance, the buyer designs sub-tier supplier selection and certification programs, implements sub-tier supplier integration strategies and works with its first tiers to solve the problems of its sub-tier suppliers. In the triangle model, the buyer, the first tier and the second tier each have mutual information sharing and communication with each member of the supply chain. This model reflects multi-tier perspectives in supply chains. The bridge model, sometimes seen as a transitional stage from the arrow model to the triangle model, together with the triangle model represents approaches of broad information sharing.
and communication in the MSS. Our findings indicate that an arrow model is a practical approach among companies in the automotive industry. The triangle model was implemented only in specific cases by very few companies interviewed in both industries.

Companies in the automotive industry often belong to several competing and decentralized MSS where self-interested firms interact (Aydin et al., 2010). Although companies in MSS do not compete for sales, they do compete for a better position and a more significant share of the revenues that flow through the same supply chain (Mena et al., 2013). Therefore, information in MSS is tightly controlled, restricted or typified by asynchronous one-way data push communication mechanisms, especially in the absence of trusting relationships or where conflicts of interest exist (Fawcett et al., 2007; Smith et al., 2007). At this level of collaboration, information is often withheld, masked, distorted and is even missing, and collaboration is overstated or underestimated (Childerhouse et al., 2003; Hallikas et al., 2004). However, it is important for supply chain partners to embrace broad information sharing and communication at the multi-tier level. Effective information sharing is considered as the initial point for building “bridges” between firms and forming supply chains (Zsidisin and Ellram, 2001) and is the key to improved supply chain visibility (Harland, 1996a; Christopher and Lee, 2004; Kleindorfer; Saad, 2005; Manuj; Mentzer, 2008b; Tang, 2006; Zsidisin et al., 2004), the driving force to decrease supply chain uncertainties and increase resilience (Lee, 2000; Hallikas et al., 2004; Christopher et al., 2011; Sawik, 2019) and the primary factor offering significant performance improvement without undermining the autonomy of individual businesses at various echelons (Mason-Jones and Towill, 1997).

**Proposition 1.** Narrow information sharing and communication covering only the immediate supply chain partners obstructs MSCRM.

### 5.2 Dependency on strategic alliances with suppliers as a MSCRM barrier

To secure the competitive advantage and manage supply chain risks and uncertainties, companies primarily in the downstream (e.g. assemblers) tend to absorb partial risk through strategic alliances, such as minority equity investment, board interlocks, joint ventures, joint R&D, joint production, co-marketing, licensing, long-term supply agreements, obligation contracting, profit-sharing schemes, property rights sharing or ownership control (Pfeffer and Salancik, 1978; Ellram, 1991; Macbeth and Ferguson, 1994; Das and Teng, 2001). Examples of companies that have built or enhanced strategic alliances with their suppliers include Toyota (Womack et al., 1990), Airbus and Boeing (Parker and Shotter, 2012) and Tesla (Hoang and Rothaermel, 2016). Many firms have experienced significant benefits from engaging in strategic alliances with suppliers (Zsidisin and Ellram, 2001).

![Information sharing and communication models in the multi-tier supply system](image-url)
Despite the positive factors associated with supplier alliances to manage multi-tier supply chain risks, there are also drawbacks if the participating companies overly depend on this strategy. Dyer et al. (2001) estimated that almost half of all alliances fail. Eisenhardt and Schoonhoven (1996) argued that alliance formation might have allowed the “rich” firms to get “richer” as firms require resources to get resources. Rossetti and Choi (2005) demonstrated that there is long-term severe supply chain risk associated with firms being integrated with their suppliers and then mistreating them for short-term gains. Hamel et al. (1989) found that alliances can lull managers into failing to develop necessary firm capabilities. Other possible drawbacks of forming a strategic alliance with suppliers include high transaction costs (Williamson, 1991), growing dependency on fewer suppliers (Harland, 1996a), increased switching and relationship handling costs (Gadde and Snehota, 2000), reduced technological flexibility (Miles and Snow, 1978) and reduced revenue streams by sharing profits (Shan, 1990).

According to the content analysis, we found a few more perspectives useful for explaining the “dark” side of being dependent on vertical supply alliances. First, as an alliance strategy primarily manages a company’s dependencies on direct resources in a dyadic business relationship, such as its immediate supplier, its interdependencies on the environment still exist (Pfeffer and Salancik, 1978; Smeltzer and Siferd, 1998), hence the potential multi-tier risks increase. Second, as a company’s physical position in the supply chain affects demand volatility, asset intensity, profitability and technological change (Hayes and Wheelwright, 1984), and upstream suppliers suffer higher volatility and “noise” than downstream firms do (Harland, 1996b). Downstream firms with additional competitive advantage through efficiently harnessing the potential of a network than competing firms tend to drive decisions, such as building alliances. An alliance partnership driven by the dominant partner may cause the asymmetrical distribution of information, local optima in the dominant partners and ultimately lead to lower value-added for the entire MSS. As reported by the interviewees in our study, some supplier alliances are “not a fair partnership,” as “suppliers are coerced to become alliance partners,” and there is “little synergy effect achieved.” Finally, the failure rate of alliances is significantly higher than that of single firms due to the opportunistic behavior of partners (relational risk) and the risk of unsatisfactory business performance (performance risk) (Bleeke and Ernst, 1991; Das and Teng, 2001, 2002). Several managers shared similar views in the interviews. For example, there is a “lack of collaboration and information sharing between alliance partners,” and a partnership is “something that exists on paper but not in practice.”

Proposition 2. High dependency on strategic alliances with suppliers hinders MSCRM.

5.3 Overreliance on ICT systems as a barrier to MSCRM
Companies are increasingly applying ICT to integrate systems and processes throughout the supply chain or as a response to the organization-level endogenous and field-level institutional pressures (Bhakoo and Choi, 2013). On one hand, ICT is essential to support multiple organizations to coordinate their activities and collaborate in supply chains (Handfield and Nichols, 1999). On the other hand, ICT has reduced or eliminated many traditional levels of separation, which once built a protective barrier around a company’s assets and processes (Smith et al., 2007). The increased access to information via the IT infrastructure brings with it many inherent security risks to organizations along the chain (Deane et al., 2009). According to a study by Tang and Zimmerman (2009), one of Boeing’s first-tier suppliers, Vought, hired Advanced Integration Technology (AIT) as a system integrator without informing Boeing. AIT was expected to coordinate with other sub-tier suppliers of Vought. However, due to cultural differences, some sub-tier suppliers did not routinely enter accurate information into Exostar, a Web-based planning system. As a result,
various first tiers and Boeing were unaware of the delay problems beforehand. It was thus difficult for Boeing to respond quickly to these delay-related issues and this finally led to the delay of its first flight of the Dreamliner airplane.

According to the content analysis, we conclude that relying too much on ICT is a barrier to MSCRM. The reasons are threefold. First, successful MSCRM is influenced by dimensions such as goal alignment between trading partners (Sahin and Robinson, 2002), trust (Handfield and Bechtel, 2002; Wu et al., 2013), commitment (Kwon and Suh, 2005) and personal exchange and interactions (Juettner, 2005). ICT is most effective when multi-tier supply chain risk is not severe, has occurred before and can be tackled with plenty of resources. However, if multi-tier supply chain risk is severe and unfamiliar or is related to supply chain integrity, compliance and quality control, or when the relationship with a remote supplier is subject to differences in business and cultural contexts, it is not always the system but the employee at the front line interacting with the supply chain partner who could be the first to notice the unusual and less obvious signals. Thus, it is often people who are necessary to ensure that these systems are working correctly and can deliver alternatives when resources are limited or when the system fails. Second, the best way to cope with multi-tier supply uncertainty and risk is to work hard to reduce it rather than expect to solve the problem by acquiring even more sophisticated forecasting software (Mason-Jones and Towill, 1998). ICT should be complemented by commensurate investment in organizational culture that promotes employees’ risk awareness and openness to sharing information honestly and frequently (Lee et al., 2000). However, some managers have the perception that by investing in ICT, the supply chain collaboration and visibility will improve. The result, as mentioned by one of the interviewees, “technology is bought and sold as the “master key” to a company’s information-sharing deficiencies. Lastly, MSCRM goes beyond information exchange between suppliers and their customers; it involves joint decision making among partners in areas of collaborative planning, forecasting, distribution and product design (McLaren et al., 2002).

Proposition 3. Overreliance on the ICT increases companies’ exposure to risks and poses a barrier to MSCRM.

6. Conclusion
As the aim of this study was to understand multi-tier supply chain risk and the barriers to MSCRM in the automotive and the civil aircraft industries, we collected empirical data explaining the source of multi-tier supply chain risk, MSCRM strategy, coverage, depth, process, managerial systems and tools and resources. Based on the interview findings within two distinct, but related industries, three barriers confronting companies in their quest for MSCRM was obtained. Narrow information sharing and communication behavior among supply chain partners are considered the first barrier to MSCRM. The second barrier explains companies’ bridging action, such as building alliances as a defense mechanism against multi-tier supply chain risk. The third barrier is the companies’ dependence on ICT. Bridging actions and relying on ICT are ways in which companies respond to the complexity and uncertainty of MSS and reflect their aim to acquire more power by maximizing independence and certainty.

From a managerial perspective, our research is appealing because it provides initial evidence on how multi-tier supply chain risk is (or is not) managed in companies from the automotive and the civil aircraft industries. Our findings help practitioners understand the barriers to MSCRM. First, we provide practitioners with an argument to embrace broad information sharing and a communication mechanism across multiple tiers to capitalize on opportunities and mitigate risks. Second, this study indicates that although companies can absorb constraints and manage uncertainty by building alliances with supply chain partners,
the “dark” side of being dependent on the alliance strategy can pose a barrier to MSCRM. Practitioners will need to decide on counteractions to overcome these difficulties. Third, we urge practitioners to think critically about the balance between ICT, corporate culture and leadership. The comparison of MSCRM in two different industries also suggests that there is no multi-purpose solution or a quick fix for imitating the best MSCRM practice. Only a suitable MSCRM approach enables a company to achieve a balanced set of goals.

We recognize that future research should continue testing the presented findings. Table 5 summarizes selected future research themes that consequentially emerge from the three propositions and their surrounding concepts. The first research theme is about information sharing and communication with suppliers and MSCRM. Many questions around the collaborative behavior in supply chains remain: what drives companies to refrain from the broad arc of information sharing and communication across multiple tiers? How can information collaboration among supply chain partners foster MSCRM? The second theme is about strategic alliances with suppliers and MSCRM. Here, power structure and goal alignment are two major concepts recognized in the study. In light of the current COVID-19 pandemic, future studies should address the impact of goal alignment on individual decentralized supply risk management as well as the effect of COVID-19 on supply chain modification toward more self-sustained regional clusters. This in turn might lead to further power shifts that have to be considered in MSCRM approaches. The future research theme is about ICT and MSCRM. Especially, leadership in risk management and resilience seem crucial. Moreover, the evolutionary development of managerial risk awareness could further enhance our understanding of MSCRM in the future.

In addition, future studies should be pursued to expand the generalizability of the findings. First, as this study focused on the automotive and the civil aircraft industries, the

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<th>Future research questions</th>
<th>Identified key concepts</th>
<th>Possible research questions</th>
<th>Relevant literature</th>
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| Information sharing and communication with suppliers and MSCRM                           | Collaboration           | (1) What drives companies to refrain from the broad arc of information sharing and communication across multiple tiers?  
(2) How can information collaboration among supply chain partners foster MSCRM? | Sequential information sharing (Yoon et al., 2020); Framework of multi-tier information sharing (Kembro, 2015);  
Connectivity and willingness of information sharing (Fawcett et al., 2007) |
| Strategic alliances with suppliers and MSCRM                                               | Power structure, goal alignment | (1) What influence does the power structure in supply chains have on MSCRM?  
(2) What impact does goal alignment have on decentralized supply risk management during the COVID-19 lockdown? | Function of the dedicated strategic alliance (Dyer et al., 2001); Decentralized supply risk management (Aydin et al., 2010) |
| ICT and MSCRM                                                                             | Leadership, employees’ risk awareness | (1) What is the role and impact of leadership in building information-sharing capability for MSCRM?  
(2) What influence does employees’ risk awareness have on MSCRM? | Risk awareness and leadership (Tang and Zimmerman, 2009; Juettner, 2005) |

Table 5. Suggestions for research agenda
results may only be applicable to these types of firms. Therefore, future studies could transfer insights to other industries such as healthcare and food in a global business context. Second, only a limited scope of supply chain parties, i.e. buyer, first-tier supplier and second-tier supplier, were covered in the study. Future research is encouraged to collect data from firms in other supply chain tiers located further up or downstream, such as the raw material supplier or the logistics service providers. Third, while the study provided initial insights, additional research might seek to test and validate our findings using other forms of data collection and methodologies, such as large-scale surveys or secondary data. Finally, it would be interesting to explore how the recent disruptive incidents, such as the outbreak of the COVID-19 and the intensifying US-China trade disputes risk judgment and thus produce different solutions. We hope that the present study provides a starting point for further investigations that will deepen our understanding of MSCRM.

References


Miles, M.B. and Huberman, A.M. (1984), Qualitative Data Analysis: A Sourcebook of New Methods, Sage, Beverly Hills, CA.


Further reading


Appendix 1

Interview guidelines

**Opening**

(1) Introductions of interviewer and interviewees.

(2) Overview of the study’s purpose.

(3) Confidentiality assurance.

(4) Permission to audiotape.

**Demographic data**

(1) Job title of the interviewee.

(2) Professional experience.

(3) Background on organization and industry.

**Lines of inquiry**

(1) What are multi-tier supply risks?
How are multi-tier supply risks managed?
Multi-tier supply risks management coverage and depth.
Multi-tier supply risks management tools and techniques.
Steps in the process using a recent risk-management example.
Risk-management resources.
What are the challenges of multi-tier supply risk management?

Additional unplanned/floatung prompts
1. Clarify more details about that.
2. Explain the background.
3. Provide some examples of it.
4. How does that function?
5. Specify the situation when that did not happen.

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