Exploring sustainable supply chain management: a social network perspective

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Abstract

Purpose – The implementation of sustainable supply chain management (SCM) calls for an acknowledgement of uncertainty inherent in complex environment. Confucianist society forms social networks in Confucianist society, called guanxi networks, influence economic behaviours and business practices in the workplace. The purpose of this study is to explore how these social networks influence the implementation of sustainable SCM. In doing so, this study aims to critically investigate the constructs of guanxi networks, their impact on flow of supply chain capital and how this leverages the implementation of sustainable SCM.

Design/methodology/approach – Two systematic literature reviews are conducted to understand the constructs of social networks in Confucianist culture and their impacts on the flow of supply chain capitals. The reviews also analyse evidence related to the economic, social and environmental practices to reveal the current state of the literature and research gaps. Propositions and a framework are developed to support future research in this area.

Findings – The constructs of ganqing, renqing, xinren and mianzi in guanxi networks have expanded the contexts of social networks in Western literature. Guanxi networks increase the flow of supply chain capital and generate trust between players, thus enhancing capabilities to implement sustainable SCM. Guanxi networks also create the mechanism of network governance with which to increase sustainable SCM implementation under the institutional logics of sustainability.

Research limitations/implications – The conceptual framework and justification are based on the reviews of current studies in the field. Future empirical study is encouraged to test the propositions, both in Confucianist culture and other countries with culture of social networks.

Originality/value – Social networks are socially constructed concepts. The constructs of guanxi networks revealed in this study have developed the knowledge of Western-based social network theory. Besides, arguments from a social network perspective provide an alternative answer to explain increased behavioural commitment and companies’ investment in sustainable SCM. This study helps practitioners understand the logic of this social norm and to use it to maximise their operation outputs, including sustainable SCM implementation.

Keywords Social capital, Trust, Sustainability, Supply-chain management, Guanxi

Paper type Conceptual paper

1. Introduction

With sustainable development, a widely recognised necessity, stakeholders expect environmental and social responsibility to be considered in business operations. Sustainable initiatives have been integrated into various perspectives of supply chain management (SCM) (Beske and Seuring, 2014), and their implications have been the focus of many studies (Beske-Janssen et al., 2015; Carter and Jennings, 2004; Sarkis, 2012). However, current studies claim that “a company is no more sustainable than the suppliers from which it sources” (Miemczyk et al., 2012, p. 478), so sustainable SCM

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To address the complexity of contemporary global value chains, increasing studies have endeavoured to investigate social networks within sustainable SCM (Beske and Seuring, 2014; Miemczyk et al., 2012). Network relationships support a high level of collaboration and integration between players (Adenso-Diaz et al., 2012; Creazza et al., 2010). Individual ties underlie inter- and intra-organisational relationships, influencing corporate strategy and the “adoption of change” required for sustainable SCM (Johnston and Linton, 2000, p. 465).

Social networks are multifaceted. Different regions could embrace a variety of social constructs and expectations, such as *wasta* in the Middle East (Abosag and Naude, 2014). In this regard, this paper focuses on the investigation of guanxi networks – social networks in Confucianist cultures. Guanxi has been widely studied in marketing and management disciplines for its contribution to build mutual trust and reciprocity among people (Gao et al., 2014). In SCM, guanxi networks appear broadly in association with topics such as buyer-supplier relationships (Chen et al., 2011; Giannakis et al., 2012), supply chain integration (Cai et al., 2010) and knowledge sharing (Cheng, 2011). However, current studies have not yet fully captured the underlying mechanisms of sustainable SCM from a social network perspective, even though guanxi networks are showed to improve collaboration with suppliers in green SCM (Luo et al., 2014).

As such, this study aims to map a theoretical framework in investigating social networks towards sustainable SCM implementations. Both Victor (1991) and Seuring and Muller (2008) have drawn attention to the flow of capital in leveraging sustainability, the former considering sustainable development generally, while the latter focuses on sustainable SCM. The flow of capital enhances capabilities and resource integration to overcome barriers to achieving sustainable development (Rydin and Holman, 2004). The social network theoretical lens helps to illuminate how relational ties transform human talent and competitive advantages into a flow of information/knowledge, materials, cash, social relations and social control (Borgatti and Li, 2009, p. 5). Therefore, the proposed framework in this study helps researchers and practitioners to understand sustainable SCM from a relational tie perspective, thereby contributing to advance knowledge in this area.

The contributions of this study are threefold. First, it develops the holistic constructs of social networks in the context of both SCM and sustainable SCM in Confucianist culture. Second, by visualising the flow of supply chain capital in social networks, the capability for managing supply chain activities is enhanced. Finally, it proposes a theoretical framework from a social network perspective to increase the implementation of sustainable SCM, contributing to the spread of sustainable practices.

Evidence to support the building of the conceptual framework was obtained from two systematic literature reviews: a review of guanxi networks in sustainable SCM, followed by a review of guanxi networks in SCM. Two literature reviews are conducted because only five relevant papers were found in the first review, which gave limited insights of the topic. Therefore, the second one was conducted to shape the understanding of how guanxi networks impact on SCM, and by extension, on sustainable SCM. Compared with previous literature reviews in the field (Carter and Easton, 2011; Touboul and Walker, 2015; Beske-Janssen et al., 2015), this study attempts to understand the current state of social network research in sustainable SCM and build the conceptual framework for further research.Aligned with the arguments from Victor (1991) and Seuring and Muller (2008), this study takes the flow of supply chain capital into account, revealing the influence of guanxi networks on sustainable SCM implementation. The flow of supply chain capital helps companies for efficient communication and effective use of natural resources and innovative approaches to achieve sustainability. The structure of the paper is as follows: after the introduction, Section 2 gives a brief review of social network theory and its impacts on sustainable SCM. Section 3 gives a detailed description of the research design and findings of the literature review. The main contribution of the paper comes in Section 4, which presents the proposed theoretical framework of guanxi networks in sustainable SCM under the logics of institutional forces. Section 5 discusses the review findings and the linkage of the theoretical framework, and further justifies the academic and practical implications along with potential critiques of the topic. The final section offers concluding thoughts and proposes paths for future research.

2. Literature review

2.1 Social network theory and its impact on supply chain management

In the past century, various sociologists (e.g. Marx, Weber and Parson) started to investigate social networks to describe social activities and organisational behaviours. Social networks have been defined as “a set of nodes (e.g. people or organisations) linked by a set of social relationships of a specified type” (Laumann et al., 1978, p. 458). These social relationships are “socially constructed” and may include kinship and social obligations, knowledge and recognition of the identity of past and current transactions (Berger and Luckmann, 1966, p. 25). In some regions, such as Asia, social networks are socially, culturally and economically specified (Chua and Wellman, 2015). This study focuses specifically on guanxi in Confucianist societies, which is regarded as the notion of “a relationship” between objects, forces or people. It also has been described as a type of social network that provides a substantial exchange of mutual trust, benefits and reciprocity (Park and Luo, 2001; Yang, 1994).

Grannovetter (1973, p.1360) argues that interpersonal networks provide “the most fruitful micro-macro bridge” to turn small-scale personal interactions into large-scale patterns of influence. Unlike universalism and bureaucracy, where rules and regulated behaviours are classified in certain categories, social networks create the mechanism of particularism, where people care about the ability to predict reliability and embrace the responsibility of each member within the network (Heimer, 1992). Social network literature has clarified the strength of connections as strong ties and weak ties based on the frequency of interaction and similarity between the two nodes (Grannovetter, 1973).

From social networks and relational points of view, guanxi often is considered a form of social capital that encompasses
2.2 Sustainable supply chain management

Many discussions in sustainable development start with the Brundtland report (1987) and the concept of the triple bottom line. In supply chain literature, a number of studies have investigated various practical issues for providing a comprehensive understanding of sustainable SCM (Luo et al., 2014; Rennings and Wiggering, 1997) with a particular emphasis on environmental and green management (Carter and Easton, 2011; Cheng, 2011; Zhu et al., 2013). Carter and Rogers (2008, p. 368) believe that sustainable SCM is:

[...] the strategic, transparent integration and achievement of an organisation’s social, environmental and economic goals (the triple bottom line) in the systemic coordination of key inter-organisational business processes for improving the long-term economic performance of the individual company and its supply chains.

It has emerged as strategically important for organisational culture to achieve long-term performance and address sustainability issues with necessary business capabilities and resources (Burgess et al., 2006; Touboulie and Walker, 2015).

To address company strategy and the culture of sustainability in supply chains, proactive firms often require sustainable SCM actions from their suppliers (Gimenez and Tachizawa, 2012; Miemczyk et al., 2012). Research has shed light on supply chain networks that include inter-connected organisations (Adenso-Diaz et al., 2012; Creazza et al., 2010). Likewise, sustainability needs to be understood from the network level (Miemczyk et al., 2012; Vorro et al., 2009).

However, in practice, companies can only commit to sustainable development when they have the necessary capabilities. Sufficient capital provides the capability for implementing environmental and social responsibilities (Victor, 1991). Therefore, this study adopts the definition of sustainable SCM proposed by Seuring and Muller (2008, p. 1700):

The management of material, information, and capital flow, as well as cooperation among companies along the supply chain, while setting goals from all three dimensions of sustainable development (i.e., economic, environmental, and social) into account, which are derived from customer and stakeholder requirements.

Given the importance of material, information and capital flow among supply chain players, this study elicits the question of whether relational ties can increase supply chain capital flow to effectively implement sustainable SCM, considering economic, environmental and social responsibilities. According to the literature, “relationship is the essential aspect for achieving collaboration” and optimal performance in a green supply chain (Gunasekaran et al., 2015, p. 2). Carter and Jennings (2002) used a survey to investigate the influence of social responsibility on supplier performance. Trust and commitment are essential mediators in discussions, and research has found that buyer trust in suppliers positively increases cooperation between buyers and suppliers, improving supplier performance. Cheng (2011) has considered the relational benefits of reducing risks and sharing knowledge in green supply chains. Building on the current literature, this study has taken a social network view, endeavouring to explore the influence on sustainable SCM through enhancement of supply chain capital flow.

3. Research design

Two systematic literature reviews were conducted. The review of guanxi networks on sustainable SCM was undertaken in the first phase to consolidate knowledge of the topic and reveal the current research gap. However, this process has yielded limited number of papers. To further investigate the research topic, a second review was undertaken to reveal the role of social networks and their impact on supply chain capital flow, as these arguably support the meeting of environmental and social responsibilities. The review findings ultimately enhance conceptual framework building.

The main objectives of the systematic reviews were as follows:

- to understand the constructs of guanxi networks;
- to investigate the influence of supply chain capital flow from the guanxi networks perspective; and
- to build a conceptual framework to answer the research aim and develop propositions for future research.

To ensure a rigorous approach to the systematic reviews, the research used the method suggested by Tranfield et al. (2003), which aims to achieve thoroughness in a replicable process and helps develop the evidence base and minimise research bias. An expert panel of three experienced academic researchers gathered for discussion of the research plan, search terms and research scope. In addition, the research findings were discussed with another six researchers who have conducted empirical studies in China, of which five are experts in the field of green and sustainable SCM, and one has published work in social capital and guanxi in SCM.

First, the review of guanxi networks in sustainable SCM was prepared. There are a broad range of contents related to sustainable SCM in the current literature, including “green supply chain management”, “environmental supply chain management”, “environmental purchasing and supplier management”, “corporate social responsibility” and “supply chain management ethics”. Being consistent with the current literature reviews of
sustainable SCM (Touboulic and Walker, 2015; Alexander et al., 2015), the databases searched included Scopus and ABI/INFORM Global. Details of the research protocol are given in Appendix 1. Finally, four papers were obtained from Scopus and nine papers from ABI. Among these, two papers were duplicates and six of the papers from ABI were removed due to the exclusion criteria. Therefore, in total, five peer-reviewed papers were used in the review of guanxi in sustainable SCM.

Content analysis was applied to analyse the data (Seuring and Gold, 2012), and the results are presented across sustainable SCM themes. Given this initial search, observation shows that the influence of social networks on sustainable SCM requires further elaboration. Thereby, another systematic literature review was conducted to examine the influence of guanxi networks on SCM to acknowledge the impact on supply chain capital flow and support to theoretical framework building.

For the second review, a detailed research protocol is given in Appendix 2. To identify publications, papers had to contain guanxi in the title, abstract or keywords, plus one term from a broad range related to supply chain functions (supply, logistics, procurement, production, inventory, warehousing and manufacturing) in any database field. The online databases of selected publishers were searched: Elsevier (Science Direct), Emerald, Taylor & Francis, Sage and Wiley. These publishers covered the most relevant management journals without filtering out other topic-related sources, such as the Asia Pacific Business Review. The search was conducted in December 2017, and the timeframe covered from 1995 after initial research indicated no significant studies beforehand. It is acknowledged that other databases can also feature occasional relevant articles (Walker et al., 2015). Therefore, a Scopus database search with the same criteria confirmed the coverage of sufficient evidence in this study.

The selection process was summarised in Figure 1. In total, 464 papers were in the pool after the initial search, together with 277 papers found in the Scopus database. Cross-checking the duplication of publishers and database, 28 papers from Scopus were added to the sample. To select the most relevant papers, the first filtering criterion was to select the papers which are relevant in the subject areas by checking the title, abstract, keywords, introduction and conclusion. Further, filtering criteria was applied to identify those papers involving substantive connection between guanxi and supply chains. These processes yielded to a final sample of 154 papers.

To synthesise the 154 identified papers, relevant coding categories were used, including basic demographic information, constructs of guanxi networks, impacts on SCM and sustainable SCM. The approach of content analysis was adopted for constructing the findings.

To ensure validity and reliability, information for each category was recorded in an Excel spreadsheet. Additionally, results of pre-coding for first 20 papers were compared within the panel to assess the quality of the searched databases and to verify the coding strategies according to the research questions, which is important in ensuring research quality (Seuring and Gold, 2012). Discussions with the six external researchers additionally verified the findings in this study.

4. Analysis and findings

A literature review is “a systematic, explicit, and reproducible design for identifying, evaluating, and interpreting the existing body of recorded documents” (Fink, 2005, p. 3). To analyse review findings, this study applied a content analysis method to capture both qualitative and quantitative primary data and to interpret the underlying meanings of terms and arguments (Mayring, 2000; Seuring and Gold, 2012). This, then, informed the framework developed in Section 5.

4.1 The influence of guanxi networks on sustainable supply chain management

Observations in this study revealed a lack of in-depth insights into the influence of guanxi networks on sustainable SCM. Green SCM seemed to be the main focus of discussion (Table I). Conceptually, it is argued that guanxi networks could leverage business performance in SCM, including green management (Geng et al., 2017). Luo et al. (2015) have addressed this argument with empirical evidence that guanxi mediates the

Table I SSMC themes in guanxi networks

<table>
<thead>
<tr>
<th>SSMC themes</th>
<th>Guanxi networks</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green SCM</td>
<td>Moderation for an organization’s business and environmental performance</td>
<td>Zhan et al. (2016),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Geng et al. (2017)</td>
</tr>
<tr>
<td>Green supply</td>
<td>Guanxi positively mediates the relationship and green supply chain collaboration</td>
<td>Luo et al. (2015)</td>
</tr>
<tr>
<td>chain collaboration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relational risk</td>
<td>Increase the level of tolerated level of risk</td>
<td>Cheng (2011)</td>
</tr>
<tr>
<td>Knowledge sharing</td>
<td>The unwritten law of reciprocity improve the willingness to share essential</td>
<td>Cheng (2011)</td>
</tr>
<tr>
<td>Purchasers’</td>
<td>Guanxi can be either positive or negative moderate the purchasers’ ethical</td>
<td>Zhuang et al. (2014)</td>
</tr>
<tr>
<td>ethical</td>
<td>making</td>
<td></td>
</tr>
<tr>
<td>decision-</td>
<td></td>
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</tr>
</tbody>
</table>

Source: Authors
buyer–seller relationship and affects decision-making to implement green supply chain collaboration. At micro level, guanxi networks generate an “ethic of sustainability” (Hammond and Glenn, 2004, p. 24) to create trust and reciprocity as a social norm. According to Zhan et al. (2016), guanxi networks in the workplace influence mind-set and attitude, leadership and management style and employee involvement. Therefore, guanxi is an important antecedent to green and lean practice for environmental performance. From a social capital perspective, guanxi networks reduce relational risk among actors, as a result of increasing the willingness of knowledge sharing regarding the green supply chain (Cheng, 2011).

The impact of guanxi networks is far more multifaceted, with both positive and negative effects on society (Chen et al., 2011). Zhuang et al. (2014) show that guanxi networks might have both of positive and negative impact on purchasers’ decision-making for ethical procurement, depending on the strength of guanxi policy. Conversely, Luo et al. (2015) indicate that a higher degree of guanxi among supply chain actors can reduce the willingness to implement green supply chain collaboration. Overall, however, there is insufficient evidence to conclude to what extent guanxi networks act positively or negatively towards sustainable practices in supply chains. This remains an opportunity for further investigation.

Meanwhile, different perspectives on the influence of guanxi networks on the “three pillars” of SCM were gathered in the second review (Table II). Guanxi networks have been particularly found to improve in economic performance, including a reduction in transaction costs (Hsu et al., 2011), increased market and business performance (Lobo et al., 2013) and financial profitability (Chen et al., 2011). Guanxi networks are believed to influence long-term business development. Based on an empirical study from Lobo et al. (2013), vegetable farmers show a tendency to trust and collaborate with buyers sharing the same guanxi networks.

A few studies have also captured some factors of social and/or environmental responsibilities (Table II). Cai and Yang (2014) showed the mediating role of guanxi networks in managers’ decision-making in green supply chain collaborations. Guanxi networks shaped stakeholders’ knowledge and perceptions to influence social and environmental policymaking (Hills and Man, 1998). Through collaboration among supply chain actors, guanxi stimulates the upgrading of technology to deal with waste and pollution (Hills and Man, 1998; Wang and Woods, 2013). Other relevant studies, including Michailova and Worm (2003); Ling and Li (2011) and Chen et al. (2013), have touched on the influence of guanxi networks on the implementation of social responsibilities. These fragmented studies suggest the need for further theoretical development into the influence of guanxi networks on sustainable SCM.

Through both of the literature reviews, this study found that current literature is focussed on environmental practices, consistent with other reviews of sustainable SCM (Carter and Easton, 2011; Gimenez and Tachizawa, 2012). However, sustainability is more than simply green or environmental management (Carter and Rogers, 2008; Seuring and Muller, 2008). Therefore, this field needs further elaboration; environmental, social and economic responsibilities must be simultaneously considered in the context of social networks and SCM.

Table II: Studies of guanxi in SSCM from the review of guanxi in SCM

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Selected authors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impacts on economic performance</strong></td>
<td></td>
</tr>
<tr>
<td>Market performance</td>
<td>Chen et al. (2011), Lobo et al. (2013), Hsu et al. (2011)</td>
</tr>
<tr>
<td>Financial profitability</td>
<td>Chen et al. (2011)</td>
</tr>
<tr>
<td>Business performance</td>
<td>Lobo et al. (2013)</td>
</tr>
<tr>
<td>Cost efficiency and effectiveness</td>
<td>Lobo et al. (2013), Hsu et al. (2011)</td>
</tr>
<tr>
<td>Administrative protection</td>
<td>Hsu et al. (2011)</td>
</tr>
<tr>
<td>Economic performance</td>
<td>Hsu et al. (2011)</td>
</tr>
<tr>
<td>Business opportunities</td>
<td>Ling and Li (2011)</td>
</tr>
<tr>
<td><strong>Impacts on social equity</strong></td>
<td></td>
</tr>
<tr>
<td>Substantial rewards</td>
<td>Michailova and Worm (2003); Park and Luo (2001)</td>
</tr>
<tr>
<td>Customer satisfaction</td>
<td>Luo et al. (2011)</td>
</tr>
<tr>
<td>Employee satisfaction</td>
<td>Hong and Engstrom (2004)</td>
</tr>
<tr>
<td>Harmony of the community</td>
<td>Ling and Li (2011)</td>
</tr>
<tr>
<td>Local residents’ health</td>
<td>Wang and Woods (2013)</td>
</tr>
<tr>
<td>Relationship quality with stakeholders</td>
<td>Chen et al. (2013)</td>
</tr>
<tr>
<td>Social satisfaction</td>
<td>Chen et al. (2011)</td>
</tr>
<tr>
<td>Employee working environment and human rights</td>
<td>Herndon (2008)</td>
</tr>
<tr>
<td><strong>Impacts on environment</strong></td>
<td></td>
</tr>
<tr>
<td>Influences implementation and environmental policymaking system</td>
<td>Hills and Man (1998)</td>
</tr>
<tr>
<td>Upgrade technology to deal with wastewater</td>
<td>Hills and Man (1998)</td>
</tr>
<tr>
<td>Wastewater, waste gap pollution</td>
<td>Wang and Woods (2013)</td>
</tr>
</tbody>
</table>

Source: Authors

4.2 The constructs of guanxi

In the review, the constructs of guanxi networks were deductively developed from previous studies (Hwang, 1987; Park and Luo, 2001), comparing and contrasting terminologies in Western studies of social network theory (Table III). The constructs of guanxi networks include four dimensions – renqing, ganqing, xinren and mianzi – and the presence of each of these within the selected papers was examined (Appendix 3).

Renqing (i.e. reciprocity) is the most common dimension examined in SCM research as reciprocation and exchanging behaviours are fundamental human social processes (Robins, 2015). It is the owing of a favour (Leung and Wong, 2001); when people offer renqing, they often expect to receive a favour in turn. The notion of exchanging mutual favours and reciprocity becomes a motive for building business guanxi (Chen et al., 2011; Yen et al., 2010). As such, renqing includes reciprocity, obligation, favours, behavioural exchange and dependency. Reciprocity generates transactional benefits in a type of bilateral governance of dependency and behavioural exchanges (Zhuang et al., 2010; Park and Luo, 2001). It then implies a social mechanism for accessing desirable resources
among a stable and structured social network. In social network studies, reciprocation and exchanging behaviours are fundamental human social processes (Robins, 2015). Justice orientation is a moral vision which draws attention to reciprocity and equal respect (Heimer, 1992). In this regard, reciprocity is less likely to be hierarchical in its function of offering and receiving favours (Hwang, 1987); however, the influence is significant in deepening and strengthening the buyer-supplier relationship in SCM (Luo et al., 2015).

**Ganqing** is similar to the context of care orientation in social network studies. It means individuals’ mutual empathetic understanding, affection, sharing and emotional identification (Yang, 1994; Yen et al., 2011). It is the other moral injunction of drawing attention to people’s needs and responding with care (Heimer, 1992). **Ganqing** describes the quality of a relationship between interactions (Barnes et al., 2011; Chen and Chen, 2004; Yen et al., 2011). Barnes et al. (2011) statistically tested the role of ganqing in cooperation and coordination in SCM and found that ganqing positively influences cooperation between buyers and suppliers, which drives satisfaction and SCM performance. Both mechanisms – justice orientation and care orientation – require people to treat others fairly and not ignore other’s needs to continually sustain good guanxi networks.

**Xinren** refers to trust and trustworthiness (Chen and Chen, 2004; Yen et al., 2011). Findings from the review show that trust is the central value in guanxi networks and has been mostly emphasised in business practices. Cai et al. (2010) used structural equation modelling to analyse collected data from 398 Chinese organisations and observed the importance of how guanxi affects trust between players, which positively impacts information sharing. In social networks, it is morally right to be trustworthy in economic life (Granovetter, 1992). Distrust, opportunism and disorder do not disappear in social networks, but the trust embedded in relationships leads individual behaviours to conform to predictable patterns. Good guanxi ties increase predictability with traits such as consistency, responsibility and benevolence (Jeffries and Reed, 2000; Ring and Van de Ven, 1994), resulting in smoother transaction arrangements (Wiegel and Bamford, 2015) and the reduction of behavioural opportunism (Lu et al., 2009).

**Mianzi** is a crucial concept in Confucian cultures, in which individuals’ respect, pride and dignity are important within a stable and structured social network. In social network studies, reciprocation and exchanging behaviours are fundamental human social processes (Robins, 2015). Justice orientation is a moral vision which draws attention to reciprocity and equal respect (Heimer, 1992). In this regard, reciprocity is less likely to be hierarchical in its function of offering and receiving favours (Hwang, 1987); however, the influence is significant in deepening and strengthening the buyer-supplier relationship in SCM (Luo et al., 2015).

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**Table III: Four dimensions of guanxi**

<table>
<thead>
<tr>
<th>Terms</th>
<th>Definitions</th>
<th>Terms in social network study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rengqi</td>
<td>Similar to the concept of owing favours or reciprocity (Chen and Chen, 2004)</td>
<td>Reciprocity</td>
</tr>
<tr>
<td>Ganqi</td>
<td>Implies affection, sentiment, and emotion (Yen et al., 2011)</td>
<td>Care orientation</td>
</tr>
<tr>
<td>Xinren</td>
<td>Relating to trust (Chen and Chen, 2004)</td>
<td>Trust</td>
</tr>
<tr>
<td>Mianzi</td>
<td>“Face”, “facework”, impression management (Hwang, 1987)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Source:** Authors

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Although previous studies have investigated guanxi through the lens of social network theory (Hammond and Glenn, 2004), this study contributes by exploring the constructs of social networks further, providing a clearer picture of what guanxi networks are and why they matter in managing supply chain issues. In social network studies, the constructs of trust, reciprocity, justice orientation and care orientation are reflected as xinren, renqing and ganqing in guanxi networks. Likewise, guanxi networks are shaped in specific institutional environments and influenced by individuals’ reputations and powers within the networks (Chang, 2011). However, guanxi networks extend the constructs of social network studies with the consideration of mianzi. Mianzi and “face” giving are essential in Confucianist culture, meaning those within the same social networks must help to prevent each other from losing face. An individual’s mianzi shows how much social power, perceived social position and prestige he or she controls

*Figure 2: The constructs of guanxi networks*
(Hwang, 1987). Therefore, having significant mianzi indicates a strong network position, which increases the tolerance level for uncertainty in supply chains (Cai et al., 2010). There is a need to further explore mianzi and its impacts on SCM decision-making.

4.3 The influence on supply chain capital
When discussing the influences of guanxi networks, there is a lack of consensus on whether guanxi remains important when institutional environments are becoming more transparent (Standifird and Marshall, 2000). The movement to eradicate corruption and bribery from government might create more sensitivity when interacting with officers (Gabriel and Zhao, 2012). But in the business environment, it is naive to draw a clear line between formal contracts and social networks. Granovetter (1992, p. 33) argued that “economic action and outcomes, like all social action and outcomes, are affected by others” dyadic (pairwise) relations and by the structure of the overall network of relations’. Hammond and Glenn (2004) explain, from a social network perspective, how the embeddedness of guanxi created order and predictability through a set of relations including weak ties and strong ties to stabilise the flow of information among ties and allow for adaptation to incremental change. Therefore, this study has taken a social network view and attempted to examine the impact on supply chain capital and sustainability implementation in SCM.

This study has found that guanxi networks influence the flow of social, financial and human capital in SCM, linked to Burt’s (1992) study in social network study (Appendix 4). Social capital lies in relations among people, identifying “certain aspects of social structures by their functions” (Coleman, 1988, p. S101). The review shows that guanxi networks substantially influence the flow of social capital in a supply chain. Guanxi networks encourage the exchange of trust, benefits and reciprocity among various stakeholders, including customers, suppliers, work competitors, government institutions and communities. As a result, interpersonal relationships and interactions enhance communication and understanding within supply chains (Cai and Yang, 2014). Cheng et al. (2012) and Yang and Wang (2011) further argued that good guanxi networks in supply chain drive long-term supply chain efficiency and development. These develop and increase confidence in relationships and encourage positive attitudes towards supply chain integration (Nonini, 2014) and collaboration (Ramasamy et al., 2006; Wang et al., 2016), thereby improving organisations’ capability to respond to customers and solve supply chain problems (Wiegela and Bamford, 2015). Not only do guanxi networks promote integration and collaboration in supply network, a high level of guanxi drives close alliances and partnerships between competitive organisations. For example, Wong and Tjosvold (2010) have collected data from 100 paired competitors in China and found that a high level of guanxi networks can reduce conflicts by encouraging cooperation rather than a competitive approach.

Among the constructs, trust plays a central role in in operational and risk management in SCM. There is consistency amongst papers identified in the review that continuous and consistent interactions cultivate trust to enable a bilateral flow of social transactions and encourage the exchange of information in operational and contractual arrangements (for example, see Ling and Li, 2011 or Ranfagni and Guercini, 2014). This can lead to improved supplier performance (Cheng et al., 2012). Guanxi networks and trust were addressed in domestic business to reduce institutional and operational risks (Berger and Herstein, 2015; Cai and Yang, 2014; Wong, 2010). Ranfagni and Guercini (2014) have also examined the role of guanxi networks to foreign companies. They conducted a case study of the Ferrero Group in China and argued that trust can reduce relational risks between foreign firms and local distributors. Based on the evidence from the review, we argue that trust is a universal context rather than specialised in a particular society, even though the actions of behaving trustworthy could be socially constructed.

Observations in this study show a clear link of guanxi network and financial capital flow in SCM. Financial capital consists of the economic resources used by companies to produce and serve their customers’ needs, including factors such as cash in hand, investments and lines of credit (Burt, 1992). This study has considered the supply chain functions and strategic goals which drive for financial capital ultimately. Guanxi networks smooth transactions and reduce operational costs in supply chain activities, which encourages actors to setup long-term strategic planning for supply chain effectiveness and efficiency (Berger and Herstein, 2015; Chung et al., 2015; Dorothy et al., 2007; Jia and Zsidisin, 2014; Fearon et al., 2013).

Sustained guanxi networks ease the process of procuring necessary resources (Ramasamy et al., 2006; Chen and Wu, 2011). Chen and Wu (2011) drew on the insights from social capital theory and, following a survey of 409 firms in China, claimed that guanxi with business partners plays an important role in resource acquisition as a corporate capability. In addition, as a type of social capital, guanxi networks facilitate firms’ access to tangible materials and intangible information regarding local supply and demand (Chan, 2008; Chen et al., 2013). Besides, mutual understanding and interdependency with suppliers drive flexibility and transparency in procurement processes. Giannakis et al. (2012) conducted two surveys and intended to investigate factors that inhibit effective supplier relationship management from Chinese suppliers for Western firms. In their results, guanxi affected the sourcing processes, including supplier search and negotiation process, and the type of contract to be signed for. Similarly, Kam and Chen (2011) found that guanxi networks in buyer and supplier relationships influence order quantities for the sourced products.

In the global supply chains, it is essential to coordinate dispersed supply and manufacturing to achieve efficiency and responsiveness. Often, this is affected by logistics competence and the evidence is mixed on whether guanxi has an influence or not. Previous studies show that in Chinese supply networks, guanxi must be acknowledged in dealing with factors for global logistics competence, including factors in IT infrastructure capacity, manufacturing flexibility, and asset specificity (Li and Lin, 2006). Gabriel and Zhao (2012) further argued that guanxi networks could improve logistics and service performance. Good guanxi in supply network helps firms to acquire timely deliveries, ordering, forecasting (Chen and Wu, 2011; Giannakis et al., 2012) and enriches a company’s knowledge pool about customers (Chen and Wu, 2011). However, critical
views posited that guanxi networks themselves do not directly affect global logistics competence and performance, and it remains uncertain the extent a strong guanxi culture can foster logistics competence in a global context (Li and Lin, 2006).

Besides, good personal relationships between staff and customers raise awareness of the latter’s needs. Organisations can then satisfy customers by, for example, producing specialised products and delivering just-in-time (Lu et al., 2009). Thereby, companies fulfil customers’ needs better than their competitors and mitigate switching behaviour by customers (Hsu et al., 2011). Though interpersonal relations occur at an individual level, Gu et al. (2009) argued that, by understanding and managing the boundary-spanning process, organisations can “corporatize” interpersonal connections into corporate relationships and transfer interpersonal trust to interfirm trust. After long-term and harmonious interactions, it is likely that actors will establish strategic goals to configure supply chains (Park and Luo, 2001) with an emphasis on market effectiveness (Chen and Wu, 2011), supply chain flexibility and operational efficiency (Lin et al., 2012).

Guanxi networks also increase the flow of human capital in SCM. Human capital refers to the skills and working capabilities available for certain tasks (Burt, 1992). It is less tangible and embodied in the skills and knowledge for individuals. Coleman (1988) argues that human capital is created in social capital in the family and community, facilitating productiveness in the workplace. In SCM, human capital is inherent with information and IT technique to improve employees’ practicing skills and working capabilities. Based on mutual trust and reciprocity, guanxi networks encourage information sharing and technology integration in supply chains. Chen et al. (2015) revealed that familial and government ties improve information associability and resource availability, facilitating support for entrepreneurial success, especially in creative industries where guanxi with political leaders influences new investment ventures. Likewise, Cai et al. (2010) found that guanxi affects information integration by building trust with trading partners. Through guanxi networks, information and technical support, such as technical innovation and manufacturing technologies, are shared and transferred from a company’s staff to its customers and/or suppliers (Luk et al., 2008). This then improves employees’ working capabilities to ensure product quality (Wiegel and Bamford, 2015) and production effectiveness (Chang, 2011; Choi et al., 2012; Ling and Li, 2011). These studies make the argument for the central role of trust in enabling knowledge transfer and information security, as discussed previously.

Good interpersonal relationships between managers and staff represent harmonious relationships between firms and their employees. Through efficient communication and shared understanding, guanxi gradually cultivates synergistic sentiments among staff members, enhancing cooperating behaviours and institutional loyalty (Wong et al., 2001). Therefore, relational risks in employee management could be mitigated (Chen et al., 2013). Furthermore, driven by emotional commitments, managers are more likely to provide training to improve technical skills (Kam and Chen, 2011), resulting in increased employee working capabilities. It is mutually beneficial for both the companies and their employees. Companies can increase their SCM performance and reduce labour costs through sufficient employee management (Choi et al., 2012), while employees have a better working environment and more opportunities for obtaining training and improving their working capabilities.

However, to some extent, the practice of guanxi networks and the experience of increasing flow of human capital in SCM could be specialised in individual cases. Hsu et al. (2011, p. 488) illustrated that foreign firms face disadvantages with networking in China due to cultural and language barriers. For domestic private firms, compared to government-owned companies, the primary advantage is “flexibility”. With fewer restrictions due to rigid financial rules, executives of domestic firms have more freedom to build relationships through guanxi and, therefore, gain higher returns from managerial ties.

Human capital can also enhance financial capital (Figure 3). Supplier management is closely linked with the social capital of buyer and supplier relationships. However, studies have emphasised how guanxi networks improve the capability of suppliers to enhance their operations performance. Lobo et al. (2013) conducted an empirical study proving that vegetable growers can effectively use good interpersonal relationships to reduce waste and improve the quality and safety of their products. Hsu et al. (2011) collected in-depth interviews with top executives from economy hotel chains headquartered in China and claimed that guanxi, functioning as managerial ties, facilitates high-quality products and services offered by employees (Hsu et al., 2011). Good relational ties between employees also drive productivity and product development (Ling and Li, 2011). Empirical studies show that guanxi networks harmonise working environments and reduce internal conflicts, leading to better performance in a variety of contexts, including lean production (Wong, 2010), enterprise resource planning (ERP) implementation (Choi et al., 2012) and mass production (Chung, 2005). Therefore, the social capital of good relationships between players significantly influences actors’ behavioural performances and yields financial capital at the organisational level.

SCM studies have raised awareness of the contribution of network and network analysis (Capo-Vicedo et al., 2010). The goal of studying a social network is to explain why networks benefit, in particular, from effectiveness and efficiency in SCM (Borgatti and Li, 2009). High-quality personal ties reduce opportunistic behaviours and promote long-term cooperation

**Figure 3** The impacts of guanxi networks in SCM

![Image of guanxi networks in SCM](image-url)
and collaboration. Sometimes, close links between individuals are criticised for increasing risks due to locked-in and inappropriate management decision-making (Chen et al., 2011; Shou et al., 2011). The flow of supply chain capital could be substantially increased by firms considering relationships within a network as a whole, rather than being locked-in to dyadic relationships with specific suppliers/customers.

Herfindahl and Kneese (1974) raised the importance of human capital to increase productivities and manufacturing outputs. This perspective was later consolidated by Victor (1991) to embrace the three elements of sustainability. Increasing supply chain capital flow enhances a company’s capability to implement sustainable SCM and to efficiently use manufactured capitals to substitute for vast consumption of natural capitals. Guanxi networks embed supply chain capital flows in business dealings, although the current research gap has not yet indicated how the flows of capital linked to guanxi network embeddedness can lead to the implementation of sustainable SCM. The purpose of this study is to bridge this gap, further exploring sustainable SCM implementation.

5. Theoretical framework building of guanxi networks in sustainable supply chain management

Theoretical framework building in this section is supported by both the underpinning literature derived from social network theory and the findings from the systematic literature reviews (i.e. constructs of guanxi networks and supply chain capital).

5.1 Institutional forces for sustainable supply chain management

Jones et al. (1997) argued that, without any particular institutional logic, a social network does not indicate any meaning of a network – a social network is the carrier for institutional logics. In emerging markets, motivations to pursue sustainable SCM include pressures from stakeholders and institutions (Zhu et al., 2013). Such institutional forces create an institutional logic of sustainable SCM implementation in social networks because all organisations are embedded within the complexity of relational and institutional contexts (Owen-Smith and Powell, 2008). The elaboration of social networks rapidly spread the institutional logic to various models of connections (DiMaggio and Powell, 1983), influencing sustainable SCM implementation in decision-making and organisational behaviours. This argument has been reflected in the study from Zhuang et al. (2014) which found that guanxi influences actors’ decision-making for ethical purchasing. Hence, the social network is the carrier of institutional forces for sustainable SCM. In other words, individual behaviours and decision-making are shaped by macro-institutional requirements. Therefore (Figure 4), we assert the following:

P1. Due to the institutional forces of sustainable SCM, guanxi networks carry institutional logics and imbue them into people’s consciousness within the network connections.

5.2 Supply chain capital flow in guanxi networks

The impacts of the extension of individuals’ friendship networks are the diffusion and spread of diverse phenomena, information and opportunities within the constructed social networks (Granovetter, 1973; Christakis and Fowler, 2007). As shown in Section 4.3, guanxi networks drive the effective and efficient flow of finance, human and social capital in supply chains. The feature of transferability in guanxi networks enables network extensions and the flow of supply chain capital (Figure 5). Supposing that guanxi ties A-B and A-D exist, A could act as a bridge to introduce B and D. Likewise, A could be connected to E and C through D and B, respectively. In guanxi literature, this is called transferability (Park and Luo, 2001), while in social network studies, it is called the connection of weak ties (Granovetter, 1973). The consequence of weak ties (such as E-C) would be more and shorter paths from the creation of the local bridge (such as A-E and A-C) (Granovetter, 1973). Capital flow along these pathways in both directions, even though there is not always a balance between them. Through network transferability, companies and their supply chains, on one hand, could better obtain the necessary financial flow to support green SCM implementation (Cai and Yang, 2014), such as environmentally friendly products development, reverse logistics and product life-cycle control. On the other hand, the extension of network size and enhanced relational ties through guanxi reduce relational risk and uncertainty in supply chain relationships, which then encourages sustainable SCM collaboration (Luo et al., 2015) and stimulates enhancement of human capital in knowledge and technology sharing (Cheng, 2011). Therefore, we develop the following proposition:

P2. The flow of SC capital in guanxi networks enhances firms’ capabilities to respond to the institutional force of sustainable practices, resulting in enhanced sustainable SCM implementation.

5.3 Influence of trust in guanxi networks

The systematic review highlighted trust as a key aspect in guanxi networks and the generation of xinren (trust) from ganqing (emotional affection), renqing (reciprocity) and mianzi (saving and building face), referring to Figure 2. In social network theory, trust links with the concept of social “generalised morality” (Granovetter, 1992), where relationship quality in stable social networks creates the general understanding and social morality of being trustworthy and willing to trust others (Levin and Cross, 2004). Trust is in the social justice and generalised morality of exchanging obligations and offering/returning renqing when guanxi partners require it. Besides, the higher the levels of ganqing and mianzi, the more possibility that one partner will trust another in practice. In this case, on one hand, a person could then build up their trust levels and cultivate social capital; on the other hand, social justice could be generated for relational governance in guanxi networks – once someone breaks the hidden rule, the cost of misfeasance
is fairly expensive, and it is difficult to rebuild social networks (Granovetter, 1985; Park and Luo, 2001).

Investment in sustainability can be specific and complex (Gimenez and Tachizawa, 2012), which can create hesitation and uncertainty for many companies considering investing in environmental and social responsibilities in SCM. Embedded trust among players does not reduce the risk and vulnerability involved in implementing sustainable SCM but increases the “willingness of a party to be vulnerable” (Mayer et al., 1995, p. 712). The structure of relationships and positions in a network shapes reciprocal influence and the scope of sustainability interactions as well as the depth of understanding, commitment and collaboration (Vurro et al., 2010). Through long-term interaction, players raise a certain degree of understanding and commitment among each other. Relational risks in inter-organisational relationships can be mitigated (Cheng, 2011), which then increases the trust level for players to integrate and collaborate for sustainable practices. For example, to reduce environmental impact, players can integrate logistics competency and research and development, share knowledge and upgrade technology. Demonstrating a reputable image and trustworthiness to different stakeholders, companies and their supply chains should provide a good working environment and fair practices, taking responsibility for the wellbeing of community and society. Ultimately, these initiatives would increase social sustainability. Therefore, we argue that:

P3. Trust in guanxi networks shapes the understanding of the institutional forces of sustainable practices, and mediates the willingness to implement and results from sustainable SCM.

5.4 Network governance in guanxi networks

Unlike authority, bureaucratic roles or institutional regulations, guanxi networks generate mechanisms that govern individuals' behaviours in terms of social selection. To be inclusively accepted in social networks, autonomous firms need to adapt, coordinate and safeguard exchanges (Jones et al., 1997). In social networks, people have a tendency to select relationships where they share similar attributes; this trend is termed “homophily” (Christakis and Fowler, 2007; Jones et al., 1997). If they share values and similarities, players are more likely to be included in guanxi networks. This is also influenced by the hierarchy constructs of ganqing and xinren (Mavondo and Rodrigo, 2001; Yen et al., 2011).

As discussed, guanxi networks increase the flow of supply chain capital and generate trust, which influences supply chain practices and performance substantially (Wiegel and Bamford, 2015). To remain informed of network economics, players need to be included as network insiders. In this case, a player ought to follow the social norms and institutional logics embedded in the social networks, which might consciously or unconsciously impact decision-making in SCM practices, such as supplier and customer selection, corporate codes of conduct and compliance for sustainability in value chains. As such, the governance of the guanxi social network is practiced by the “imposition of the rules of inclusion” (Castells, 2011, p. 775).

Another argument about network governance is that, through frequent interactions and communications, people share understanding and vision about sustainable SCM and reduce heterogenic behaviour in the social network (Christakis and Fowler, 2007). Companies that passively react to sustainable SCM tend to balance the trade-off of adaptation and coordination in sustainable SCM with their network members and the potential benefits embedded in the networks. Therefore, we propose the following:

P4. Guanxi networks create the governance mechanisms of social selection and network homogeneity to enforce supply chain practices towards institutional forces of sustainable practices, resulting in the increase of sustainable SCM implementation.
6. Discussion and implications

6.1 Discussion
Growing evidence shows the challenges of lacking corporate capitals while managing institutional and stakeholder pressures towards sustainable SCM (Vurro et al., 2010). Different approaches to sustainable SCM focus on organisational or transaction-specific situations, even though it is commendable to establish a wide range of considerations for sustainability in SCM (Carter and Jennings, 2004; Vurro et al., 2010). In the discussion of sustainable implementation and performance measurements in SCM, researchers call for the involvement of all actors to tackle sustainable supply chain issues, such as information asymmetry (Beske-Janssen et al., 2015; Sarkis, 2012), and to drive sustainability commitment. In emerging areas and transitions, improving accessibility for resources is crucial to assure quality standards and overcome supply chain problems (Dries et al., 2014).

This paper has shed light on the influence of social networks on sustainable SCM implementation. In this study, we have argued that guanxi networks increase the flow of supply chain capital for efficient and effective supply chain practices (Figure 5). This result addresses the second research objective for the paper. Observations show that the main types of capital influenced by social networks in supply chains are financial, human and social capital, within which social capital influences the flow of financial and human capital (Figure 3). These types of capital are necessary to increase the implementation of sustainable SCM under institutional forces and network governance. Consequently, a conceptual framework was built to meet the final objective of the paper.

Driven by guanxi networks, social capital with various stakeholders reduces uncertainty and risk in supply chain practices. Through efficient communication and behavioural exchanges, guanxi networks strengthen buyer and supplier relationships (Geng et al., 2017) and mitigate uncertainty for sustainable SCM implementation, including green SCM (Zhan et al., 2016) and green supply chain collaboration (Luo et al., 2015). The guanxi network is a hierarchical concept advocating long-term satisfaction from both sides (Hwang, 1987; Yen et al., 2011), which then cultivates prolonged relationships for reserving necessary capital and resources for sustainable SCM implementation.

Building up guanxi networks with stakeholder influence of financial capital in supply chain performance in procurement, production and services is a necessary part of logistics to achieve strategic goals. Social networks decrease transaction costs and so lead to financial gain (Chen et al., 2011). It is not necessary that every firm invest in sustainability practice when they enhance their financial capital; however, in many ways, business and supply chains struggle to show the financial merit of investments in implementing environmental and social responsibilities in a variety of intangible and tangible assets (Barnett, 2007). Therefore, sufficient financial capital is regarded as the fundamental condition to invest in implementing sustainability responsibilities in a supply chain.

The influence of human capital in sustainable SCM is mainly comprises knowledge and technical skills in improving working capabilities in supplier and employee management. Social network inheres opportunities to spread the technical skills and professional knowledge of sustainable SCM to a wider audience in supply chain networks. This raises awareness and increases behavioural commitment to the implementation of sustainable SCM. Supply chain capital is spread in social relations with repeated contact between people over a long period (Burt, 1992), meaning the flow of capital is more likely to be increased through the logic of "helping your friends is helping yourself". In reality, not all companies have knowledge of sustainable development or facilitate the capabilities of investing in sustainability (e.g. recycling materials or reducing CO2 emissions). The key players, who are not necessarily experts in the field but know more about sustainable SCM, could offer to help and show their willingness to do so by, for example, sharing relevant information (Hammond and Glenn, 2004).

Understanding what business is actually about is comprehensive. After building the relational bridge as Figure 5 shows, to what extent actors proactively engage in the flow of supply chain capital remained uncertain. According to Cox (1999), companies can only succeed by possessing their power and control over someone – customers, suppliers, employees or even social network members in the discussion here. Even though social networks mitigate power asymmetry, the flow of supply chain capital may not be equally distributed among supply chain actors – the actors possessing more power could dominate the flow of supply chain capital over other parties. For example, a company can dominate the financial flow in the social networks based on their economies of scale; or a focal company could decide the degree of sharing core information with their suppliers or customers. The discussion of guanxi networks and their impacts on flow of supply chain capital develop the insights of how interpersonal ties influence on supply chain practices. However, it is not a linear relationship when human factors involve.

Guanxi networks create the governance mechanism to constrain behaviour to the minimum requirements for performing sustainability in SCM. This is driven by the requirement of following the social norms of renqing, xinren and mianzi to secure transactional benefits and supply chain capital flow in networks. Conversely, companies positioned in the centre of networks with a certain density would initially participate in implementing and diffusing sustainable SCM due to institutional force and global competitiveness. Organisations would execute collaboration and integration across organisational boundaries to acquire resources embedded in the networks (Chen et al., 2011). To avoid behavioural heterogeneity, they would elect partners who share similarities and help “insiders” implement sustainable SCM with financial and human capital support.

A critique may call attention to a counter-factual case, such as “Are there any comparisons with sustainable businesses with no guanxi or equivalent?” or “Is it possible that guanxi networks can lead to non-sustainable business practices?” The first critique questions the relationship between interpersonal ties and formal governance mechanisms. Xin and Pearce (1996) argue that personal connections are substitutes for formal institutional support. According to their empirical results, particularly in private companies, executives sought to compensate for a lack of formal institutional support (such as financial support from banks) by cultivating personal networks. This is consistent with a study by Hsu et al. (2011), which
shows that private companies tend to be more flexible in using the resources of social networks. Therefore, private companies might find the developed model in Figure 4 more applicable to making good use of personal connections for cultivating trust and increasing supply chain capital flows in the networks for sustainable SCM implementations. State-owned companies and foreign companies, though, seem to rely less on personal networks, and they might face more pressure from institutional forces in implementing sustainable practices. However, regardless of firm ownership, it is naïve to draw a clear boundary between the influences of social networks and formal governance. Heimer (1992) argues that helping one’s friends and colleagues can increase productivity for one’s organisation and its supply chains. Therefore, interpersonal relationships will always exist when people interact with each other within and across organisational boundaries.

The second critique questions the possibility of guanxi networks causing non-sustainable business practices. Such evidence, as identified from the systematic review, suggests that the answer is yes. Luo et al. (2014) found that guanxi networks can reduce the willingness to implement green supply chain cooperation, though most studies have shown the opposite. A high level of guanxi may require investment of more time and money in cultivating relationships. The dark side of guanxi could be linked with bribery, corruption and high social costs (Chen et al., 2011). Because of these possibilities, this study considered the institutional force of sustainable development in its model. In the short term, firms might take advantage of guanxi networks to achieve economic goals; however, in the long run, under the institutional pressures of sustainable development, practitioners would cognitively select those who share similar values of sustainability to sustain economic development.

6.2 Implications

6.2.1 Social network theory and the impact on sustainable supply chain management

For academic research, this paper first extends the construct of social network theory from the Western context. Without understanding the constructs of guanxi networks, it is difficult to interpret the mechanisms underpinning business and supply chain practices from a social network perspective in Confucianist culture. In Western literature, driving factors for network connectedness usually rely on reciprocity, trust and care in some conditions (Heimer, 1992) while, in Confucianist culture, ganqing and mianzi play essential roles in guanxi networks used to sustain long-term relationships and enhance social influence. We also found that ganqing, renqing, xinren and mianzi are interconnected (Figure 2). From this perspective, the development of trust could be enhanced by exchanging renqing and ganqing among individuals and increasing reputation and mianzi in a society. Social capital and trust have been widely studied in supply chain literature (Cheng et al., 2011). This review provides insight into building and taking advantage of social networks and their constructs in Confucian societies to support supply chain collaboration and sustain supply chain performance. This study has also attempted to fill the current research gap with regard to sustainable SCM. Literature reviews (Touboulc and Walker, 2015) show that the social network perspective of behavioural commitment to sustainable SCM is lacking in insight and that social network research is called for (Wichmann and Kaufmann, 2016). Sustainable SCM requires involvement from players thorough the supply chain (Tachizawa and Wong, 2014); however, how to generate this effort remains unspecified in the literature. This study offers an alternative answer: through increasing the flow of supply chain capital, including financial, human and social capital, a company can increase its capability and collaboration in investment in environmental and social responsibilities in the supply chain. In additional, social networks play a complementary role to institutional forces in creating network governance of encouraging organisational behaviour and supply chain practices to implement sustainable development.

In addition, global SCM is rather complex and embraces many cultures, In China and in other emerging areas, such as the Middle East, Brazil and Russia, social networks play an important role in dealing with local stakeholders and institutions (Abosag, 2015; Abosag and Naude, 2014; Chen et al., 2010). Testing the framework in these alternative environments would show the wider generalisability of the propositions and whether cultural uniqueness exists with regard to SCM.

6.2.2 Implementation through managerial practice

Guanxi networks exist objectively and significantly influence SCM observations. By taking advantage of interpersonal ties, companies can gain necessary supply chain capital and increase the flow of capital in the social network, which then enhances the companies’ capabilities in dealing with supply chain issues, including sustainability development. Currently, sustainable SCM is yet to be institutional and stakeholder driven (Carter and Easton, 2011). However, research has indicated that investing in sustainability practice, such as corporate social responsibility, has yielded beneficial financial performance to some extent (Barnett, 2007). Proactively implementing sustainable SCM helps a company to gain a competitive advantage and ultimately enhance its economic performance. The value of implementing sustainable SCM is clear, and this study explains how (through the flow of supply chain capital and trust in social networks) and why (through institutional force of sustainability development) a company and its supply chain ought to implement environmental and social responsibility apart from simply pursuing economic accountability in the long run.

Practitioners also need to be aware that, in weak institutional environments, materialisation and gift-giving occurs to directly exchange renqing, which is considered corrupt, immoral and against company procedures in using guanxi (Huang et al., 2011). Therefore, it is necessary to ensure that behaviours comply with legal regulations and company principles. However, reciprocal benefits for practitioners can also be obtained through ganqing, xinren and mianzi, as addressed in Figure 2. However, given that ganqing, xinren and mianzi are hierarchical processes, actors need to cultivate them during every interaction. As previously noted, ganqing is closely linked with a care orientation in western networks, thereby embracing empathy and care are important for relationship development.

One’s prestige and reputation in the society relates to Mianzi and Hwang (1987) has given a thorough discussion of the power of mianzi in Confucius culture. To increase mianzi and
social influence, companies and practitioners need to behave trustworthy while sincerely caring for people and the society. Michelon (2011, p. 79) argued that “a company’s reputation is a determinant of sustainability disclosure”. In other words, implementing sustainable SCM can enhance corporation reputation, which then empower mianzi for employees from the corporation. Xinren is fundamentally important for relationship management in either the East or West as discussed. It is necessary to behave trustworthy and be responsible for the network members. Therefore, by facilitating the knowledge of the constructs of guanxi networks, actors could be more proactive towards relationship building and engagement in daily business activities and avoid unethical practices.

7. Conclusions

By reflecting the social network perspective put forward by Granovetter (1973, 1992) and Burt (1992), this paper considers how social networks can support the implementation of sustainable SCM. Social networks are socially constructed and, while found in many cultures, there has been a focus on Confucian cultures, and specifically guanxi networks. The systematic literature reviews have provided insights into the current state of the art in the constructs of guanxi networks and their influence on the flow of supply chain capital and sustainable SCM. The constructs of social networks in Confucian cultures are reflected as ganqing, renqing, xinren and mianzi, which affect supply chain practices substantially. Regarding to the research topic, there is a good range of research that address the influence of guanxi networks on the flow of supply chain capital, namely, social, financial and human capital, but a paucity of work that considers sustainable SCM explicitly. General works cover some aspects of sustainable SCM, but opportunities remain for exploring these aspects in more depth.

The proposed theoretical framework and propositions give awareness of how formal institution and personal ties affect the implementation of environmental and social practices in a supply chain. Institutional forces for sustainability have provided the logic of sustainable practices in SCM, whereas implementations in different regions are socially embedded. Research calls for the acknowledgement of the uncertainty adhered in a complex environment (Alexdander et al., 2015). The framework is inherent with this complexity, finding ways to increase network economics, trust and network governance for companies and their supply chains to implement environmental and social practices.

This study makes three main contributions. First, a systematic review of the constructs of guanxi networks extends the context of social network theory from Western literature. This shows the value and necessary approach to building and maintaining guanxi ties in Confucian culture to leverage business and supply chain performance. Second, the study reveals the logic of building trust and increasing supply chain capital flow in social networks. This is essential for assurance of business operation and strategic planning for long-term corporate goals. Finally, by understanding the mechanisms of sustainable SCM implementation from a guanxi network perspective, this study provides propositions through which to develop the research area.

Being conceptual in nature, this paper draws on secondary empirical evidence to support its arguments. This represents a limitation, and further research could draw on empirical evidence to test the proposed propositions. The next phase in the research would be to examine further the conceptual framework addressed in Figure 4. Four propositions have been developed with detailed constructs of the variables (e.g. the flow of three capital in supply chains), which supports the development for various quantitative tests. Survey and social network analysis could be adopted to discuss on how the constructs of guanxi influence the network structures, including centralisation and density, and how this affects the levels of flow of supply chain capital and SCM performance. Drawing on the influence of firm ownership (Xin and Pearce, 1996), moderating tests could establish whether guanxi networks influence sustainable SCM practices more in domestic firms than in foreign-owned companies. These developments reflect on the complex nature of business environment as discussed in Section 6.1.

In addition, investigating the underlying mechanism of implementing sustainable practices requires in-depth insights from qualitative studies, such as case study or ethnography. For instance, is there alignment between the description of social sustainability by companies and the interpretation of this from their employees? How social networks impact on sustainability disclosure and under what circumstances do companies empower their employees and suppliers to drive sustainable SCM? Researchers should also consider how to observe the negative aspects of guanxi, and whether questioning through conventional methods will generate insights.

Finally, the circular economy is another emergent topic in sustainable SCM that requires a high degree of integration in supply chains (Ghisellini et al., 2016). Given that the literature suggests guanxi networks stimulate recourse and relational integrations in SCM (Cat et al., 2010; Nonini, 2014), further research could be developed to investigate the influence of social networks on the performance of the circular economy.

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### Sustainable supply chain management

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Fink, A. (2005),
Dorothy, A.Y., Yu, Q. and Bradley, R.B. (2007),
Grannovetter, M. (1992),
Fearon, C., Yang, J. and McLaughlin, H. (2013),
Dries, L., Gorton, M., Urutyan, V. and White, J. (2014),
Fenton, C., Yang, J. and McLaughlin, H. (2013),
Herfindahl, O. and Kneese, A.V. (1974), Natural Theory of Natural Resources, Charles E. Merill, Columbus, OH.


Further reading


Appendix 1

Table AI  Research protocol of the literature review I

<table>
<thead>
<tr>
<th>Research protocol</th>
<th>Context: set of “sustainable SCM” and guanxi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducts of review</td>
<td>Descriptions</td>
</tr>
<tr>
<td>Publishers and database</td>
<td>Scopus and ABI</td>
</tr>
<tr>
<td>Publication type</td>
<td>Peer-reviewed papers only: These papers represent the final stage of completion</td>
</tr>
<tr>
<td>Language</td>
<td>English only: this ensures the wide range of coverage, while avoiding heterogeneity in translation. Also, this ensures transparency and the ability to replicate the review</td>
</tr>
<tr>
<td>Data range</td>
<td>Exploring all peer-review papers published in all date range</td>
</tr>
<tr>
<td>Search terms and Search fields</td>
<td>(TITLE-ABS-KEY (guanxi) AND TITLE-ABS-KEY ( green OR ( environment* OR sustainab* OR ethic* OR responsib* OR &quot;triple bottom line&quot; OR &quot;ecol&quot; ) ) AND TITLE-ABS-KEY ( &quot;supply chain&quot; OR ( supply OR purchasing OR procurement ) ) )</td>
</tr>
</tbody>
</table>
| Exclusion criteria | In total, 15 papers were circulated in Scopus and ABI. Exclusion criteria include:
1) duplicated papers from the database;
2) Relevance to the research topic. For example, some papers appear “environmental” in the searching areas but it is irrelevant |

Source: Authors

Appendix 2

Table AII  Research protocol of the literature review II

<table>
<thead>
<tr>
<th>Research protocol</th>
<th>Context: set of “SCM” and guanxi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducts of review</td>
<td>Descriptions</td>
</tr>
<tr>
<td>Publishers and database</td>
<td>Elsevier (Science Direct), Emerald, Taylor &amp; Francis, Sage and Wiley: publishers which covered the most relevant management journals while not filtering out other related sources</td>
</tr>
<tr>
<td>Publication type</td>
<td>Peer-reviewed papers only: These papers represent the final stage of completion. There is no restriction on the journals included because this is an international research topic which could be published to audiences with various interests</td>
</tr>
<tr>
<td>Language</td>
<td>English only: this ensures the wide range of coverage, while avoiding heterogeneity in translation. Also, this ensures transparency and the ability to replicate the review</td>
</tr>
<tr>
<td>Data range</td>
<td>After running initial search, no major studies were published before 1995. Therefore, the data range started from 1995</td>
</tr>
<tr>
<td>Search terms and Search fields</td>
<td>Supply (OR logistics OR procure* OR production OR inventory OR warehouse* OR manufactur*) in all fields AND “guanxi” in title, abstract or keywords</td>
</tr>
<tr>
<td>Exclusion criteria</td>
<td>This approach captures a full picture of the influence of guanxi in a broad range of supply chain functions</td>
</tr>
<tr>
<td>#1 Semantic relevance to the research topic</td>
<td>In the subject area selections, some topic areas are less relevant to the research topic, such as engineering, medicine, chemical engineering and could therefore be excluded directly in the sample</td>
</tr>
<tr>
<td>#2 Relevance to the research problem</td>
<td>However, some areas, such as social science, psychology and humanities, could be relevant to the research topic depending on the contents of individual studies. In this case, the authors checked each paper one by one to select the most relevant to the research topic</td>
</tr>
<tr>
<td>Exclusion criteria</td>
<td>In some cases, even though papers cover both research themes in the relevant topics, they did not provide evidence showing the interaction between two themes. Therefore, efforts were made to exclude such cases as they provide limited knowledge contributing to the research objects of this study</td>
</tr>
</tbody>
</table>

Source: Authors
### Appendix 3

#### Table AIII  Constructs of guanxi networks

<table>
<thead>
<tr>
<th>Clusters</th>
<th>Definition</th>
<th>Included aspects</th>
<th>No. of papers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renqing</strong></td>
<td>People within interpersonal relationships expect reciprocity concerning</td>
<td>Reciprocal expectation, utilitarian</td>
<td>153</td>
</tr>
<tr>
<td>Reciprocity</td>
<td>equity and the exchange of favours</td>
<td></td>
<td>62</td>
</tr>
<tr>
<td>Obligation</td>
<td>Informal relationships require one to fulfil obligations in the form of</td>
<td>Social obligations</td>
<td>44</td>
</tr>
<tr>
<td>Favour</td>
<td>reciprocation of gifts and favours</td>
<td>Favouritism, indebtedness, personal favours</td>
<td>38</td>
</tr>
<tr>
<td>Behavioural</td>
<td>This refers to the exchange of favours to promote cooperation and</td>
<td>Mutual impacts, mutual benefits, personal</td>
<td>9</td>
</tr>
<tr>
<td>exchanges</td>
<td>shared social experience among individuals</td>
<td>exchanges</td>
<td></td>
</tr>
<tr>
<td><strong>Ganqing</strong></td>
<td>People within interpersonal relationships expect reciprocity concerning</td>
<td>Reciprocal expectation, utilitarian</td>
<td>106</td>
</tr>
<tr>
<td>Emotional closeness</td>
<td>equity and the exchange of favours</td>
<td>Human affection, human sympathy, interpersonal harmony</td>
<td>78</td>
</tr>
<tr>
<td>Commitment</td>
<td>This refers to the confidence for the exchange within the partner and the</td>
<td>Protection, shared interests, cooperation,</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>willingness to take risks</td>
<td>long-term orientation, longevity</td>
<td></td>
</tr>
<tr>
<td><strong>Xinren</strong></td>
<td>This refers to the confidence for the exchange within the partner and the</td>
<td>Interpersonal trust, trusting relationships</td>
<td>130</td>
</tr>
<tr>
<td>Trust</td>
<td>willingness to take risks</td>
<td></td>
<td>109</td>
</tr>
<tr>
<td>Credibility</td>
<td>Credibility between individuals can increase trust, reliability and</td>
<td>Social reputation, assurances</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>reputation</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mianzi</strong></td>
<td>Saving “face” includes a set of behaviours aimed at preserving one’s own</td>
<td>saving face</td>
<td>46</td>
</tr>
<tr>
<td>“Facework”</td>
<td>and the other’s dignity</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>One party who is dependent on its partner’s resources and capabilities</td>
<td>Interdependency</td>
<td>33</td>
</tr>
<tr>
<td>Dependency</td>
<td>values the relationship and therefore seeks to advance and stabilise it</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>Adaptation</td>
<td>This refers to a form of international inter-firm and external cultural</td>
<td>Localisation, adaptation</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>and social learning and localisation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The total numbers of papers for renqing, ganqing, xinren, mianzi and other are calculated by adding up the number of papers in each sub-category.

**Source:** Authors
Appendix 4

Table AIV  Review findings for the influence of supply chain capital in guanxi networks

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Impacts of guanxi networks</th>
<th>No. of papers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social capital</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relationship</td>
<td>In social networks, firms tend to rely more on arm’s length relationships to build good relationships and commit to formal and informal collaborations</td>
<td>79</td>
</tr>
<tr>
<td>Reduced uncertainty</td>
<td>Social ties increasingly serve as mechanisms to reduce uncertainty and increase predictability because the players are likely to hedge their risk by using private or particularistic channels</td>
<td>41</td>
</tr>
<tr>
<td><strong>Financial capital</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement</td>
<td>They improve efficiency, save time and ease the procurement of necessary production resources</td>
<td>46</td>
</tr>
<tr>
<td>Production</td>
<td>Guanxi is important in internal integration, external adaptation and collaboration during production</td>
<td>38</td>
</tr>
<tr>
<td>Logistics</td>
<td>Global logistics’ competencies and logistics infrastructures can be enhanced by leveraging guanxi networks</td>
<td>22</td>
</tr>
<tr>
<td>Strategic goals</td>
<td>Through close personal relationships, the supply chain strategically forms a variety of flexible and synchronising prototypes</td>
<td>18</td>
</tr>
<tr>
<td>Customer management</td>
<td>An organisation can obtain operational benefits by including downstream parts of the SCM</td>
<td>11</td>
</tr>
<tr>
<td>Quality</td>
<td>Good guanxi with main suppliers can help companies acquire quality products and superior services</td>
<td>8</td>
</tr>
<tr>
<td><strong>Human capital</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information technology</td>
<td>Information integration is necessary to help internal functions within the company identify critical issues</td>
<td>28</td>
</tr>
<tr>
<td>Supplier management</td>
<td>Personal relationships between individual buyers and suppliers can dramatically influence supplier selection, development and shared organisational values</td>
<td>27</td>
</tr>
<tr>
<td>Knowledge and learning</td>
<td>Good guanxi fosters understanding of knowledge and market signals</td>
<td>16</td>
</tr>
<tr>
<td>Employee management</td>
<td>Good guanxi with employees are expected to improve engagement and collaboration and control turnover rates</td>
<td>10</td>
</tr>
</tbody>
</table>

Source: Authors

Corresponding author
Haiyan Emma Lu can be contacted at: Haiyan.Lu@plymouth.ac.uk

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Bridging the gap between supply chain risk management and strategic technology partnering capabilities: insights from social capital theory

Irène Kilubi
Deloitte Consulting, Munich, Germany, and
Helen Rogers
Business School, Nuremberg Institute of Technology, Nuremberg, Germany

Abstract

Purpose – As companies seek to continually innovate to remain globally competitive, they also need to be mindful of the impact of the potential associated supply chain risks. Hence, the purpose of this study is to explore the causal nexus of relationships linking supply chain risk management (SCRM) and strategic technology partnering (STP) capabilities (i.e. organizational capabilities, technological and innovative capabilities, learning and exploitation capabilities, complementary capabilities and network and partnership capabilities) as identified by Kilubi (2016).

Design/methodology/approach – The authors investigate STP capabilities that may positively influence SCRM and in turn foster organizational performance. By using conceptual theory building, the authors create a conceptual framework and use it to guide future investigation through research propositions. Social capital theory serves as the theoretical background.

Findings – Five STP capabilities have been identified as positive mediators for the relationship between SCRM and organizational performance, in particular flexibility and responsiveness.

Originality/value – This paper focuses on bridging the gap and identifying commonalities between two principal research disciplines, STP and SCRM, examining how these can be used to assist in the controlling and management of future risks. This study contributes to the ongoing development of SCRM and STP by integrating insights from social capital theory, supply chain management and strategic management.

Keywords Performance, Organizational capabilities, Supply chain risk management, Social capital theory, Collaboration, Dynamic capabilities, Strategic technology partnering, Strategic technology partnership(s)

Paper type Conceptual paper

Introduction

Background to the study

As global dispersion of supply chains has become commonplace; internationally oriented companies have been faced with increased and, in some cases, severe supply chain risks (Christopher and Holweg, 2011; Huq et al., 2016; Rogers et al., 2012; Tang and Musa, 2011). In particular, the incidence of natural disasters, as well as major economic fluctuations, has posed considerable challenges to supply chain managers (Chopra and Sodhi, 2004; Craighead et al., 2007; Ellis et al., 2011). Understanding supply chain risk, and recognizing the partnerships required to best manage them, is hence a key success factor for many firms. At the heart of this is the cultivation of a proactive risk management culture, which also includes supply chain activities (Ambulkar et al., 2015; World Economic Forum, 2016). At the forefront of SCRM, risk identification represents the first critical step, as it aims at discovering all potential risks that an organization may encounter (Kleindorfer and Saad, 2005; Ritchie and Brindley, 2007). Hence, only by knowing one’s (potential) risks SCRM can be used to leverage the appropriate risk mitigation measures.

Supply chain risk management (SCRM) aims at monitoring and controlling unanticipated risks by means of adequate measures to withstand uncertainties and the high levels of complexity inherent in globalized supply chains (Bandaly et al., 2014; Tang and Musa, 2011; Vilko et al., 2014). Hence, the capability to resist external threats and implement countermeasures in supply chain networks is strategically important. Based on both traditional and emergent literature, we theorize that firms that focus on strategic capabilities are better at managing supply chain disruptions (Huq et al., 2016;
Kristal et al., 2010; Wu et al., 2006). According to Hagedoorn and Schakenraad (1994, p. 291):

Strategic technology partnering is the establishment of cooperative agreements aimed at joint innovative efforts or technology transfer that can have a lasting effect on the product-market positioning of participating companies.

In the strategy and organization literature, strategic technology partnering (STP) is often posited as a critical enabler of firm competitiveness, as it is strongly linked to factors such as creating market value by means of joint forces (Cho and Pucik, 2005), responding to uncertainty and risks (Stevens and Dimitriadis, 2004) and surviving volatile or lagging demand cycles (Fisher, 1997). On this basis, we consider that both STP and SCRM are critical success factors for company performance and can be seen as key empowering agents (Mukherjee et al., 2013; Ritchie and Brindley, 2007). Owing to the increased globalization of trade and the emergence of (increasingly) high-velocity markets, we suggest that SCRM along with STP capabilities positively affects the management of external risks (Dogsen, 1993; Eden et al., 2008; Vilkamo and Keil, 2003).

Considering the significance of both SCRM and STP as competitive factors in turbulent and dynamic market conditions, it is perhaps surprising that the linkage between these two important factors has not been widely explored in the literature (Bierly et al., 2014). When conditions are unfavorable and uncertain, it becomes essential to understand which capabilities can enhance the performance of the organization (Hearnshaw and Wilson, 2013; Ponomarov and Holcomb, 2009).

STP capabilities derive its significance from business trends such as the globalization of business operations, rapid technological changes and increased time-to-market, as well as increased customer expectations (Eden et al., 2008; van de Vrande et al., 2011). In a similar vein, the globalization of markets, reliance on external skills and knowledge and increased outsourcing and offshoring are examples of why SCRM is relevant today (Lockamy and McCormack, 2010; Ritchie and Brindley, 2007). Social capital theory (SCT), on the other hand, is considered to be one of the fastest growing areas of organization network research. In 2015, the British Academy of Management held a workshop to debate “Crisis as Failed Strategy,” whereby strategic management experts from academia and industry discussed how to combine risk management and strategic management issues (i.e. strategy, performance, risk and failure) [British Academy of Management (BAM), 2015].

SCRM, which is primarily managed in production and logistics departments, deals with the identification, evaluation and control of supply chain risks to better respond to market changes. STPs, on the other hand, are primarily managed by the R&D and strategic business development departments. STP concerns cooperation between companies that contribute their individual tangible and intangible resources in the area of R&D with the aim of strengthening their competitive position. On the basis of conventional and emerging literature, we consider both STP and SCRM to be critical success factors for company performance that can furthermore be seen as empowering agents (Mukherjee et al., 2013; Ritchie and Brindley, 2007). More precisely, we advocate that the capabilities needed for STP serve as enablers for effective SCRM.

In this paper, we investigate strategic technology partnerships, a topic which, in the context of resource sharing, collaborative forms of cooperation and risk management in supply chains, suggests new interesting results for business management and, in particular, supply chain management. The focus is on the importance of risk management in the supply chain and its interrelationship with STP. SCRM, on the one hand, helps organizations to cope with risks on a global scale, while STP, on the other hand, focuses on fostering collaboration between two or more parties that will have a sustainable effect on the innovativeness of the respective partners.

**Conceptual framework aims and objectives**

Supply chain research has not yet directly investigated the relationship between STP capabilities and SCRM in business settings. Research from other fields, however, implies that such a relationship might exist (Gölgeci and Ponomarov, 2013; Zacharia et al., 2011). Hence, this research seeks to shed light on how firms may leverage STP capabilities to effectively manage supply chain risk for improved performance. More specifically, we explore whether STP capabilities can be leveraged to mitigate and avert disruptions through SCRM and therefore foster a higher level of organizational performance. Schmenner et al. (2009) indicate the need for deconstructing theories to build new and superior theories. We argue that companies possessing STP capabilities are better able to mitigate and respond to supply chain risks, as uncertainty can be managed through cooperation (Spekman et al., 1998). We further propose that STP capabilities provide a mediating role between SCRM and organizational performance. We examine this through two performance variables – flexibility and responsiveness.

Moran (2005, p. 1129) advocates that inter-organizational capital “may well prove to be the firm’s most enduring source of competitive advantage.” The external networks of an organization, according to the SCT, is a strong contributor toward performance (Leenders and Gabbay, 1999), as is the ability to respond in a quick and speedy manner to the updated conditions of the market (Merschmann and Thonemann, 2011). In this regard, risks and costs can be reduced through the long-term supply chain (SC) effectiveness that has been established through mutually beneficial relationships, shared values and trust (Vasileiou and Morris, 2006). In other words, social capital in the SC context may be viewed as the information, trust and norms of mutual benefits inherent within SC structures (Woolcock, 1998). Individuals and organizations within social networks have been the focus of research, and the social capital is used to strengthen the supplier relationship (Uzzi, 1997).

Drawing on conceptual theory building, we explore some of the links between SCT and STP capabilities (organizational capabilities, technological and innovative capabilities, learning and exploitation capabilities, complementary capabilities and network and partnering capabilities) to improve understanding of their linkage in the scientific area (Kilubi, 2016). SCT, serving as a theoretical basis, encourages the dialogue between SCRM and STP capabilities and provides input to the
development of a conceptual framework. Along with this framework we present five propositions to be empirically tested in future research.

The research aim is to supplement existing SCRM literature by integrating relevant aspects from STP theory. The corresponding research question is:

**RQ1.** How does supply chain risk management enable organizational performance (using strategic technology partnering capabilities as a mediating factor)?

The first part of the paper focuses on a review of organizational performance as an independent variable, the explanatory variable of SCRM and the mediating role of STP capabilities. This leads to evaluating how STP may support the effectiveness of SCRM. We then present a conceptual framework, together with propositions, that seeks to explain this relationship. Finally, we discuss our findings, both the theoretical and managerial implications, as well as the limitations, and the areas for further research.

**Literature review and theoretical foundation**

**Organizational performance**

A superior organizational performance implies that a company is achieving its market-oriented targets (Yamin et al., 1999). In previous studies, supply chain performance has been measured by considering market-oriented factors such as flexibility and responsiveness (Blome et al., 2014; Gunasekaran et al., 2008; Reichhart and Holweg, 2007). Supply chains that strive for excellence must also excel in competitive factors such as flexibility and responsiveness (Hult et al., 2006; Wu et al., 2006), where flexibility encompasses both the level of flexibility within the SC process, as well as the product or service offered (Boyer and Lewis, 2002). Flexibility can be viewed as an internal element within a business that shows how the processes and structures are organized and as an external element concerning how customers define organizational performance (Oke, 2005). Generally, firms seek to react to uncertain conditions with increased flexibility. Flexibility refers to the ability of an organization to respond to market changes with little or no impact on costs, resources or performance (Morlok and Chang, 2004; Naim et al., 2006; Upton, 1995). Risks and uncertainties in supply chains may take many different forms, for instance, quality of products, reliability of suppliers or competitive behavior (Matopoulos et al., 2015; Lee et al., 2001). A viewpoint within the supply chain literature furthermore considers flexibility as a means of response to managing risks and uncertainty (D’Souza, 2002; Sheffi and Rice, 2005; White et al., 2005).

In this paper, the focus is on flexibility and responsiveness as measures for organizational performance describing the relationship between SCRM and STP. Previous research indicates these factors as necessary prerequisites to quickly respond to customer needs (especially in marketplaces characterized by high levels of uncertainty) and have argued that a flexible and responsive SC is an efficient way of handling risks (Gosling et al., 2010; Lau et al., 2006; Yi et al., 2011). In line with Tachizawa and Gimenez (2010), flexibility is also important to foster the ability of an SC to respond faster to changing customer demands, hence enhancing the responsiveness of the SC and increasing organizational performance (Qurnfeh and Tarafdar, 2013).

According to Ketchen and Hult (2007), most supply chains have been focusing on dimensions such as cost or quality, however, costs, for instance, play a secondary role if the potential lasting and productive relationships exists:

Within best value supply chains, however, strategic decisions are made with concern for the chain as the primary driver. This strategic supply chain management opens the door to unique blended strategies that transcend the firm and provide the chain with increased agility and adaptability (Ketchen and Hult, 2007, p. 578).

Supply chain responsiveness is perceived as the degree and speed to which the supply chain partners are in the position to jointly respond to environmental changes in their business setting. It also refers to the dynamic capability of a firm that enables it to constantly learn new skills and adapt them to be better prepared for change (Teece et al., 1997). Thus, we consider supply chain responsiveness to be one of the key dimensions of a firm’s supply chain effectiveness (Wu et al., 2006). Catalán and Kotzab (2003, p. 677) define supply chain responsiveness in a comparable way, namely “[…] as the ability to respond and adapt time-effectively based on the ability to ‘read’ and understand actual market signals.” In particular, fast-moving industries require companies to react quickly to changing market dynamics. This in turn leads companies to realize the advantages of responding quickly to modified business conditions (Cao and Zhang, 2011; Hult et al., 2000a, 2000b; Handfield and Bechtel, 2002; Kim and Lee, 2010). Therefore, in this paper we focus on incorporating STP capabilities in the SCRM literature and investigating whether they could be leveraged to foster organizational performance, more precisely, flexibility and responsiveness.

**Supply chain risk management**

SCRM is defined as “the identification of potential sources of risk and implementation of appropriate strategies through a coordinated approach among supply chain members, to reduce supply chain vulnerability” (Manuj and Mentzer, 2008a, p. 205). Of primary concern within SCRM is the proactive, as well as the responsive, approach to handle supply chain risks in critical situations (Sodhi et al., 2012). Any approach in SCRM should strive for understanding, identifying and reducing risks in the SC in a holistic manner through collaboration between the SC members (Kilubi and Haasis, 2015). In an industrial environment that is marked by high levels of complexity and volatility, companies are obliged to manage their supply chains in an efficient manner to improve their flexibility and responsiveness (Christopher and Lee, 2004; Manuj and Mentzer, 2008b; Sodhi et al., 2012; Wagner and Bode, 2008).

Hence, SCRM may be viewed as a key dimension of a firm’s survival. To support our arguments, we rely on SCT, which will be explained in the following section.

**Theoretical foundation – social capital theory**

The main theoretical anchor in this research is SCT, considered by many as a fast-growing area of organization network research. SCT has also experienced increased interest in social networks within supply chains (Carey et al., 2011; Min et al., 2008; Oh et al., 2006; Villena et al., 2011). SCT describes the benefits actors can gain from their partnership ties and the network in which they are
rooted (Kim et al., 2011). In line with Nahapiet and Ghoshal’s (1998, p. 243) view, we consider that SCT is “the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit.” The central logic of this perspective becomes clear through the example of a company that forms network ties of relationships with another organization that are valuable resources for the respective company, such as a purchasing contract (Zaheer et al., 2010; Borgatti and Li, 2009). SCT applies to the analysis of inter-organizational relationships as firms share data, synchronize their plans and create products conjointly (Galaskiewicz, 2011). In line with the SCT, we consider that SCRM is – like STP – an ongoing process that requires the long-term commitment and dedication of all supply chain members involved (Giunipero and Eltantawy, 2004; Mahapatra et al., 2010; Manuj and Mentzer, 2008b). Table I provides an overview of the SCT in the SCRM and STP contexts.

Having higher levels of strategic capabilities usually indicates that a firm can achieve competitive edge in terms of higher flexibility and greater responsiveness when compared to its challengers (Ingham and Mothe, 2002; Vilkamo and Keil, 2003). These capabilities in turn enhance organizational performance (Mentzer et al., 2000). An organization possessing a short time-to-market and rapid product innovation can enjoy first-mover advantages, such as greater sales volume and market share. This implies that supply chains with high levels of STP capabilities will have high levels of organizational performance. Hence, a positive relationship between SCRM and organizational performance through STP capabilities can be assumed.

**Linking supply chain risk management and organizational performance**

Intra-organizational support is required for effective SCRM, considering the process-related nature of supply chain collaboration (Li et al., 2006; Pradabwong et al., 2015). According to Barratt (2004), two elements are necessary prerequisites to enhance organizational performance: top management dedication and the support of other cross-functional departments connected to supply chain management. The level of intra-organizational support could determine the level of process-related adaptation between the supply chain members and the potential outcome and success of supply chain collaborations (Ireland and Bruce, 2000; Zaheer et al., 2010). Wagner and Bode (2008) found that SCRM was of paramount importance in managing SC risks. They proposed four measures to assess the impact of SC risks on SC performance: delivery speed, delivery dependability, order fill capacity and customer satisfaction. Skipper and Hanna (2009) suggested that external collaboration, top management support, resource alignment and the use of information technology strongly contribute to the flexibility of supply chains and hence mitigate disruption risks. Sodhi et al. (2012) proposed that increased collaboration with SC partners including risk sharing results in elevated supply and process flexibility. Wieland and Wallenburg (2012) revealed that adopting flexibility is essential to cope with customer-related risks. Here, SCRM can help to positively affect organizational performance through the means of flexible methods. Moreover, an investigation conducted by Thun and Hoenig (2011) showed that companies applying sophisticated SCRM realize greater flexibility and responsiveness. Hence, every initiative (including SCRM) should result in an improved organizational output, reflected in higher performance. In light of the SCT, we conclude that SCRM is – just like STP – an ongoing process that implies long-term commitment and dedication of all involved supply chain members (Mahapatra et al., 2010; Giunipero and Eltantawy, 2004; Manuj and Mentzer, 2008b). The social capital theory has its foundation in Sociology:

Social Capital is the goodwill available to individuals or groups. Its source lies in the structure and content of the actor’s social relations. Its effects flow from the information, influence, and solidarity it makes available to the actor (Adler and Kwon, 2002, p. 23).

Based on the literature review, we hypothesize that specific STP capabilities mediate the relationship between SCRM and organizational performance (flexibility and responsiveness). Our investigation shows that the full and partial mediation of STP capabilities on the relationship between SCRM and flexibility and responsiveness, respectively, enhances firm performance. Considered at a higher level of abstraction, these relationships indicate a contribution to theory that explains to which extent STP capabilities can foster effective SCRM.

Consequently, we propose:

**P1a.** There is a positive relationship between supply chain risk management and organizational performance.

**The mediating role of strategic technology partnering capabilities**

STP capabilities in a supply chain context implies the ability of an organization to identify, use and assimilate both internal and
external resources/information to facilitate the entire supply chain activities (Bharadwaj, 2000; Collis, 1994). Specifically, capability is viewed as “the ability to make use of resources to perform some task or activity” (Hafeez et al., 2002, p. 40). An example of this is Apple’s capability in generating radical, breakthrough innovations. This definition is in line with Wang and Ahmed (2007), who conclude that when firms prove capabilities of deploying resources to achieve a wanted goal, they are likely to result in improved performance. Following Kilubi (2016), we consider STP capabilities to be second-order constructs that encompass five dimensions: organizational capabilities, technological and innovative capabilities, learning and exploitation capabilities, complementary capabilities and network and partnership capabilities.

Each of these capabilities (as shown in Table II, together with the corresponding literature) highlights the ability to smoothly process both inter-organizational and intra-organizational operations which are of paramount importance for every excellent supply chain. Additionally, they place great emphasis on the dynamics of today’s supply chains, enabling firms to respond and effectively react to changes in the market field (Amit and Schoemaker, 1993). Thus, the assumed positive impact of any strategic capability may be reduced under highly risky conditions.

STP assists with managing external uncertainty due to globalization of business activities, rapidly changing technologies, increased time-to-market, increased customer expectations, etc. (Eden et al., 2008). Extant research suggests that firms are motivated to enter into these partnerships, for instance, to share and reduce risks (Hagedoorn et al., 2006). Enablers that lead to higher flexibility through STP capabilities such as those mentioned by Vilkamo and Keil (2003) include sharing of risks and commitment from partners. This is in line with other studies that acknowledge the increasing importance of STP capabilities in embracing rapid technological change to increase performance (Huang and Yu, 2014; Noseleit and de Faria, 2013). SCT implies that collaborations such as joint activities and information-sharing reduce risks and offer superior organizational performance (Schiele et al., 2015). Similarly, SCRM activities undertaken to achieve or foster organizational performance may become ineffective or even have an unexpectedly negative impact when the company is lacking the necessary strategic capabilities. As a result, we suggest the following mediating proposition:

P1b. Strategic technology partnering capabilities positively mediate the relationship between supply chain risk management and organizational performance at the firm level.

We discuss these relationships for each STP capability in detail in the following sections.

### Conceptual framework development

#### Organizational capabilities

Organizational capabilities are found in structures, processes and formalized procedures and are grounded on practiced routines through the coordination of functional activities. Firms may accumulate an extensive range of competencies over time, which give rise to their competitive edge, and identifying and measuring these organizational capabilities has been the focus of previous studies (Vilkamo and Keil, 2003). Organizational capabilities are essentially a set of valuable assets and competencies (Wang and Ahmed, 2007). With regards to SCT, partners that upgrade the relations and communication with different contacts at diverse levels (e.g. technical and managerial) and several functions (e.g. quality, engineering and sales) permit the formation of a social structure that favors both sides of the partnership (Cousins et al., 2006).

It is well recognized that social capital between two partnering organizations leads to more effective and frequent communication and thus improves performance (Krause et al., 2007; Lawson et al., 2008). Therefore, SCT may be leveraged to fully embrace the mechanism of resource sharing in a commercial context (Horn et al., 2014).

According to Lau et al. (2006), firms are focusing on achieving greater market responsiveness, achieved by restructuring organizational structures and amalgamating information and communication technologies that can leverage knowledge within and between the organizations. In a business environment driven by accelerating complexity, it is of paramount importance for organizations to adapt to fast-changing customer needs as quickly as possible. One way to do so is to implement organizational measures and structures that foster flexibility and responsiveness to enhance the firm’s ability to effectively embrace changes (Braunschweig and Suresh, 2009). SC risks are spread across the entire supply chain, meaning it is a great advantage to include a cross-functional team with diverse competencies for joint problem-solving (Speier et al., 2011).

Therefore, we propose:

P1. Organizational capabilities positively mediate the relationship between supply chain risk management and flexibility/responsiveness at the firm level.

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**Table II** Literature on STP capabilities

<table>
<thead>
<tr>
<th>STP capabilities</th>
<th>Key contributions</th>
</tr>
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<tbody>
<tr>
<td>Complementary capabilities</td>
<td>Carey et al. (2011), Chen et al. (2013), Johnson (2013), Krause et al. (2007), Lawson et al. (2008), Uzzi (1997)</td>
</tr>
</tbody>
</table>
Technological and innovative capabilities

Technological and innovative capabilities imply that organizations possess the required technical and scientific competencies to design new technologies, solutions, processes and products to foster its long-term viability. Notwithstanding this, the graveness of disturbances may have a beneficial effect on activating an organization’s responsive innovation capabilities, as innovative companies are ready to react rapidly and adequately to changes (Craighead et al., 2007). Innovative and inventive firms are more likely to embrace innovative solutions to impede, to hold off or overcome adverse impacts of any unforeseen events that endanger their SC efficiency (Gölgeci and Ponomarov, 2015). Thus, a firm’s capacity to develop rapid problem-solving solutions is a “must have” when confronted with supply chain disruptions. Likewise, firm innovativeness is closely connected with appropriate reactions to economic and environmental changes. Feller et al. (2013) concluded that for companies surrounded by a turbulent and risky business environment, their major competitive edge lies within their technological expertise. Flexibility is based on the notion that companies are able to quickly modify their process-related systems and structures to change, e.g. product or service features according to customer expectations (Bagchi and Skjoett-Larsen, 2005; Gosain et al., 2004). Collaboration in product development within the supply chain is influenced by the cognitive capital that represents shared values and goals (Krause et al., 2007). In addition, collaboration generates new knowledge through joint product design, collaborative research or collective process innovation, which enhance the capability of the supply chain to respond promptly to environmental changes (Christopher and Holweg, 2011). Following Rajesh et al. (2015), when the activities of two companies are well-coordinated, supply-related risks are reduced and performance is improved. Chen et al. (2013), in their study, examine SC collaboration as a risk mitigation strategy. Their evaluation reveals that each type of collaboration reduces its respective supply chain risks. At this point, the members of the SC share their understandings and explain how improvements may take place and how tasks may be efficiently completed (Handfield and Bechtel, 2002). If strategic technology partners have high levels of cognitive capital according to the SCT, their expectations will be far better aligned (Handfield and Nichols, 2002). Cognitive capital thus reduces risks (Poppo and Zenger, 2002), thereby fostering the effect of technological and innovative capabilities. As a result, technological and innovative capabilities represent the foundation for generating inventive and advanced solutions to environmental challenges (Parmigiani et al., 2011). Consequently, we propose:

\[ \text{P2. Technological and innovative capabilities positively mediate the relationship between supply chain risk management and flexibility/responsiveness at the firm level.} \]

Learning and exploitation capabilities

Learning and exploitation capabilities can be considered as endogenous capabilities, formed over lengthy periods through “learning-by-doing” and experience. The result is a repertoire of extensive skills and knowledge that enables firms to acquire, assimilate, transform and exploit external knowledge for improved organizational performance. Cognitive capital, as one dimension of SCT, and as defined by Nahapiet and Ghoshal (1998), is based on shared language and joint understanding of basic concepts and assumptions (Bolino et al., 2002). Given that cognitive capital reduces uncertainty, in terms of STP, a shared view on concepts like risk management is a prerequisite to focus joint efforts on the right “levers” (Handfield and Nichols, 2002). Based on such a cognitive alignment, partners know better what to expect from each other and encounter fewer situations where unexpected behavior or misunderstandings occur (Inkpen and Tsang, 2005). It thus facilitates joint understanding (Tsai and Ghoshal, 1998) and free communication and exchange of resources based on common objectives and interests (Purra-Requena et al., 2010). Although learning and knowledge management have been acknowledged as significant factors in fields such as organization science, this is not quite yet the case in SCM research (Bessant et al., 2003). Notable studies include the following: Kotabe et al. (2003) found a linkage between knowledge transfer, supplier-buyer relationships and the duration of such relationships. Hult et al. (2007) showed that knowledge development has a positive effect on the organizational performance of supply chains. Next, Hernández-Espallardo et al. (2010) explored the meaning of knowledge exchange in supply chains. Moreover, Bode et al. (2011) concluded that the mediating effect of previous experience underlines the importance of organizational learning from occurred SC disturbances. In this connection, aspects of SC flexibility have been evaluated by multiple authors (Sánchez and Pérez, 2005; Vickery et al., 1999) who have concluded that a flexible supply chain model is quickly able to adapt to changing scenarios. Having the capacity to take activities and to respond along these lines to data assembled is an ultimate type of learning (Sinkula et al., 1997).

As indicated by Coleman’s (1994) extensively shared perspective, social capital encompasses any part of social and learning structure, encouraging the creation of significant value and supporting the activities of entities belonging to the respective social network.

Thus, the third proposition suggests:

\[ \text{P3. Learning and exploitation capabilities positively mediate the relationship between supply chain risk management and flexibility/responsiveness at the firm level.} \]

Complementary capabilities

The term complementary capabilities implies pooling distinct skills and know-how, or technological diversity between partners, which in turn motivates creativity and novel solutions to challenges. In other words, they indicate the degree to which companies “get along” and capitalize on potential synergies that can be critical to success (Kilubi, 2016). This corresponds to investigations that reveal that strategic technology partners with other enterprises engender long-term relationships with suppliers and customers and can support with external resources to complement internal capabilities (Rothaermel, 2001; Zollo et al., 2002). Indeed, if companies aim at reducing
risks and costs, they will merge comparable assets in light of the SCT view (Miotti and Sachwald, 2003).

Synergies in a business context between organizations are created when different supply chain partners bring in their individual but still complementary resources to gain maximum benefits for all parties involved. Ansoff (1988) puts forward that the positive outcome of pooling complementary resources results in the better usage of assets along the supply chain, including intangible assets such as knowledge about customers, technological competence and organizational structures. Social capital between partners develops through different factors, such as mutual interdependence (Nahapiet and Ghoshal, 1998). Recent research has emphasized the value of social capital, finding that it reduces monitoring costs and enhances cooperation and therefore increases performance (Carey et al., 2011; Cousins et al., 2006; Lawson et al., 2008). Tanriverdi (2006) proposes two main synergy effects:

1. super-additive value through complementary assets; and
2. sub-additive economies of scope through comparable assets.

Collaborating in knowledge-intensive areas such as new product development generates novel solutions, which directly impact the capability of a supply chain network to rapidly react to changing market conditions (Chen et al., 2013; Christopher and Holweg, 2011).

The fundamental notion of SCT in this setting is that relationships in supply chains rely on each other’s resources for mutual problem-solving (Hughes and Perrons, 2011). “The positive conditions necessary for the exchange of such resources depend upon the development of social capital within these relationships” (Schiele et al., 2015, p. 134). Hence, the fourth proposition is as follows:

**P4.** Complementary capabilities positively mediate the relationship between supply chain risk management and flexibility/responsiveness at the firm level.

**Network and partnership capabilities**

A supply chain consists of a sequential network of interdependent relational entities, fostered through strategic collaboration (Chen and Paulraj, 2004). Hence, network and partnership capabilities refer to a relational perspective on common competitive benefits (Dyer and Singh, 1998; Lavie, 2006), as suggested by the SCT, understood as the ability to effectively build and handle a multitude of interfirm partnerships. Following Rajesh et al. (2015), when the operations of two firms are well coordinated, the capability of suppliers and their performance are improved, continuity of supply is ensured and supply-side risks are reduced. Higher levels of collaboration, more effective and efficient business relationships and increased responsiveness toward changing environmental demands as typified by Toyota and their Japanese suppliers, generally, tend to pay off. Thus, higher levels of responsiveness can be gained through SCs with rich relational resources, and this may increase the value creation process across the SC (Hunt and Davis, 2012; Uzzi, 1997).

Social capital describes the benefits that actors can gain from their partnership ties and from the network in which they are rooted (Baker, 1990). The central logic of this perspective is exemplified by a company that forms network ties of relationships with another organization that are valuable resources for the respective company, such as a purchasing contract (Zaheer et al., 2010). Relational ties are formed with stakeholders (including suppliers, government agencies, unions and competitors) as part of the relational resource. The existing variations as part of the relational resource are considered a natural outcome of supply chain competition (Borgatti and Li, 2009). Partners that upgrade the relations and communication with different contacts at diverse levels (e.g. technical and managerial) and several functions (e.g. quality, engineering and sales) permit the formation of a social structure that favors both sides of the partnership (Cousins et al., 2006) in terms of flexibility and responsiveness: “That is, the guiding idea of social capital is the recognition of another’s goodwill toward a certain entity as a valuable resource” (Schiele et al., 2015, p. 134).

Even competing supply chains realize greater gains through collaboration and take advantage of closer relationships that leave room for joint improvement potentials (Barratt, 2004). Moreover, Wu (2008) revealed that relationships between buyers and suppliers that are characterized by a high degree of collaboration may generate new insights. Accordingly, the fifth proposition states:

**P5.** Network and partnership capabilities positively mediate the relationship between supply chain risk management and flexibility/responsiveness at the firm level.

The above five propositions, taken together with the findings of the literature review, support the framework presented in Figure 1. This presents a conceptual framework highlighting the key linkages between SCRM, STP capabilities and organizational performance.

**Discussion**

In this study, we examined the relationship between SCRM and organizational performance, as well as the key enablers that can shape this linkage. There are several indications that supply chains possessing STP capabilities have a higher likelihood of successfully implementing and conducting SCRM, resulting in higher organizational performance, namely, higher flexibility and responsiveness. Furthermore, we developed corresponding propositions related to the mediating role of STP capabilities. Despite of advances in SCRM concepts, parallel progression in theory improvement and endeavors to comprehend the social interactions in SCRM have lagged behind.

The main theoretical contribution is that our study considers STP capabilities as an important positive mediator of firms’ SCRM. With the end goal to establish a hypothetical ground for the social interactions of SCRM and STP, we drew from the SCT and developed a conceptual framework. Regarding our research question:

**RQ2.** How does supply chain risk management enable organizational performance (using strategic technology partnering capabilities as a mediating factor)?

We portrayed the STP capabilities that foster enhanced performance in a risk-managed supply chain. Attaining,
developing and leveraging effective capabilities are indispensable to firms’ long-term survival, especially in today’s turbulent, chaotic and uncertain market environments (Helfat and Winter, 2011). Through conceptual theory building, we demonstrated that enhancing STP capabilities within SCRM can positively impact organizational performance in several ways.

Figure 1 presents five STP capabilities as a basis for exploring SCRM as an enabler for organizational performance. All links will not be equally strong, and they will not necessarily all be present within every supply chain network. The framework should not be interpreted as an attempt to map out causes and effect; rather, it provides a vehicle for considering how SCRM may be linked to organizational performance, in particular, flexibility and responsiveness, through the mediation of STP capabilities. Indeed, although each link is identified independently, these are likely to be interrelated in important and complex ways. Furthermore, the formative STP capabilities are also likely to be interdependent with, for example, network and partnership capabilities and complementary capabilities to be viewed as mutually reinforcing capabilities.

Therefore, we believe that the enhancement of STP capabilities through SCRM can have a direct impact on a firm’s flexibility and responsiveness (Wu et al., 2006). Consequently, we suggest that STP capabilities directly influence the effectiveness of a supply chain’s risk management, and thus in turn, its organizational performance. Theoretical support for the positive influence of STP capabilities on SCRM is provided by the SCT literature. We considered why a company’s organizational performance benefits from STP capabilities through SCRM, resulting in a tentative framework. This is in line with Feller et al. (2013), who use a mixed-method approach and conclude that for companies operating in chaotic and risky business environments, viable competitive advantage derives largely from their technological capability. On this note, with its derivation and development, the complementarity of the SCRM and the STP has been demonstrated. As a result, the integration of the two separate but complementary research streams leads to the achievement of new systems of sustainable competitive advantage that base upon the grounds of the dynamics of the environment. This is reflected, for example, in flexible procurement and production processes and agile measures related to disruptive changes and a risk-sensitive culture to increase the value-adding of SCRM (Gosling et al., 2010; Stevenson and Spring, 2007; Yi et al., 2011). High levels of STP capabilities imply innovative supply chain products, processes and services (such as supply chain design by modular products or the integration of the supply chain in the new product development), inter-organizational SCRM teams, empowerment for creative, new ideas and a decentralization of decision-making autonomy to respond quickly and flexibly to risky events.

Theoretical contributions

We maintain that the analysis of STP capabilities for SCRM remains underdeveloped in the academic domain, despite indications of the significant role this can play in mitigating supply chain risks (Bierly et al., 2014; Gölgeci and Ponomarov, 2013; Zacharia et al., 2009). The ability to sustain a flexible and responsive supply chain is becoming strategically important within organizations. SCRM may be further reinforced when the respective supply chains take into account STP capabilities with the aim of improving organizational performance. By focusing on the relationship between STP capabilities and SCRM, along with their effect on organizational performance both across a firms’ supply chain networks, this paper justifies the need for further enquiry. Our contribution emphasizes the value of bridging the SCM and strategic management research domains and explores the potential advantages of interdisciplinary research between the two research fields (Hitt, 2011). Furthermore, five mediating factors, namely, organizational capabilities, technological and innovative capabilities, learning and exploitation capabilities, complementary capabilities and network and partnership capabilities, on the critical link between SCRM and organizational performance were considered. The paper reveals that there exists a positive relationship between SCRM and organizational performance (P1a), and that STP capabilities positively mediate the relationship between SCRM and organizational performance at the firm level (P1b).

As a result, this paper offers insights into the potential contingent factors that mediate the effect of SCRM. In summary, the impact of STP capabilities implies that the value of SCRM in challenging times is contingent upon reliable and consistent tangible and intangible assets. Thus, STP capabilities appear to be key enablers of SCRM effectiveness, as they strengthen the effects of risk-mitigating efforts. These findings are in line with the assumptions of the SCT in networks (Inkpen and Tsang, 2005; Kim et al., 2011) and now warrants further testing.

Managerial implications

Several implications for managers emerged. First, the conceptual framework provides supplemental insights into strategic management, specifically when conscious decision-
making under complex conditions is critical for the long-term success of a business. Notably, management is asked to embrace strategic capabilities and to plan and manage their supply chain networks in a way that it enables a more effective and sustainable approach to respond and to handle supply chain risks.

Previous research provided indications that strategic capabilities of an organization can be applied to reduce disruptions in the SC, but the “how” question remained unanswered. It is this “how” which needs to be analyzed further through investigation and analysis (Wong et al., 2011). What will be increasingly necessary is a predictive, integrative and proactive approach. SC disruptions may be existent within organizations that have profoundly embedded and interdependent supply chains (Hallikas et al., 2004; Kleindorfer and Saad, 2005; Wagner and Bode, 2008). Several practical examples highlight the significance of SCRM to organizational performance. At IBM, for instance, a cross-functional working group developed an online tool that evaluates supplier and SC risks. It addresses SC risk in terms of identifying the most critical suppliers and their respective plant locations that related to IBMs $12bn yearly spend. As a second example, Intel has fundamentally enhanced supply chain responsiveness regarding their microprocessors, whereby their responsiveness improved by almost 300 per cent within two years. This was achieved by means of advancements such as intra-organizational joint effort and collaboration, postponement, standardization, automated processes and structured problem solving (Arbøjørn and De Haas, 2009).

Knowledge sharing initiatives must be encouraged as firms can greatly benefit result from history, previous experiences and collective learning within the company. A SCRM community within the organizations should be established that exchanges best practices and provides practical tools in which the organizational knowledge is codified to make the most of previous lessons learned. The existing knowledge can be dispersed using codification tools such as guidelines, databases, checklists and manuals, which help replicate the best practices across the organization. Moreover, through sharing mechanisms such as workshops, seminars, task forces and job rotation, employees are motivated to exchange these best practices, SCRM-related data and information and know-how to their colleagues (Sluyts et al., 2011). Skipper and Hanna (2009) suggest that external collaboration, top management support, resource alignment and the use of information technology strongly contribute to the flexibility of supply chains and hence mitigate disruption risks.

It could prove beneficial for firms to contemplate their SC resources, for instance, strategic partnerships with suppliers and postponement, which relate to yields that may potentially improve responsiveness and in turn organizational performance. Flexibility to build responsive production processes to respond to any external changes has become imminent (Lavastre et al., 2012). A firm can also increase its flexibility by getting support from external providers to acquire additional capacity when necessary. For example, DHL has worked with several vehicle producers to establish joint aftermarket logistics structures (Christopher and Holweg, 2011). Essentially, it is of utmost importance to identify and understand the capabilities that are relevant for risk reduction and mitigation, as these capabilities are likely to significantly impact the organizational performance of supply chains.

Organizations should invest in their STP capabilities to remain competitive and increase their organizational performance, as well as to overcome the inherent risks associated with global operations. Potential measures of improving organizational performance through the mediating effect between STP and SCRM are not specifically addressed in this paper; however, it is revealed that a combination of internal and external capabilities should be leveraged, as suggested in the Literature review and Discussion sections. Therefore, such capabilities can be manifested as agile responses to risky events to realize a desired level of organizational performance.

Limitations and future research direction

The main limitation is that this study only focuses on STP capabilities as mediating variables for the relationship between SCRM and organizational performance. Hence, future research should define whether there are other potential internal and external mediators of the relationship between SCRM and organizational performance. Next, we have only considered flexibility and responsiveness as measures for organizational performance. The variable could have multiple items and multiple dimensions of quality, reliability, cost, etc., which could also be taken into account. Beyond these limitations, our study offers some future research potential that could be undertaken. First, the conceptual framework offers a language for conceptualizing STP capabilities in SCRM. Thus, future studies may devote to the general question of how can organizations leverage strategic capabilities against supply chain risks.’ This study suggests that STP capabilities can be exploited to successfully manage supply chain risks and boost organizational performance. Second, the framework provides the foundation for theory building within the STP-SCRM domain. The next step is to continue to refine the framework by conducting empirical qualitative and quantitative studies based on the five established propositions. Third, the proposed conceptual framework is the first concept to connect SCRM and STP to one research stream. Both research fields of SCRM and STP have been considered in isolation from each other. However, both areas deal with the challenge of adapting to a dynamic and rapidly changing business environment.

The framework is particularly suitable as a starting point for future empirical research, which in turn could then be operationalized into a model. In particular, we recommend empirically testing the STP capabilities in an SCRM context to examine the effects on organizational performance of supply chain networks. In addition, our findings propose that STP capabilities could be exploited for reacting to unforeseeable changes under dynamic and uncertain market conditions. Firms need to remain competitive to survive. Rather than purely focusing on business expansion and organizational performance, they need to also channel resources to their innovative and creative capabilities, as well as proactively plan for managing risks and disturbances in uncertain situations (Autry and Griffis, 2008; Rothenberg and Hess, 2007). From a theory development perspective, viewing the SCRM and STP.
research streams as complementary will encourage a more holistic strategic approach, which in turn may provide insights into strategies to assist in improving organizational performance.

References


Supply chain risk management
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**Further reading**


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A complex adaptive systems governance framework for regional supply networks

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Abstract
Purpose – This paper aims to propose an empirically grounded governance framework based on complex adaptive systems (CAS) principles to facilitate formation of well-connected regional supply chains that foster economic development, adaptability and resilience of mining regions.

Design/methodology/approach – This study is an exploratory case study of the South Australian (SA) mining industry that includes 38 semi-structured interviews with the key stakeholders and structural analysis of the regional supply network (RSN).

Findings – Findings demonstrate the applicability of the CAS framework as a structured approach to the governance of the mining industry regional supply chains. In particular, the findings exemplify the relationship between RSN governance, its structure and interconnectivity and their combined impact on the adaptability and resilience of mining regions.

Research limitations/implications – The data set analysed in the current study is static. Longitudinal data would permit a deeper insight into the evolution of the RSN structure and connectivity. The validity of the proposed framework could be further strengthened by being applied to other industrial domains and geographical contexts.

Practical/implications – The proposed framework offers a novel insight for regional policy-makers striving to create an environment that facilitates the formation of well-integrated regional supply chains in mining regions through more focussed policy and strategies.

Originality/value – The proposed framework is one of the first attempts to offer a holistic structured approach to governance of the regional supply chains based on CAS principles. With the current transformative changes in the global mining industry, policy-makers and supply chain practitioners have an urgent need to embrace CAS and network paradigms to remain competitive in the twenty-first century.

Keywords Australia, Supply chain management, Governance, Complex adaptive systems, Case studies, Network organization, Regional supply network, Mining regions

Paper type Research paper

1. Introduction

The current pace of transformative changes in the global business environment demands that regional economies be adaptable and resilient to economic shocks. In the regions with one dominant industry, it is particularly important to develop well-interconnected local supply chains. If highly intertwined, the supply chains form a regional supply network (RSN) that acts as a conduit for information and knowledge exchange among local firms, enabling organisational learning and innovation diffusion across related and unrelated industries. It acts as a local ecosystem that contributes to local capability development and innovations that ultimately enhance economic adaptability and resilience of industrial regions.

However, local supply chains in regions where resource extraction is a dominant economic activity are often hierarchical and fragmented. Local suppliers lack access to opportunities and industry knowledge, being “locked in” to a few clients in the region. This undermines the local suppliers’ capability development and, as a result, the economic resilience of mining regions. To address this problem, regional policymakers seek new governance approaches to facilitate formation of well-integrated and interconnected regional supply chains.

Supply chain management literature and practice increasingly adopts network-centric and complex adaptive systems (CAS) frameworks as an alternative to linear and top-down approaches. These frameworks allow for more efficient resource allocation and increased operational performance of industrial supply chains (Choi et al., 2001; Pathak et al., 2007). Supply chains can be viewed as complex networks, driven by internal mechanisms and co-evolving with the environment. CAS view explains how micro-level interactions lead to the emergence of macro-level structures, that is, how supply chain...
relationships of firms lead to the emergence of a supply network as a collective aggregate.

In evolutionary economic geography (EEG), CAS frameworks are applied to address adaptability and adaptation of industrial regions (Hu and Hassink, 2015; Martin and Sunley, 2007; Martin and Sunley, 2015) and diffusion of technological innovations (Boschma and Frenken, 2011). EEG frameworks also recognise the role of local inter-firm networks in building the adaptive capacity of industrial regions (Broekel and Boschma, 2012; Crespo et al., 2016).

Although a variety of CAS frameworks were offered to explain the evolution of supply chain networks including their operational and innovative performance (Choi et al., 2001; Hearnshaw and Wilson, 2013; Pilbeam et al., 2012), as well as the adaptability and resilience of industrial regions (Hu and Hassink, 2015; Martin and Sunley, 2015), the relationship between RSN structure and governance, and their combined effect on the adaptability and resilience of industrial regions, has not been discussed.

The purpose of this paper is to offer an empirically grounded conceptual framework that uses CAS principles to govern RSN structure and interconnectivity to enhance the adaptability and resilience of industrial regions.

The main research question addressed in this paper explores the following:

RQ1. In what way could an RSN be governed to enhance the adaptability and resilience of industrial regions?

In particular:

Q1. Could an RSN be viewed as a complex adaptive system (CAS) and governed as such?

Q2. How could the governance process be structured?

Q3. How could a structured governance approach assist regional policymakers in enhancing the adaptability and resilience of industrial regions?

To answer the research question, this paper draws on supply networks, CAS and EEG literature to propose an empirically grounded CAS framework for RSN governance. The proposed structured governance approach will facilitate the transition of regional supply chains towards an interconnected and well-integrated network that would facilitate innovation diffusion and local capability development, leading to enhanced adaptability and resilience of industrial regions to economic shocks.

The proposed CAS governance framework includes the CAS of interest; the governing body; the environment; external factors and system constraints; and a feedback mechanism. The framework’s emphasis is on the RSN structure and connectivity that allows for monitoring the level of integration of local mining equipment and technology services (METS) firms and thus effectiveness of the governance process.

The proposed framework draws on the case study of the South Australian (SA) mining sector. An exploratory case study was conducted to develop the conceptual framework and answer the research questions. To develop the proposed framework, in-depth interviews with key mining industry stakeholders in South Australia—mining companies, their METS suppliers and policymakers—were conducted between September 2015 and February 2016. In addition, a data set from the supplier database—industry capability network (ICN)—was used to analyse the structure of the RSN in the SA mining region.

The paper is organised as follows: Section 2 provides theoretical background with the discussion of economic adaptability and resilience of mining regions including the role of the RSN structure and governance in achieving this. Research methodology and data collection procedures are discussed in Section 3. Section 4 describes the application of the proposed governance framework to the case of the SA mining industry and analysis of the supply network structure in the SA mining industry. Section 5 concludes the paper by discussing the contribution and outlines its limitations and potential for future research.

2. Theoretical background

2.1 The regional supply chain structure and the adaptability and resilience of mining regions

2.1.1 Resource extractive regions and the formation of the mining industry supply chains

Sustainable economic development of resource extractive regional economies and their resilience to economic downturns is often associated with the establishment of linkages from mining to other industry sectors. This happens through the integration of local firms into mining industry supply chains, gradual capability development, stimulating a gradual shift to service economy, resulting in increasing returns and economic growth (Chapman et al., 2002; Kaplan, 2012; Scott-Kemmis, 2012).

Mining companies typically own mines and conduct exploration activities. Concentration plants and the local supplier base are usually located in proximity to the mines. Gradually, mining companies sub-contract or outsource non-core activities to local service firms that cannot be considered as a part of the mining sector, but may belong to other industries that are often referred to as METS.

METS include a diverse range of firms supplying services and products to the mining sector. These METS firms could be a part of any sector of the economy as long as a substantial portion of their income directly or indirectly comes from the mining sector (Scott-Kemmis, 2013). These include, but are not limited to, capital and mining equipment providers, contract mining services, geological and exploration services, providers of mining consumables and professional services, such as engineering, consulting, mining information technology and software providers. Often, regional METS are limited in the geographical scope of their operations to a particular mining region and operate as a part of the supply chains for local mining companies.

In the positive scenario of regional development, the gradual formation of the links between the METS and the mining companies results in the emergence of a mining sector RSN—an interconnected set of regional supply chains formed as a result of long-term contractual and collaborative relationships between mining companies and local firms, operating within the mining region and supplying various services. When METS firms supply their services to several mining companies or
contractors simultaneously, the individual supply chains in the mining region become intertwined and interconnected with multiple shared suppliers and customers. Because of geographical proximity, long-term collaborative relationships between suppliers and mining companies in RSNs are common (Martinez-Fernandez, 2010; Scott-Kemmis, 2013; West, 2014).

The major drivers of an emerging interconnected RSN are:

- the reorganisation and technological upgrades of extraction and technological processes, prompting constant reconfiguration of supply chains (Scott-Kemmis, 2013);
- the increased outsourcing of the non-core activities by resource extractive companies to service providers (Knobblock, 2013; Scott-Kemmis, 2013); and
- the establishment of collaborative relationships between mining companies and local suppliers (Kaplan, 2012; Morris et al., 2012; Walker and Minnitt, 2006; Warrian and Mulhern, 2009).

This RSN serves as a conduit for knowledge and technology transfer between major resource extractive companies, their large multinational supply chain partners and local METS through sub-contracting arrangements and various forms of collaboration. Local METS benefit from belonging to the RSN through organisational learning and tacit knowledge exchange that enables to boost their innovative capacity and business performance (Soosay et al., 2008).

2.1.2 Hierarchical organisation of the mining industry supply chains

Research has demonstrated sub-optimal performance of local supply chains in resource-extractive regions organised in a hierarchical manner (Arias et al., 2014; Cappelen and Mjøset, 2009; Ritter, 2004; Walker and Minnitt, 2006; Warrian and Mulhern, 2009). Supply chain hierarchy represents a structure in which firms are ordered with respect to their tier position in the supply chain (A sells to B, which sells to C, etc.) (Luo et al., 2012). In the mining industry context, a hierarchical structure of regional supply chains is often attributed to the enclave type of economic organisation, with the power concentrated in a few large multinational corporations, acting as “hubs” for the mining region, which distribute work packages to the suppliers in a hierarchical top-down manner, starting from the engineering, procurement and construction management (EPCM) providers to lower tier suppliers (Phelps et al., 2015).

Such a structure is usually characterised by low horizontal interconnectivity between lower tier suppliers, causing them to become highly dependent on a very few major resource companies and EPCM contractors in the region. Suppliers thus become “captive,” that is, highly dependent on these major clients and experiencing power imbalance, which stifles capability development (Gereffi et al., 2005). Commonly located at the periphery of the mining industry supply network, these suppliers have limited access to business opportunities, knowledge and information (Arias et al., 2014; Atienza et al., 2016). Thus, limited horizontal interconnectivity results in limited knowledge and technology transfer. The competitiveness and diversification of local suppliers to the resource sector is therefore curtailed, reducing the resilience of the regional economy (Warrian and Mulhern, 2009, Phelps et al., 2015).

These types of hierarchical supply chain structures can be observed in the resource regions of many developing countries, for example, in Latin America (Phelps et al., 2015; Silvestre and Neto, 2014) and Africa (Bloch and Owusu, 2012; Farooki, 2012; Morris and Fessehaie, 2014; Taura and Watkins, 2014), as well as in developed countries (Scott-Kemmis, 2013; Warrian and Mulhern, 2009). The challenges associated with the transition from hierarchically structured regional resource supply chains to more efficient network structures in many developing and already developed countries is reported by researchers (Scott-Kemmis, 2013; Walker and Minnitt, 2006; Warrian and Mulhern, 2009). For example, Warrian and Mulhern (2009) reported the negative legacy among local small- and medium-sized enterprises (SMEs) in Canada from their past dependence on vertical supply chain organisation impacting on their ability to navigate a networked economy. Furthermore, a shortage of skilled and motivated labour, underdeveloped links between small suppliers and research organisations, the inability to protect intellectual property and low collaboration between local suppliers often impede innovative development of local METS (Scott-Kemmis, 2013; Warrian and Mulhern, 2009). The low level of collaboration among small METS suppliers and mining companies, as well as overseas competition that hinders the formation of RSNs in resource sectors, was reported for the Australian mining equipment and technology suppliers (Scott-Kemmis, 2012). A similar problem was observed among South African resource sector suppliers, where the importance of horizontal and vertical collaboration for fostering innovative and the capability development was highlighted (Walker and Minnitt, 2006).

The global nature of the resource industry contributes to the increased sub-contracting by mining companies of international service providers at the expense of local supplier engagement, thus creating “connectivity gaps” between higher and lower tier suppliers in the RSN. Because of a high level of integration of resource industries into global supply networks, the procurement strategies and decision-making of large resource companies often take place outside the resource region and usually do not favour local METS suppliers (Arias et al., 2014; Taura and Watkins, 2014; Warrian and Mulhern, 2009). This contributes to the hierarchical organisation of regional supply chain structures with limited knowledge spillovers and other positive externalities, derived from the interconnectivity.

These challenges encourage regional policymakers to direct their efforts towards increasing the integration of local METS into resource supply chains. A number of frameworks for increasing the competitiveness of local firms that supply services to the resource sector have been discussed in the literature (Kaplan, 2012; Morris et al., 2012; Scott-Kemmis, 2013; Warrian and Mulhern, 2009). However, scholars acknowledge the scarcity of research into the mechanisms and drivers that facilitate the formation of mining clusters, networks and knowledge transfer in mining regions (Arias et al., 2014; Chapman et al., 2004; Figueiredo and Piana, 2016; Knobblock, 2013). There is also a growing need for policymakers and industry stakeholders to adopt a holistic view and apply policies and practices that maximise value for the
supply network as a whole, rather than for individual firms, to ensure innovative development of industrial regions (Chapman et al., 2004).

2.2 Complex adaptive systems and network governance frameworks

2.2.1 Complex adaptive systems frameworks in supply network research

CAS frameworks have been advocated by scholars as an alternative to linear and top-down ones. CAS are considered able to address the range of governance issues associated with the complexity and interconnectivity of industrial supply chains, such as system-level optimisation, improved incentives alignment and better resource allocation (Choi et al., 2001; Nair et al., 2009; Pathak et al., 2007). CAS frameworks are also more attuned to supply chain innovation and are more representative of the increasing structural and behavioural complexity of supply chains (Hollstein et al., 2017; Pathak et al., 2009; Provan and Kenis, 2008), whereas more traditional approaches tend to focus on engineering and operations management and address technical and logistical aspects of supply chain organisation and performance. However, in practice, hierarchical and linear supply chain models are most common (Nair et al., 2009; Pathak et al., 2007).

The seminal works of Choi et al. (2001) and Surana et al. (2005) acknowledge the need for CAS approaches that would recognise the networked structure of supply chains to enable system-level optimisation. Choi et al. (2001) define supply networks as CAS driven by internal mechanisms and co-evolving with the environment. The CAS view is particularly useful for explaining how simple micro-level interactions, strategies and behaviour can lead to the emergence of a supply network as a collective aggregate at the macro-level (Pathak et al., 2007).

Viewing a supply network as CAS, its effectiveness and efficiency can be interpreted as non-linear functions of individual firms’ behavior, the supply network topology and the multiple forces acting in the system, which result in collective, self-organised behaviour. The performance of the network will depend on the adaptivity of organisational entities forming the network, a topology with interconnectivity between multiple supply chains, self-organising and emergent system performance and an external environment that coevolves with the system (Pathak et al., 2007).

It can be assumed that a CAS supply chain will contain numerous components with functions and inter-relationships that imbue the system as a whole with a particular identity and a degree of connectivity or connectedness (Choi et al., 2001). Many different independent agents act in the system, but they exist in multifaceted relationships with other agents in the business environment (Fuller and Moran, 2001). The nature of the relationships varies from vertical linkages through supply and distribution channels to horizontal ones – joint ventures, partnerships and strategic business alliances (Hyland et al., 2003; Powell et al., 2005).

Scholars have highlighted the importance for firms to recognise the impact of broader indirect supply chain connections (Choi et al., 2001; Luo et al., 2012; Nair et al., 2009; Surana et al., 2005). At the firm level, connectedness within a supply network has been reported to enhance its innovativeness, market power and business performance. The impact of the supply network, as a “business ecosystem”, on the firms’ innovative performance in terms of their structural position in the network and their access to network resources has been demonstrated in a range of industries, e.g. electronics, automotive and maritime (Bellamy et al., 2014; Greve, 2009; Kito et al., 2014; Luo et al., 2012).

2.2.2 The role of network governance in economic development of industrial regions: evolutionary economic geography and complex adaptive systems views

EEG demonstrates growing interest in CAS governance frameworks, which can explain and facilitate the formation of clusters and networks of interconnected firms, leading to enhanced innovations and knowledge transfer within industrial regions, thus improving their adaptability and resilience (Cooke, 2012; Crespo et al., 2013; Gomez et al., 2016). CAS frameworks are useful for identifying endogenous mechanisms leading to the emergence of industrial clusters in regions where firms are linked not only through economic interactions but also through social connections due to close geographical proximity (Cooke, 2012; Crespo et al., 2013; Fuller and Moran, 2001; Martin and Sunley, 2007; Suire and Vicente, 2014).

CAS frameworks in EEG literature highlight the role of network governance in fostering the adaptability and resilience of industrial regions (Cooke, 2012; Martin and Sunley, 2007; Simmie and Martin, 2010; Suire and Vicente, 2014). Regional networks emerge at the regional or “meso” level from the micro-level relational dynamics of spatially proximate economic agents (Dopfer, 2011; Giuliani, 2005). These “bottom-up” decentralised economic interactions of firms drive the formation of macro-level structures in the form of industrial agglomerations, networks and clusters (Boschma and Martin, 2007).

Several EEG frameworks have been developed to address the adaptability and resilience of resource extractive regions (Chapman et al., 2004; Hu and Hassink, 2015). However, scholars studying resource extractive economies still acknowledge the scarcity of research into the mechanisms and drivers of the formation of collaborative clusters, networks and knowledge transfer in mining regions (Arias et al., 2014; Chapman et al., 2004; Figueiredo and Piana, 2016; Knoblock, 2013).

2.2.3 Regional supply networks as complex adaptive systems: governance, structure and operational performance

CAS frameworks and models address the network-centric nature and complexity of supply chains that influence the operational performance at the firm and overall supply chain outcomes (Choi and Kim, 2008; Choi et al., 2001; Nair et al., 2009). The literature shows that supply network structure impacts the overall business performance, capabilities and innovative capacity of participating firms (Bellamy et al., 2014).

However, research into the relationships between network governance and structure and its implications for network performance is limited in supply chain management (Pilbeam et al., 2012). There is a paucity of research that relates supply network governance to network structure and performance (Pilbeam et al., 2012; Statsenko et al., 2018).
2.2.3.1 Supply network connectivity and network outcomes. Relationships between network structure and connectivity, and associated network outcomes, have been discussed by scholars, including analogies between different types of efficient real-world network structures (e.g. ecological, biological and physical) and human-constructed supply networks (Hearnshaw and Wilson, 2013; Kito et al., 2014; Saavedra et al., 2009).

A combination of network parameters results in a certain level of network connectivity and a particular network structure. The types of the node degree distribution, network density and clustering coefficients, average path lengths and modularity levels influence network connectivity and structural configuration (Newman, 2003).

For example, in supply networks, as well as in other types of networks, the lesser the average geodesic (i.e. path length) between two points (i.e. firms) in a network, the higher the network connectivity. This results in the easier access to the diverse resources inherent in the network and the more efficient the information and knowledge diffusion for the firms. Another characteristic of real-world networks is the clustering coefficient — a measure of the degree to which nodes tend to cluster together. A high clustering coefficient coupled with a short average path length often implies a “small-world” network structure with effective information diffusion and flexibility (Watts and Strogatz, 1998). Another configuration of a real-world network is a “scale-free” structure. It is characterised by a small number of highly connected hubs and a large number of nodes with very few interconnections (Barabási et al., 2000). Scale-free supply networks have been found to be resilient to external threats and disturbances (Thadakamalla et al., 2004). If there is also a sufficient network density, this is a sign of network adaptability and responsiveness (Hearnshaw and Wilson, 2013; Thadakamalla et al., 2004; Zhao et al., 2011). A low clustering coefficient associated with lower connectivity, that is, with many structural holes in a supply network, implies that firms experience fewer constraints on opportunistic behaviour. This results in limited trust and collaboration, causing inefficiencies and poor system-wide coordination.

On the other hand, a well-interconnected supply network has a high density and a high clustering coefficient, which prevent opportunistic behaviour, enhancing system properties (Choi et al., 2001; Pathak et al., 2007). Subsequently, the creation of horizontal connections in the supply chains improve information sharing (e.g. exchange price and point of sale information), collaboration (e.g. collaborative plans, sharing costs and synchronising demand requirements) and social capital, allowing for the emergence of a “macroculture” (Hearnshaw and Wilson, 2013). However, over-connectivity or overembeddedness in the inter-firm network is counterproductive for the individual firms and the network as a whole, leading to excessive network closure, which impedes the influx of new ideas and knowledge (Uzzi, 1996, 1997). Furthermore, high density networks often produce a “lock-in” effect, where over-connectedness reduces adaptability and makes the network vulnerable to cascading effects (Thadakamalla et al., 2004). Thus, an increase in connectivity leads to an overall network improvement only up to a certain threshold and takes an inverted U-shape relationship (Uzzi, 1997).

Modularity is a structural characteristic of a network that can be divided into a set of almost non-overlapping modules that have high connectedness within a module, but relatively moderate amounts of links between the modules (Newman, 2006). Modularity is also associated with functional segregation, with modules able to perform specialised functions (Rubinov and Sporns, 2010). In the supply chain context, networks possessing communities with overlapping boundaries have higher connectivity and better diffuse and transmit information across the entire network, as opposed to networks with more of an isolated community structure (Hearnshaw and Wilson, 2013).

The size of the largest connected component in the network, where a path exists between any two nodes, is another measure of network connectivity that positively correlates with the supply network robustness (Thadakamalla et al., 2004).

2.2.3.2 Supply network governance and operational performance. Supply network governance and policy studies originate from organisational studies that have examined the mechanisms operating in inter-organisational networks that guide overall network performance (Grandori and Soda, 1995; Jones et al, 1997; Provan, 1993). Network governance relies on coordination and the self-organisation and motivation of independent actors, who are involved in complex relationships and interactions (Keating et al., 2015). It depends on a set of instruments, as well as mechanisms, that can be used to coordinate network organisations to deliver collective outcomes and participate in cooperative decision-making (Hollstein et al., 2017). This is in contrast to coordination mechanisms based on hierarchy or market regulations. Supply network governance is focused on the interorganisational and relational aspects of supply chains and also seeks improvements to the overall supply chain system rather than individual firms (Harland and Knight, 2001).

Formal and informal mechanisms of network governance are identified in the literature. While formal governance is often referred to as a set of standards, processes and contracts agreed upon by the industry and used to guide firm behaviour in supply chains, informal governance involves such mechanisms as social norms, values, culture, trust and power (Pilbeam et al., 2012). The complementary relationships between formal and informal or relational governance facilitate knowledge creation, knowledge integration and communication in the supplier network (Gurcanyllar-Yenidogan and Windsperger, 2015). The informal norms from prior ties enhance efficiency of interorganisational exchange relationships (Gurcanyllar-Yenidogan, 2017). Organisation science literature discusses system-level informal mechanisms of network governance, referring to such drivers as trust, reputation, macroculture, collective sanctions and restricted access (Grandori and Soda, 1995; Jones et al., 1997; Provan and Kenis, 2008). Macroculture incorporates informal rules and routines shared by a firm’s employees or a network’s members and cannot be achieved by control measures introduced by a single hub firm or even a coordination body.

System policy studies relate network connectivity to the flexibility of socio-economic and socio-political systems. Social systems governed by network principles tend to be flexible, as
opposed to rigid or fragile governance types based on hierarchical principles (Duit and Galaz, 2008). Connectivity in socio-economic systems waxes and wanes in a process referred to as “self-organised criticality”. At a critical point, the complex system will be in balance. Operating far from the critical connectivity level destabilises the system and causes sub-optimal operational levels.

Thus, network connectivity and its structural parameters are influenced by governance mechanisms operating in CAS and should be considered as important for understanding overall system performance. Applying this view with the purpose of RSN optimisation, supply network structural parameters are the result of the governance applied, endogenous self-organisation mechanisms and the external environment – regional and global economy. The RSN performance, including effective resource allocation, incentives alignment and operational characteristics – responsiveness, resilience, adaptability and innovativeness – is a function of the network structure (Figure 1, Statsenko et al., 2018).

Thus, RSN performance, including effective resource allocation, incentives alignment and operational characteristics – responsiveness, resilience, adaptability and innovativeness – is a function of the network structure (Figure 1, Statsenko et al., 2018).

To date, no framework has been found that can offer a structured approach to the governance RSNs, although it is recognised that their complexity and interconnectivity enhance the resilience and adaptability of regional economies. Despite a growing number of CAS frameworks in regional development and supply network research, few studies have discussed the influence of CAS on the RSN structure and or the connectivity that impacts economic development in industrial regions by means of more effective resource allocation, incentives alignment and enhanced innovativeness of local firms. Recognition of the behaviour inherent in CAS, and the network-centric structure of regional supply chains offers a novel framework for policymakers and practitioners to assist the integration of local firms into regional supply chains, increasing interconnectivity, which ultimately leads to the enhanced adaptability and resilience of industrial regions.

This paper proposes a CAS governance framework for regional mining industry supply networks based on empirical data from the SA mining industry. Policymakers, as a governing body, can apply CAS principles to govern the interconnectivity of RSNs and thus create a regional “ecosystem”, allowing for more effective information and knowledge diffusion. The proposed framework offers a systemic approach for more effective and efficient allocation of resources and provides a novel insight into developing regional policies aimed at facilitating the economic development of industrial regions.

2.2.4 A complex adaptive systems governance framework for regional supply networks in the mining industry

CAS frameworks recognising the complexity of inter-firm networks in regional development literature (Crespo et al., 2013; Martin and Sunley, 2007) and supply chain management literature (Choi et al., 2001; Pathak et al., 2007), as well as general CAS governance framework (Gorod et al., 2015), were used to develop a framework for RSNs governance. A mining industry supply network localised in a particular geographical region is formed as a result of economic interactions underpinned by physical proximity between regional suppliers and mining companies. This RSN is a CAS which evolves its structure due to endogenous processes. It also co-evolves with the external environment represented by the regional economy and global mining industry supply chains and also is influenced by the governing body, in this case, regional policymakers.

A general CAS governance framework proposed by Gorod et al. (2015) guided the development of the conceptual framework. It contains six major elements:

1. the CAS itself;
2. the external environment affecting the system (which cannot be controlled by a governing body);
3. a feedback mechanism;
4. a governing body;

Figure 1 The conceptual framework linking RSN governance, connectivity and performance

Source: Adapted from Statsenko et al. (2017)
5 constraints on the governing body; and
6 governance mechanisms (Figure 2).

The CAS governing body could be identified within or external to the supply network – the assembler or major client in the value chain, a consortium of industry and certification bodies developing industry standards or different layers of government – which establishes taxes and regulations, or both of them (Luo et al., 2012; Provan and Kenis, 2008).

The governing body has an agenda or multiple agendas to be able to govern the CAS, by imposing constraints and incentivising the CAS agents – firms operating in the industry supply networks – thus facilitating or inhibiting the formation of supply chain links (Gorod et al., 2015). The feedback mechanism is necessary for the governing body to monitor CAS behaviour (Gorod et al., 2015). The governing body also experiences external constraints that limit the effectiveness of the governance mechanisms applied.

3. Research methodology

3.1 The case study

A case study of the SA mining sector has been used because the Government of South Australia currently implements a range of programmes to facilitate the development of high value-added METS services by encouraging the formation of supply chain connections between local firms and mining operators (Department of State Development, 2015).

The economic landscape of South Australia is significantly affected by large-scale mining projects that are key sources of market demand for local technology and services suppliers. In 2015, METS contributed 2.6 per cent to the gross state product. This represents $2.4bn and 17,830 full-time employees (FTE), more than in the mining sector itself, which had 13,509 FTE (Department of State Development, 2015). Agglomerations of mining services suppliers can be found within major industrial towns, including Adelaide, Whyalla, Port Augusta and Port Pirie. Knowledge-intensive business services, such as consultancy, project management and IT, are primarily located in the state capital, Adelaide, while companies specialising in manufacturing and mining services are often based in regional towns.

METS suppliers represent an aggregation of suppliers of manufactured inputs and construction services. The linkages to the mining industry can be observed from the input-output tables, i.e. the intermediate purchases by the state’s mining sector (e.g. coal, oil and gas extraction, iron and non-ferrous ore mining and non-metallic mineral mining).

The METS sector was estimated to directly employ 8,400 people in 2012/13 (1.1 per cent of the state total). The FTE employment was estimated to be 11,300 (1.6 per cent of the state total).

3.2 Research design and methods

This paper aims to build an understanding of the factors influencing the development of effective well-connected regional supply chains in the mining industry by interpreting the relationships and interdependencies through the general CAS governance framework (Gorod et al., 2015). Theory building through recursive analysis was undertaken following Eisenhardt’s (1989) approach.

Pragmatism, as a research paradigm, and the case study research design enabled the use of mixed methods for data collection and interpretation. The case study allows a contemporary phenomenon to be investigated within the natural context, especially when the boundaries between phenomenon and context are unclear (Yin, 1981). The case study research involves collecting data from the context in which phenomena occur and generating an understanding that is grounded in the perspectives of research participants (Bryman et al., 2012). To answer the research questions, an exploratory case study and mixed-methods research design was adopted (Eisenhardt, 1989).

Qualitative interviews. In total, 39 semi-structured interviews with SA mining industry stakeholders were conducted during September 2015-June 2016 to informed governance framework development. This included mining operators, Tier I and lower-tier services suppliers, supply chain consultancy and policymakers. The types and names of organisations are shown in Tables I and II.

To identify the governance framework constituents – CAS boundaries, governance body, governance mechanism and feedback, external factors and constraints – qualitative data from in-depth interviews and secondary sources – industry and government reports and media were analysed using thematic analysis and coding with the support of NVIVO software. The information and insights from the industry stakeholders and policymakers were interpreted through the lens of the CAS governance framework and were verified by them.

Social network analysis. To reconstruct the RSN structure in the SA mining regions, social network analysis was used. To

![Figure 2 The CAS governance framework](Image)
Thus, only presence or absence of the supply chain connection between two companies matters (Table III).

The data set used to demonstrate the applicability of the proposed framework in the case study is the most comprehensive reported to date on SA mining sector supply networks.

The resulting data set that represents the resource sector’s related supply network contains data of 2,482 nodes with 13,362 relationships. Two researchers independently performed the procedure and the results were cross-validated.

The adjacency matrix was imported into UCINET 6 software and the Polinode Web service to visualise the structure of the mining sector RSN. The commonly calculated network statistics, including network density and clustering coefficient, degree centrality (Borgatti and Li, 2009) and Louvain modularity (Blondel et al., 2008) were used to identify interconnected clusters or communities of local companies that were integral to the SA mining RSN. The Louvain modularity algorithm was used to identify densely connected communities of local companies in the RSN. The Louvain method for community detection is a method for extracting communities from large networks (Blondel et al., 2008).

4. Findings

4.1 The complex adaptive systems governance framework for the emergent structure of the mining sector regional supply networks

Figure 3 depicts the CAS governance framework as applied to SA mining sector supply network. Guided by the general CAS framework it includes:

- the CAS – the SA mining industry RSN;
- external factors influencing the CAS – economic and global mining supply chain trends; industry standards, environment and safety regulations; declining ore grades; power structure and relations; infrastructure issues;
- governing body – the SA government, implementing policies to incentivise integration of local SMEs into the mining industry supply network;
- constraints for the governing body – knowledge and information, financial;
- governance mechanisms – programmes and policies implemented by regional authorities; and
- feedback mechanism – the RSN structure and interconnectivity.

4.1.1 The complex adaptive systems: the South Australian mining industry supply network

4.1.1.1 Mining industry supply chain structure. A typical mining industry supply chain is characterised by tiered procurement. Tier 1 suppliers working directly with the mining companies vary depending on the stage of the mining project. Tier 1 companies are large international engineering procurement and construction management (EPCM) providers, which sub-contract smaller local service providers. Original equipment manufacturers (OEMs) producing capital equipment (e.g. fans, mills, crushers, drilling rigs and furnaces), supplemented by aftermarket services, also often operate as Tier 1 suppliers. The mining project development...
<table>
<thead>
<tr>
<th>METS Company</th>
<th>Tier</th>
<th>Capabilities</th>
<th>Size</th>
<th>Ownership</th>
<th>Position</th>
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</tbody>
</table>
and construction phase is usually outsourced by mining companies to Tier 1 contractors (Companies 10, 13). Tier 1 usually engages their globally established supply chains, which makes it challenging for local suppliers to enter. At the mining operations stage, it is more likely that mining companies will directly engage local firms for small projects, such as IT, construction, engineering and consulting (Companies 4, 7, 17-24). Tier 2 suppliers could be component manufacturers servicing OEMs with types of equipment or processes and represent a wide spectrum of standard and specialised component manufacturers (Company 20).

Tier 3 and Tier 4 sub-contractors provide professional services for EPCMs or Tier 2 firms (Companies 1-3, 5, 6, 8, 9, 11, 14, 16, 17, 21).

4.1.1.2 Mining industry regional supply networks as complex adaptive systems. As multiple supply chains are often highly intertwined, an RSN emerges as a holistic entity at the regional level. Mining companies and regional METS service providers are CAS agents that operate independently yet remain interconnected through supply chain relationships. The structure and interconnectivity of the RSN influence individual METS firm performance, as well as industry dynamics in the mining region. The conceptual representation of the mining industry supply network in a mining region, consisting of five mining companies and their regional suppliers, is shown in Figure 4.

The mining supply network configuration is flexible, allowing for a variety of possible arrangements and connections among constituent companies. Companies 4, 14 and 18 comment that at one stage of a mining project, they could be a sub-contractor to a Tier 1 EPCM provider, that is, a Tier 2 supplier to a mining company. At another stage, the supplier deals directly with the mining operator, thus becoming a Tier 1 supplier. One supplier could be a part of more than one mining company supply chain. “Many-to-many” relationships exist throughout the whole supply network. These can be found between mining companies and Tier 1 suppliers, as well as in subsequent layers both within and between the tiers. Referring to Figure 4, the overlap in the supply networks of Companies A and E through sharing the same suppliers can be observed. The complexity and dynamic reconfiguration of the RSN is a result of supplier diversity and the vast number of interconnected organisations participating at different stages of a mining project. In addition, the companies that are part of the mining sector supply network also belong to supply networks of other industry sectors, such as energy, manufacturing, water and defence (most of the interviewed companies, except Companies 3, 7 and 22).

4.1.2 External environment

External factors are the exogenous forces affecting resource industry RSN connectivity, which are beyond influence of the governing body. This includes, but is not limited to, the existing industry structure and relations, the global economy and technology trends, environmental and industry regulations and standards and declining ore grades.

Resource industry RSN connectivity and relational governance. The current mining industry structure in SA is influenced by the dominance of large mining companies and Tier 1 contractors and their established preferred suppliers. Mining companies usually outsource the design and construction of mining projects to EPCMs to reduce risks and costs. In turn, EPCM providers pass risks through established global supply chains, making it difficult for SA firms to enter the
mining industry RSN (Companies 2, 5, 9, 10, 14). There are a number of large and middle-sized highly connected companies in the region that provide integrated services serving as major contractors for local METS firms (Companies 4, 6, 10, 13, 18, 23). As a result, historically, RSNs in the SA mining industry are structured around key companies in a hub-and-spoke manner. To address this, the SA Government puts in place programmes facilitating horizontal collaboration among lower tier suppliers, thus encouraging horizontal interconnectivity. At the micro level, trust and knowledge of local capabilities helps in building complementary partnerships among lower tier suppliers, thus encouraging horizontal interconnectivity. At the micro level, trust and knowledge of local capabilities helps in building complementary partnerships among lower tier suppliers, thus encouraging horizontal interconnectivity. 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Global economic trends. Economic recessions, leading to a downturn in demand for mining commodities, force mining companies to introduce cost reduction strategies, such as shutting down resource exploration activities and shifting operating mines to maintenance (this was common to all major and junior mining companies). Because of the high dependence of the Australian mining industry on demand for mineral commodity from China, there has been a downturn in the SA mining sector since 2012 which has impacted local supply network integrity. Slowing economic activity is perceived as both a barrier and an opportunity for local firms (Austmine, 2015). For example, the amount of work for exploration and drilling services companies has been reduced because of the closure of greenfield and brownfield exploration activities performed by junior and major mining operators (Companies 17 and 19). Lower tier service suppliers also experienced a substantial decrease in the number of opportunities for tenders (almost all the interviewed Tier 3 and 4 suppliers).

More innovative local service providers and engineering and project management services suppliers, perceive the downturn in the mining sector as an opportunity. Some local services firms successfully moved up in the mining supply chain, substituting for high-cost EPCM providers (Companies 4, 22 and 23). Most of the interviewed METS, regardless of their core capabilities and tier position, look for opportunities in other markets through overseas expansion (Companies 4, 7, 9, 11, 16 and 22), or diversification to another sector (Companies 4, 5, 8, 9, 12, 16 and 23). Re-focusing on customer relationships and introducing value-adding services is another way to survive through downturn. Most of the suppliers introduce new services by solving client problems in innovative ways (all of the Tier 2-Tier 4 companies interviewed). These strategies significantly affect the structure and interconnectivity of the resource industry RSNs.

Industry associations assist by facilitating networking and collaboration among local suppliers and providing access to information about upcoming tenders. However, their efforts were reported to have disappointed expectations (almost all interview participants).

Competitive pressures from global mining industry supply chains. Local firms face increasing global competition in the mining industry sector from internationally established supply chains. The competition for work packages has increased both from interstate and overseas. An increased level of competition from low-cost imported services is among the top five challenges for mining services suppliers in Australia (Tier 2-Tier 4 companies and industry associations). Tier 1 EPCM providers and OEMs increasingly outsource non-core activities such as design, procurement and contract management services to less expensive offshore service providers (Companies 4, 10, 13 and 14). There is a clear trend towards the concentration of production, services capacity and specialisation in a few global hubs (Companies 4, 10, 13, 14, 18 and 21). This decreases the interconnectivity of the regional mining industry supply network. The counter force to this are the actions taken by the governing body and formal and informal governance mechanisms in the RSN. To tackle reduced interconnectivity,
the SA Government has put in place programmes and projects facilitating collaboration between major mining companies in the region and local firms (Companies 3, 5 and 17). There are a number of grants, with local universities involvement, to incentivise local suppliers to deliver innovative solutions to mining companies (government reports).

Industry standards, environment and safety regulations act as a formal network governance mechanism. The mining industry operates with strict occupational health and safety standards that must be met by suppliers. Cost of compliance is one of the most often cited challenges for small service suppliers (Companies 5, 6, 9, 17 and 23). The certification process requires a significant financial and time investment, which is always a constraint for small firms. This forces local SMEs to operate under the supervision of a larger contractor, who will cover risks while dealing with the mining companies or EPCM providers.

To counteract this constrain, the SA Government, as a governing body, has introduced funded programmes to assist local firms in assessing their readiness to supply to the mining sector. These programmes sponsor the consultancy support for local METS to obtain the required certification and accreditation. SA Government introduces initiatives that facilitate collaboration between industry associations, mining companies and EPC/EPCM providers to engage local suppliers and sponsor networking events for local suppliers (Department of State Development, 2015).

Declining ore grades causing difficult conditions of mining operations encourages search for innovative solutions from local suppliers. The depletion of mineral reserves forces mining operators to mine at deeper levels, locate ore bodies more accurately and process larger amounts of ore. This creates the need for more complex knowledge of intensive solutions at every stage of the mining project, from exploration to site remediation, and forces suppliers to innovate and introduce more effective solutions (Companies 6, 10 and 14).

This acts as a uniting force for innovative local firms, which seek new connections within the RSN with more established and resourceful players to collaborate and implement innovative solutions.

The SA Government actively promotes local innovations through sponsoring technology parks and business incubators with the active involvement of local universities. The research grants and R&D tax reduction programmes is another governance mechanism put in place to enhance local innovations. However, a number of firms acknowledged that the application process is cumbersome and is not worth the effort (Companies 4, 7, 9 and 10). The founder and owner of a successful internationally operating software developing company comments:

[... ] The R&D tax deduction is a waste of time [... ] You’re sort of forced to use a consultant to make the R&D claim. It’s not a very big amount anymore [... ] A huge amount of paperwork. We’re probably to stop bothering [... ].

4.1.3 Governing body
For the purpose of this paper, the SA Government was considered as a governing body. A major concern for the regional authorities is the integration of local services suppliers into mining sector supply networks.

4.1.4 Constraints
The constraints faced by the SA Government in relation to the development of local services suppliers include international and federal regulation and policy, stakeholder agendas, knowledge and tools, and budget limitations.

Regulatory and policy constraints. The policies of different jurisdictions, including those at the international and federal levels, often constrain initiatives aimed at developing local competitive advantage. The SA Government, as a governing body, cannot introduce “local content” policies to encourage mining companies to source locally, as at the international level, World Trade Organization’s arrangements on trade related investment measures restricts local policies aimed at encouraging “local content” for companies (government representatives, Company 14).

For example, the objectives of the state government do not always correspond with the initiatives implemented at the federal level, which has a nationwide view (government representatives). Many companies see the multilayered structure of the Australian Government as an impediment to the successful development of local supply chains (Companies 2, 4, 5, 7, 9, 16-18 and 23).

Knowledge and tools constraints. Often, regional authorities are suspiciously perceived as lacking an understanding of industry needs. Consequently, most local firms view government initiatives as having no value and participate reluctantly (Companies 2-5, 19 and 23).

The low visibility of the local mining services suppliers sector in SA is a challenge for regional authorities (Econsearch, 2015). The Australian and New Zealand Standard Industrial Classification (ANZSIC) does easily allow capturing diverse services. Technology and equipment suppliers belong to diverse industries and there is a general failure to monitor SA METS sector development and evaluate the level of integration of mining industry regional supply chains. In 2015, the first attempt was made to extract systematic statistical data to construct the profile of the METS sector in SA by using ANZSIC (Econsearch, 2015).

4.1.5 Governance
The SA Government undertakes the governance of the mining sector RSNs, including programmes and initiatives to assist local firms in integrating into the mining industry supply chains. To assist local METS providers, the SA Government introduces incentives and provides rules and regulations, such as royalty and payroll taxes, as well as implementing regional development initiatives, aimed at influencing the decision-making process of mining companies and their suppliers (government departments and industry associations). Regional authorities actively establish collaborative initiatives with the industry associations, mining companies and EPC/EPCM providers to facilitate local supplier engagement. Innovative firms can get access to grants, get R&D tax reduction and access to large companies to commercialise and implement innovations (Department of State Development, 2015).

Techno parks and business incubators, such as the Tonsley and Mawson Lakes initiatives, were established in Adelaide to facilitate various forms of collaboration across local supply chains. This space is mainly occupied with start-ups with innovative potential or well-established high technology firms,
whereas most SMEs and individual entrepreneurs do not perceive immediate value in these initiatives (industry associations and government departments).

Regional authorities sponsor industry networking events organised mainly through state-based industry associations. This is reported as more beneficial for small local firms, as local suppliers can build informal networks and relationships with potential clients (almost all of the interviewed companies). At the same time, interviewed firms still acknowledged that networking per se does not lead to winning contracts in the sector (Companies 1, 4–6, 8 and 15). A business development manager of an engineering design company comments on a government initiative conducted by an industry association to assist local METS firms:

[... ] We get inundated with these sorts of things every week. It’s very hard to work at. You can spend a lot of money and get no real value out of them. I think, in theory it looks good, but we haven’t committed to it at all [...].

The ICN is an independent organisation financially supported by the Australian and New Zealand state and territory governments, which has close affiliation to the national and state government. The primary objective of the ICN is to provide local suppliers with opportunities in different sectors by informing them of the upcoming tenders, as well as assisting project managers of large projects to find local suppliers. Despite the fact that registration in the ICN database is free of charge, the advantageous position at the top of the list demands a fee. Recently, the SA Government has requested from mining companies and EPCM providers to list large-scale mining and infrastructure projects at the ICN online platform to assist local firms with opportunities to win work in the sector. Although major mining companies and EPCM providers follow these rules, local suppliers report that the value of ICN membership is unclear to them (Companies 3–5, 7, 14, 16, 19, 22 and 23):

[...] We’ve been registered in that [ICN] previously. I’ve not been aware of any direct opportunities that have come from that [...] (Company 4).

When information about upcoming tenders appears in the ICN, the supply chains are already formed, and it is often too late to apply. Local firms report that the information received through the informal and personal connections is more timely and valuable when tendering (all Tier 2–4 service providers). A Tier 2 METS company general manager doubts the usefulness of the system:

[...] It’s not the best system [...] you might find that for a few months, they’ll be quite proactive with it, and then that’s it. You do struggle getting information out of them [...] (Company 23).

The SA Government supports the Global Maintenance Upper Spencer Gulf Resource Industry Cluster (GMUSG) initiative. GMUSG is an organisation operating in SA, which draws its membership from businesses across the SA Upper Spencer Gulf region. The members offer engineering and maintenance services to the mining sector. GMUSG has more than 100 members and serves as a front-end sub-contractor to higher-tier suppliers in the mining sector, drawing on the capabilities of its members and having a long history and good reputation in the region (Company 10, GMUSG interview).

For example, the Resource Supply Chain Panel Programme, run by GMUSG in cooperation with Enterprise Connect, assesses local firms’ readiness to become a supplier to the mining sector. The Resource Supply Chain Index includes the assessment of a firm’s management, quality and occupational health and safety (OH&S) systems against standard mining project tenders.

The PACE supply chain development programme operated by the Resource Engineering Skills Alliance provides training and consultancy support in terms of meeting the required certification and accreditation, preparing tender documentation and formulating business value propositions that improve marketing by tailoring value proposition to mining company needs.

4.1.6 Feedback

Currently, the SA Government actively implements initiatives to establish feedback mechanisms that allow for tracking the development of local suppliers to the mining sector. Among the initiatives, the first attempt to develop a framework with aggregated economic indicators of the METS sector was undertaken in 2015 (Econssearch, 2015). Mapping the local supplier capabilities is another feedback mechanism by which information about local supply chains can be obtained (Department of State Development, 2017).

The RSN structure and interconnectivity if tracked on a regular basis is a dashboard for the governing body to monitor the outcomes of the implemented incentives and regulations in the regional mining industry. An example of the RSN structure analysis is provided further.

4.2 Analysis of the regional supply network structure

The structural parameters of the SA regional mining industry supply network are shown in Table IV. It allows implications to be drawn for regional policymakers and supply chain practitioners.

4.2.1 Regional supply network structural parameters

As per Table IV, the average degree in the SA RSN is 5.28, which indicates the average number of suppliers or customers the firm is connected to randomly. However, analysis confirmed that degree distribution in the SA RSN follows a power law, implying a “scale-free” structure for the RSN. A “scale-free” network has a very small number of the highly connected nodes, whereas most SMEs and individual entrepreneurs do not perceive immediate value in these initiatives (industry associations and government departments).

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In the context of the RSN in a mining region, this implies that a simultaneous rapid drop in demand for the METS services from a number of regional customers, or the exit of
several suppliers, will not significantly affect the regional mining industry. However, if such a drop in demand was to involve a major hub firm, there is the potential for a significant negative cascading effect in the regional mining industry. Evidence from the recent downturn in mineral commodity prices supports this. When the major SA mining hubs adopted cost-cutting strategies, mining operations and exploration activities in the region subsequently shut down. Significant regional supply chain restructuring took place, followed by the exit of a large number of local suppliers because of the inability to maintain workflow.

High network density and the clustering coefficient are signs of well-coordinated, flexible and adaptive networks. The density of the RSN in the SA mining region is 0.001, which is comparable to other industrial supply networks reported in recent studies (Kito et al., 2014; Luo et al., 2012). However, compared to other resilient and adaptive real-world networks (Newman, 2003), it is not dense enough to assume sufficient adaptability and coordination. Furthermore, a shorter average path length increases network responsiveness and the efficiency of information diffusion, often associated with a "small-world" network structure (Watts and Strogatz, 1998). The average path length in the SA RSN is 4.11, which means that an average firm A is connected to any firm B through four other firms in the RSN. The clustering coefficient of 0.028, compared with other real world networks (Newman, 2003), is modest. The combination of the average path length and the clustering coefficient does not imply the presence of a "small-world" structure and efficient information diffusion.

However, in general, the interview data from representatives of the SA METS confirm the collaborative nature of the relationships between suppliers and customers in the SA mining sector (Statsenko et al., 2018). The SA mining industry RSN acts as conduit for knowledge and information transfer within and between SA mining and related industries in the region. From the EEG perspective, this implies that firms connected to the network, and particularly to its “core”, benefit from “industry intelligence” through information and knowledge diffusion enhanced by geographic proximity (Balland et al., 2015; Frenken et al., 2015). Knowledge transfer among related sectors through the RSN increases the number and variety of skills and technologies associated with higher levels of regional adaptability and resilience (Boschma, 2014; Cainelli and Iacobucci, 2015).

The key players in the SA mining industry RSN. Several hub companies have emerged within the RSN structure (Figure 5). As might be expected, the most influential players were the mining and mineral processing companies that generate demand for METS companies in the region.

However, more interestingly, a number of key players in the RSN emerged that do not belong to the mining sector per se (such as Companies 10, 13 and 24). These are large engineering and construction companies with a presence in other sectors, including defence, infrastructure, civil and construction. Relationships with these companies are of particular interest to local METS firms into the regional supply chain, because they create demand for regional METS suppliers by offering sub-contracting opportunities while bridging industry sectors in the region.

These companies operate across sectors, facilitating diffusion of technology, practices and industry knowledge. For example, the representative from Company 23, being a long-term supplier to a Tier 1 engineering service provider for a mining company, talked about the importance of a solid reputation in the sector:

[...] You’ve got your range of previous contacts you’ve worked with over the years. It certainly puts you in good stead [...] [...].

Often, by performing work sub-contracted to major Tier 1 companies, local suppliers learn about a client’s problems, which might allow them to become a direct supplier to a mining company in the future:

[...] the Tier 1 being a guidebook, might have people come and go [...] so eventually that’s why a local supplier comes and develops the direct connection through, to [mining company]. Then it also requires, on the mining company’s side, for the mining company to actually see the value in the specific technology that the local supplier’s bringing. Often, they got to go through Tier 1 to get in, but they might form a roundabout relationship [...] (Company 14).

Furthermore, the size of largest connected component of the SA RSN is 98 per cent (Table IV). This implies that 98 per cent of companies in the network are interconnected because of shared suppliers and clients from several industry sectors. Such a level of interconnectivity between the mining industry and local industries indicates that a diffusion of information and knowledge is taking place, given the boundary-spanning roles of key players in the SA mining industry. Suppliers can then apply the knowledge accumulated through the provision of services to the mining industry in unrelated sectors, such as agriculture. The regional network structure, therefore, provides insights into the mechanisms of creation of unrelated variety in the region (Boschma, 2014; Cainelli and Iacobucci, 2015).

The analysis of the mining industry supply network highlights the contribution of major clients to the SA economy in terms of generating demand for local firms. In Figure 5, each network node represents a company in the RSN, and the size of a node reflects the number of direct connections with other firms in the region. This data equips regional policymakers with information about the “key players” or “network influencers” in the region, who are able to leverage changes in the regional economy and contribute to related and unrelated variety in the region.

Densely interconnected communities in the RSN. The mining industry RSN has a clear core-periphery structure, with densely interconnected core and more loosely connected peripheral community of firms.

Out of the 56 densely connected communities observed in the SA mining supply network, 2 communities are clustered around the two biggest oil and gas and mining companies. This indicates the dominance of a few major clients in the region that form the core of the RSN. These communities comprise densely interconnected companies, holding 74 per cent of all connections in the network. The first community clearly corresponds to the energy sector with suppliers aggregated around several oil, gas and coal producing companies of different sizes [Figure 6(a)]. The second community is clustered around the biggest multinational mining company operating in South Australia [Figure 6(b)].

The presence of overlapping communities confirms the modular structure of the network. The individual modules are densely interconnected “communities”, with fewer connections
between each other. This contributes to effective information transmission and knowledge diffusion (Hearnshaw and Wilson, 2013). However, should one segment of the RSN collapse or be disrupted, the detrimental effect on the whole network is lessened by the loose connection between the modules.

Less connected peripheral clusters in the RSN. The sparsely connected peripheral communities, holding the remaining 26 per cent of the connections, represent the rest of the SA mining industry RSN. Two of these communities are shown in Figure 7. The community representing the manufacturing sector comprises companies performing automation and control, with power and electrical services aggregated around a large EPCM provider and automotive manufacturers. This segment reflects the recent decline in the SA automotive sector, which is still creating a concern for the regional policymakers (Department of State Development, 2015). Many suppliers to the automotive sector are currently seeking to integrate into the regional mining industry supply networks. Firms supplying to the defence and maritime sector represent another community. Other communities mainly comprise smaller mining or engineering companies and their suppliers. These segments should be further examined to evaluate the opportunities for the constituent firms to connect to the core of the SA regional mining industry supply network.

System-level insights into the RSN structure have implications for the development of mining regions. The framework elucidates higher-order factors influencing the development of the RSNs in the mining sector, including:

- Network structure – central interconnected communities of local companies within the local supply network: The collaborative
Regional hubs – companies significantly influencing mining sector RSN dynamics and contributing to the local economy. These are predominantly large mining operators and Tier 1 and Tier 2 providers (Atienza et al., 2016).

Peripheral communities (firms) appear disconnected from the network core and may require support and integration into the main component: This is especially relevant for new entrants that need access to networks and industry-specific knowledge at early stages of development (Huggins et al., 2015; Huggins and Thompson, 2014).

Linkages between mining and other economic sectors through supplier-customer relationships and diversified firms provide insights into diversification paths (Chapman et al., 2004) and creation of related variety in the region (Boschma, 2014; Cainelli and Iacobucci, 2015): Tightly intertwined elements of the mining and other sectors in the supply network highlight the need for inter-sectoral and inter-departmental coordination of policy development (Morris and Fessahaie, 2014).

Firm connectedness within the regional mining supply network – the number of connections per supplier/customer provides insight into a firm’s “embeddedness” and, as a result, its level of integration into the RSNs and its contribution to the regional economy: Firm-level characteristics such as degree, closeness, betweenness and information centrality can provide further insights into firm position in the regional network and can serve as a long-term indicator of its adaptability and resilience. Although interpretation of the individual firm position is outside of the scope of this study, the firm-level analysis of the regional mining industry supply network can provide useful insight into individual firm operational performance and innovativeness. Structural and relational embeddedness literature and methodology can guide this type of analysis (Bellamy et al., 2014; Carnovale and Yeniyurt, 2015; Uzzi, 1996; Uzzi, 1997).

5. Discussion and conclusion

The proposed CAS governance framework offers a structured approach to the governance of RSNs, with particular emphasis on network structure and interconnectivity. The framework includes the RSN as a CAS; the governing body – the SA Government; the external factors influencing both the CAS and the governing body; the constraints for the governing body; the formal governance – regulations, incentives, programmes – and informal governance – social norms, trust and reputation; and a feedback mechanism – the RSN structure and connectivity.

Recognition of the network-centric nature of the regional supply chains permits the use of the RSN structure and interconnectivity as a feedback mechanism to monitor and incentivise formation of well-integrated local supply chains enabling effective technology and knowledge diffusion. This contributes to building local supplier capability at the firm level and enhanced adaptability and resilience of the economy at the regional level.

Implications for policy and practice. The proposed framework draws on empirical data from the SA mining industry RSN that exhibits structural characteristics of a complex network. By adopting a CAS view, regional policymakers can efficiently incentivise integration of local firms into the regional supply chains in the mining regions through monitoring the interconnectivity and structure of the RSN. Visualisation of the RSN structure allows companies to assess their level of integration in the RSN and increase awareness of the surrounding “business ecosystem” in which they operate. Awareness of the broader supply network connections enhances business operational performance (Kim, 2014), which can assist local firms in developing strategies for better positioning and collaboration across mining industry supply chains.

The network-centric nature of mining industry supply chains draws the attention of the policymakers and industry stakeholders to the need for new paradigms and strategies that focus on system-level optimisation to achieve better operational results not only for individual companies or stakeholder groups but also for the regional mining industry as a whole. The RSN parameters and structure, as a feedback mechanism, offer a new insight to the policymakers and industry stakeholders into how to analyse and monitor RSN integration. At the network level, it allows for analysis of linkages developed between the local mining industry and other sectors, including identification of clusters and emerging industries (Chapman et al., 2004; Hu and Hassink, 2015).

Contribution to theory. The proposed framework contributes to the supply chain management literature by offering a novel governance framework with a holistic perspective on the regional supply chains in industrial regions. It is a first step towards developing a structured approach to the governance of RSNs with the purpose of enhancing the adaptability and resilience in regional economies through well-connected
regional supply chains. The findings confirm that the structure and connectivity of the RSN is critical for shaping the dynamics of knowledge, information and technology diffusion in mining regions. The impact of the supply network as a “business ecosystem” on local METS firms’ innovative performance, in terms of their structural position in the network and their access to network resources, has been demonstrated in other industries (e.g. Bellamy et al., 2014; Luo et al., 2012; Carnovale, 2014). From a regional perspective, RSNs in mining regions act as “knowledge” or “innovation” network, discussed in regional development literature (Balland et al., 2014; Crespo et al., 2016; Giuliani, 2013).

The proposed framework conceptualises the RSN as a CAS, with particular emphasis on its structure and interconnectivity as key feedback parameters in the governance process. This allows for a holistic representation of the problem space for regional policymakers and stakeholders concerned with the development of the mining regions and encourages more effective governance approaches.

Limitations. Analysis of the RSN structure does not reveal its dynamics and evolution. Any effort to map an inter-firm network, including this research, can only represent a snapshot of reality in time. However, a sequence of such snapshots would allow for tracking changes in the network over time. Furthermore, the boundaries of the SA mining industry RSN cannot be clearly defined, which has been acknowledged in many studies dealing with inter-firm networks. Nevertheless, the primary purpose of this study was to demonstrate the value of recognition and governance of the RSN at the system level. As a result, the implications and conclusions drawn in this paper are not definitive but rather suggestive. Despite the data set being the most complete to date to describe the SA mining industry, it still represents a limited sample of the population of SA METS firms supplying the mining industry.

For the future research, a pool of network data is created to undertake the longitudinal analysis of the changes in SA mining industry RSN structure and connectivity in relation to external factors. This will be used to undertake a firm-level analysis to test relationships between a firm’s position in the RSN and its innovative and operational performance. Simulation and modelling of the external environment and RSN adaptation will also be conducted. In addition, the opportunities for expanding the application of the proposed framework to RSN governance in mining regions and industry sectors are explored.

Notes

1 Industry Capability Network (ICN) is an independent organisation financially supported by Australian, New Zealand, state and territory governments. The primary objective of ICN is to provide local suppliers with opportunities in different sectors by informing them about upcoming tenders as well as assisting project managers of big projects to find local suppliers. The ICN database contains information about 70,000 suppliers across Australia.

2 Since the SA RSN has a scale-free structure, this parameter cannot be interpreted adequately.

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**Further reading**


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On the road to carbon reduction in a food supply network: a complex adaptive systems perspective

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Abstract

Purpose – In acknowledging the reality of climate change, large firms have set internal and external (supplier oriented) targets to reduce their greenhouse gas emissions. This study aims to explore the complex processes behind the evolution and diffusion of carbon reduction strategies in supply networks.

Design/methodology/approach – The research uses complex adaptive systems (CASs) as a theoretical framework and presents a single case study of a focal buying firm and its supply network in the food sector. A longitudinal and multilevel analysis is used to discuss the dynamics between the focal firm, the supply network and external environment.

Findings – Rather than being a linear and controlled process of adoption implementation outcomes, the transition to reduce carbon in a supply network is much more dynamic, emerging as a result of a number of factors at the individual, organisational, supply network and environmental levels.

Research limitations/implications – The research considers the emergence of a carbon reduction strategy in the food sector, driven by a dominant buying firm. Future research should seek to investigate the diffusion of environmental strategies more broadly and in other contexts.

Practical implications – Findings from the research reveal the limits of the control that a buying firm can exert over behaviours in its network and show the positive influence of consortia initiatives on transitioning to sustainability in supply networks.

Originality/value – CAS is a fairly novel theoretical lens for researching environmental supply network dynamics. The paper offers fresh multilevel insights into the emergent and systemic nature of the diffusion of environmental practices in supply networks.

Keywords Case study, Supply chain management, Climate change, Consortium, Complex adaptive systems, Sustainable supply networks, Carbon reduction

Paper type Research paper

1. Introduction

In the past four decades, sustainability has become a useful umbrella concept for thinking about the relationship between the economic and environmental systems, but its high level of abstraction and complexity makes it difficult to operationalise at the level of the supply network (Carter and Rogers, 2008; Matthews et al., 2016). A recent management paper has encouraged scholars to start conducting research into the relationship between supply networks and specific environmental problems to produce more fine-grained accounts of corporate sustainability strategies (Whiteman et al., 2013).

This paper responds to this call by focussing on the issue of anthropogenic climate change as it one of the most serious man-made environmental problems (IPCC, 2013). Climate change is thought to be contributing towards phenomena such as water scarcity and accelerated rates of species extinction (WWF, 2014). Consequently, there is broad agreement within the discourse on sustainability that the sustainable economy will need to be a low-carbon economy (IPCC, 2007; OECD, 2010; UNEP, 2011; WRI, 1998), and carbon reduction is often seen as a proxy for sustainability performance (Bai et al., 2012).

Climate change is a system-level challenge that cannot be resolved at the level of the firm. Firms will need to pursue
cooperative inter-organisational strategies to effectively mitigate climate change (Pinkse and Kolk, 2010). In a scenario where competition takes place between supply networks (Lamming et al., 2000; Bakker and Kamann, 2007), instead of between isolated firms, a buying firm is deemed to be more sustainable than its suppliers (Caniêlts et al., 2013; Krause et al., 2009; Lee et al., 2013). Buying firms are liable for emissions not only within their own boundaries but also across their extended supply networks (Hartmann and Moeller, 2014). Efforts to transform processes and practices to significantly reduce carbon emissions require the efforts of interconnected actors in supply networks, including dominant buying firms and their suppliers (Lee and Klassen, 2008; Nair et al., 2016; Lee, 2008), as well as non-traditional stakeholders such as non-governmental organisations (NGOs) (Gold et al., 2013; Rodriguez et al., 2016). These connections are complex and one cannot assume that environmental strategies and innovations will diffuse linearly and in a predictable manner (Nair et al., 2016).

Yet, most research on sustainable supply chain management (SSCM) and green SCM has been rooted in assumptions of linearity and control, with a primary focus on the relationships between dominant buyers and first-tier suppliers (Miemczyk et al., 2012; Carter and Easton, 2011). Research considering carbon reduction strategies within supply networks is no different. It has particularly focussed on issues related to carbon emissions and auditing (Lee and Cheong, 2011; Lee, 2012; Lee, 2011; McKinnon, 2010), to commercial and legal pressures for carbon emissions reduction (Zhu et al., 2013; Hitchcock, 2012; Zhu and Geng, 2013) and to the development of decision support models (Koh et al., 2013; Hsu et al., 2013a; Hsu et al., 2013b). Little empirical evidence and theoretical discussion of the unfolding of the transition to low-carbon supply networks has been presented to date.

Hence, there are opportunities to expand the scope of scholarship in this area from the linearity of direct buyer–supplier relationships to multi-tier and multilateral studies (Walker et al., 2014; Tachizawa and Wong, 2014) and to consider ways in which environmental strategies proliferate and are shaped through the network. In attempting to address the identified shortcomings of current research, we pose the following question as the overarching aim of our research:

RQ1. How does a carbon reduction strategy emerge in a supply network?

In this research, we embrace the view that carbon reduction in supply networks is non-linear and emerges through a negotiation process between the actors in these networks. In addressing the overarching question, we aim to shed light on this negotiation process and more specifically explore the influence of the interactions between different agents within the supply network on the implementation of a carbon reduction strategy, the main changes and events that shape the process and the challenges encountered in the process.

Our study frames a supply network as a “complex adaptive system” (CAS), i.e. a dynamic system that is difficult to predict and control (Choi et al., 2001, Carter et al., 2015b). While CAS has been used to analyse supply networks (Pathak et al., 2007; Nair et al., 2009; Choi et al., 2001; Surana et al., 2005), studies specifically using CAS as a framework in the field of SSCM remain scarce. A notable exception is the work of Nair and colleagues on environmental innovation diffusion (Nair et al., 2016) that calls for more research around supply network dynamics associated with positive changes such as environmental strategies. We subscribe to their definition of diffusion as a process by which ideas propagate across supply networks and amplification as the process within which a wide diversity of external organisations, besides the buying firm’s suppliers, are involved in innovation or change processes more generally (Nair et al., 2016).

We use a multilevel analysis to map factors that play out in the evolution of a carbon reduction strategy in a supply network. Through the lens of CAS, we discuss the processes at play in moving towards more sustainable supply networks.

To capture the complexity of a supply network, we focus on a carbon reduction strategy implemented in the supply network of a large buying firm in the food sector. The food system is under increasing public scrutiny regarding carbon emissions (Maloni and Brown, 2006; van der Vorst et al., 2009). Food production presents a significant challenge regarding energy consumption because it requires vast amounts of natural resources, such as water, land and energy, making the sector a constant focus of climate change regulation in several countries (Mena et al., 2014). Nevertheless, there is lack of research on large-scale carbon reduction initiatives in food supply networks. Our study provides an in-depth account of the emergence and diffusion of a carbon reduction initiative that has the goal of diffusing a farm-based tool that can track carbon emissions and support the development of carbon reduction strategies across a supply network.

The remainder of this paper is structured as follows. Section 2 presents a review of the literature concerning food supply networks and carbon reduction strategies. The CAS framework and research question are presented in Section 3. Section 4 presents the research design. Section 5 presents the case study findings, which are then addressed in Section 6. In Section 6, we formulate a number of propositions and articulate the managerial implications of the research. Finally, the paper concludes with research limitations and recommendations for future research in Section 7.

2. Literature review

2.1 Food supply network research

The steady growth of the food sector in the past few decades has broadened food distribution from a local to a global scale (Rodríguez, 2012). Forecasts suggest that growth will continue and that by 2050, the world will need to feed more than nine billion people, requiring nearly 70 per cent more food than is consumed today (Denis et al., 2015). Despite the scale of production within the food sector and concentration of firms within it (Beske et al., 2014), the upstream processes of fresh food produce, such as agriculture and dairy production, remain characterised by a dispersed base of smallholder farms, i.e. family-run businesses, where control stays within the family through generations (Ehrhott et al., 2011).

The complex and dispersed food industry faces many pertinent corporate social responsibility issues (Pullman et al., 2009), is highly exposed to public criticism (Maloni and Brown, 2006, van der Vorst et al., 2009) and faces significant
risks, especially with regards to agricultural sustainability (Hamprecht et al., 2005). This has been demonstrated through a number of high-profile scandals, including the horsemeat scandal in Europe and the case of Norwegian salmon production. As a result, there is a growing concern about the social and environmental issues related to food production (Vasileiou and Morris, 2006) and the role of leading multinationals within food systems (Whipple et al., 2009).

The food system is embedded within distinctive social, economic and environmental processes (Thompson and Scoones, 2009) and the increasing drive to manage these and demonstrate good performance in this area have driven the proliferation of sustainability standards (Tallontire, 2007; Henson and Humphrey, 2008). Several companies have begun addressing these sustainability issues by developing or adopting existing standards and certifications, participating in sustainability programme, and defining new modes of governance for food production process (Henson and Humphrey, 2008). Yet, the sharing of sustainability performance gains and the bearing of the investment required are likely to be impacted by the power imbalances characterising food supply networks (Pullman et al., 2009; Cox et al., 2007).

Traditionally, buyer–supplier relationships in food supply networks are predominantly adversarial and focussed on direct suppliers (Mena et al., 2013), and often, firms have addressed sustainability through a risk-perspective setting controls to track the risk of supplier misconduct (Seuring and Müller, 2008). However, as sustainability pressures intensify, buying firms are slowly moving towards a collaborative approach to suppliers and sub-suppliers (Grimm et al., 2014). Supplier development programmes may include transfer of knowledge, resources and the deployment of new organisational practices (Bai and Sarkis, 2010). Recent literature has mapped the cases of Waitrose (Spence and Bourlakis, 2009), Nestlé (Alvarez et al., 2010) and Danone (Gold et al., 2013) as evidence of a shift towards more collaborative approaches to smallholder farms.

2.2 Carbon reduction in food supply networks: between control and emergence

For many food firms, the carbon impact of their suppliers is several orders of magnitude greater than that of their own operations (WRI and WBCSD, 2009); however, only 10 per cent of companies actively measure their supply network’s carbon emissions (Accenture, 2009). Achieving carbon reductions requires calculation of the impact of both direct and indirect emissions (Lee, 2012); engagement and commitment throughout the supply network (Koh et al., 2013); and a monitoring process to ensure improvements are occurring.

Carbon emissions, one component of life-cycle analysis (LCA), has increasingly been applied by large companies not just at individual ingredient or product level but beyond this to assess brand product portfolios (Milà i Canals et al., 2010) and even across their entire supply networks (Lee, 2011). This has been driven at least in part by increased recognition of the need to take responsibility for and include Scope-3 greenhouse gas (GHG) emissions, those outside the direct influence of the company, if they are to truly reduce the impacts associated with their business practices (CarbonTrust, 2006). Pressures from governments and consumers who are relying on large multinational companies to reduce their full value chain GHG emissions through regulatory (e.g. carbon reduction commitment) and voluntary initiatives (e.g. certification of products and environmental product declarations) have further exacerbated the need to address supply network emissions.

Previously however, agricultural emissions were omitted from GHG inventories (Russell, 2011) for a number of reasons, including lack of scientific consensus for accounting methodologies; large uncertainties in terms of the impact of carbon mitigation strategies; and difficulties in gathering data over different spatial and temporal dimensions. Over the past decade, a number of LCA-based carbon reporting tools have been developed in the agricultural sector, particularly in the UK (Whittaker et al., 2013). These tools vary in how they account for GHG emissions from the various activities involved in agriculture. There is consensus, however, around the fact that such tools do provide a way to “educate” farmers about sources of emissions and climate change generally and can serve to facilitate more transparent information sharing between the parties involved in agricultural products chains (Whittaker et al., 2013).

The literature has produced an impressive body of knowledge on how focal firms work towards driving down carbon emissions within their supply networks. These insights include the drivers, pressures and motives for transitioning to low-carbon supply networks (Hitchcock, 2012; Hua et al., 2011); the approaches and methodologies for carbon reduction (CarbonTrust, 2006); and supply network design and operational decision making (Benjaafar et al., 2013; Chaabane et al., 2012; Cholette and Venkat, 2009; Jones, 2002), showing that collaboration and communication both play key roles in effectuating carbon reduction strategies. Open communication helps strengthening relationships across the supply network (Mena et al., 2013). Through collaborative activities based on open communication, firms learn how to assimilate information and transfer experiences across organisational boundaries, thus characterising communication and collaboration as essential components to drive reduction in carbon emissions across the supply network (Theißen et al., 2014).

Much of the SSCM literature stresses the potential for focal firms to control their supply networks and shift them towards a more sustainable trajectory, as can be seen in the following definition: “SSCM is the designing, organizing, coordinating and controlling of supply chains to become truly sustainable” (Pagell and Shevchenko, 2014).

This emphasis on control makes sense, as SSCM studies are often concerned with the deliberate strategies of the buying firms within a supply network. However, this focus has created a gap in the literature as we rarely consider the emergent aspects of SSCM strategies, i.e. the interactions between buying firms and suppliers, which may be significantly different from intended behaviour, e.g. through the resistance of some supply network agents (Touboulc et al., 2014). This may be due to a tendency to over-emphasise the deliberate aspects of SSCM strategies at the expense of their more emergent aspects. To explore the non-deliberate aspects of a carbon-focussed SSCM strategy, we adopt Mintzberg and Waters’ (1985)
The concept of strategy in which strategy consists of both deliberate and emergent strategies.

Deliberate strategy is strategy that was intended and realised, whereas emergent strategy consists of the responses to unanticipated events that were not intended and were not originally formulated as part of the strategy to be implemented (Mintzberg and Waters, 1985). Using this construction of strategy to look at carbon reduction strategies within a supply network leads us to question the linear view of the carbon reduction process in which the focal firm in a supply network formulates the carbon reduction strategy and the suppliers simply implement it unquestioningly and unproblematically. Instead, it opens up the possibility that the carbon reduction strategy that is implemented will be different from the formulated strategy as the focal firm and its suppliers negotiate its meaning, manage tensions between their interests and respond to unanticipated events.

By ignoring the emergent aspects of SSCM strategies, the literature has tended to bracket the question of how suppliers engage with, or indeed fail to engage with, the carbon reduction strategies of their buyers. This leads to supplier engagement being assumed rather than being a phenomenon to be investigated empirically. Given that supplier engagement is considered a prerequisite for a successful carbon reduction strategy within a supply network (OECD, 2010), this represents a significant gap within the literature.

3. Conceptual framework: sustainable supply networks as complex adaptive systems

To study the emergence of carbon reduction strategies, our study frames a supply network as a CAS, that is “dynamic, complex, and difficult to predict and control” (Carter et al., 2015b). Because of the complexity of supply networks, it is believed that it is a difficult, resource-intensive process to effect meaningful changes within them (Choi et al., 2001; Carter et al., 2015b), such as transitioning them towards a more environmentally sustainable path. To overcome these challenges, there has been a rise in network-level collaborations (Bendell et al., 2010; Hamprecht et al., 2005; Fadeeva, 2005). Figure 1 presents the original CAS framework.

As can be seen from the above figure, the CAS framework has three dimensions: internal mechanisms, environment and co-evolution. CAS posits that the behaviour of a supply network is determined by the interaction of the agents within the system. Agents can be individuals or organisations. The behaviour of agents is determined by their schema, i.e. their “norms, values, beliefs, and assumptions” (Choi et al., 2001) and will determine how agents make sense of environmental pressures external to the supply network and the behaviour of other agents within the network, e.g. buyers trying to understand the behaviour of their suppliers. To make supply networks more sustainable, agents will need to share a schema that attaches the highest importance to sustainability. If sustainability is attached to a secondary importance within the schema of agents, the transition to sustainability will be more difficult. In such instances, focal firms may attempt to change the schema of their suppliers, e.g. through supplier development.

A CAS is self-organising (Pathak et al., 2007), and the structure of a CAS is determined by the interaction among agents. It cannot be assumed that one agent within a supply network is able to determine its structure and control its evolution. The emergent structures of a supply network will necessarily evolve in ways that have not been anticipated. Hence, unilateral movements from the focal firm may be ineffective if they build resistance from other agents in a CAS.

The complexity of a CAS is determined by its levels of connectivity and dimensionality (Choi et al., 2001). Connectivity can be measured both quantitatively and qualitatively as the number of connections that exist between agents within the network and the way in which they are connected. Quantity and quality are not necessarily related as agents who are weakly tied may have high quality connections, i.e. because they are unknown to each other, the agents may be able to exchange novel knowledge (Granovetter, 1973). The level of connectivity within the CAS will also influence its dimensionality, i.e. the degree to which agents can behave autonomously. At low levels of connectivity, agents have high levels of autonomy, and the CAS will emerge in ways that are difficult, if not impossible, to predict or control. Higher levels of connectivity may decrease the autonomy of agents, but this is not always desirable, e.g. in the area of innovation, some degree of autonomy is necessary (Nair et al., 2016).

The external environment of a CAS is a major influence on its self-organisation and emergence. Analysis using the CAS lens...
needs to be sensitive to what is happening in the environment of the CAS and how agents are responding to these environmental changes. To understand the environment, the CAS framework provides two concepts: rugged landscapes and dynamism (Choi et al., 2001). Rugged landscapes are environments that are difficult to map and make sense of. This makes it difficult for the CAS to optimise its performance. Making sense of the environment is further complicated by dynamism. The CAS framework considers that a CAS and its environment will exist together in a process of co-evolution as the CAS both responds to and causes changes within its environment. This means that a CAS will exist in a state of quasi-equilibrium in which there is a constant tension between stability and change. When change does occur, it is likely to follow a non-linear pattern (Pathak et al., 2007), which makes it more difficult to establish causality between action and results. This does not mean, however, that the evolution of a CAS is purely chaotic. Instead, CAS works with the concept of a non-random future in which agents internal and external to a CAS are able to identify patterns within the process of co-evolution.

The above process is characterised by a continuous tension between control and emergence. For example, the focal firm within the supply network, may attempt to exert control over the system, but this will depend on their ability to change the schema of other agents and consequently the rules upon which the system is based (Choi et al., 2001). SSCM is the attempt to do precisely this in relation to sustainability, but the degree of adaptation possible will likely be constrained by the complexity of the supply network. Moreover, changes in a CAS tend to be non-linear (Pathak et al., 2007), which makes it more difficult to establish causality between action and results. Additionally, changes in a CAS may lead to changes in the wider environment, which in turn may affect the CAS quasi-equilibrium (Nair et al., 2009). In brief, the CAS lens explains the complexity of supply networks through a combination of internal mechanisms, the environment and co-evolution (Pathak et al., 2007).

Sustainability represents a good example of this evolutionary process. As concerns about the sustainability of the economic system have become widespread in society, the schemas of agents within many supply networks have changed to become more environmentally and socially responsible. Similarly, exemplars in the area of SSCM have influenced the behaviour of other supply networks. Further, connectivity and dimensionality within supply networks have changed as new agents have been brought in to help manage buyer-supplier relationships, such as NGOs, and the autonomy of suppliers in relation to social and environmental concerns has been reduced as the focal firms within supply networks have increased their monitoring of suppliers in these areas. As supply networks negotiate these changes, they exist in a state of quasi-equilibrium. While the changes effected may not always be as the agents within the supply network intended, there is a discernible pattern within many supply networks of adaptation to the agenda of sustainable development.

The CAS framework offers an alternative to an oversimplification of supply networks as solely encompassing the portion of agents and processes that are visible to and controlled by the focal firm (Carter et al., 2015b). Previous research has acknowledged the complexity of supply networks, particularly regarding sustainability. Matos and Hall (2007) draw on two constructs from the CAS literature, namely, complexity and rugged landscape, to analyse the implementation of an LCA tool at the supply network level. Nair et al. (2016) explore CAS to unveil how environmental innovations emerge and proliferate in supply networks. Our study builds on their work by exploring the CAS framework as a lens to gain mid-range theoretical insights on the implementation of carbon reduction strategies within a supply network.

4. Research design

Our research approach is qualitative. There is limited amount of research that has explored the emergent aspects of SSCM strategies. We were not interested in providing large quantitative data related to carbon reduction but rather in gaining in-depth insights into the transformation process required to reduce carbon emissions within a supply network, which provides us with the opportunity to engage in theory elaboration. An embedded case study was therefore selected as a suitable methodology because it enabled detailed investigations of organisations and organisational processes to be conducted whilst capturing the contextual factors and social embeddedness of the phenomenon under study (Yin, 2003; Miles and Huberman, 1994).

4.1 Case selection

In a case study research, there is a trade-off between using multiple cases to increase the breadth of data and delving deeper in a single case to provide greater depth of analysis. In this study, the researchers have favoured the latter option. This study therefore focusses on a single critical case, and this choice is justified by criticality, uniqueness and opportunity to learn (Stake, 1995), as well as by the labour-intensive nature of a multilevel research (Mena et al., 2013). First, the chosen case study is critical as it represents an exemplar in the industry of a continuous supply network-level effort toward reduction in carbon emissions. Findings from a leading initiative can be useful for benchmarking purposes (Barratt et al., 2011). Second, it is unique because of its engagement in an industry-level consortium in the food sector oriented towards climate change. Finally, a critical case offers the researcher a unique opportunity to analyse a phenomenon previously inaccessible to scientific investigation (Bryman, 2012), in this case to stress existing understanding of SSCM practices.

Supply networks are difficult to capture in their totality and require a labour-intensive data collection (Dubois, 2009). SCM research has increasingly chosen the single-case approach to explore network-level or multi-level analysis, because this strategy facilitates a fuller understanding of the dynamics and different dimensions of the observed phenomenon (Dubois, 2009). Recent examples include the study of a multi-stakeholder programme led by multinational firm aiming to improve sustainability across the supply network (Álvarez et al., 2010) and a multi-tier response to an extreme event, i.e. a disaster (Johnson et al., 2013). In both cases, the boundaries of a network-level case offer a fruitful room for contributing to SCM theory.
When case analysis is set at the network level (or multilevel), there is cross-analysis of multiple sources (Lewis and Brown, 2012). Moreover, single-case research allows a longitudinal account of the dynamics of collaborative efforts (Alvarez et al., 2010), supporting theory elaboration. In theory-elaboration studies based on a single case, the sense of generality results from the development of new constructs or new relationships currently not incorporated in the general theory under study, which reconcile theory and the empirical context (Ketokivi and Choi, 2014).

4.2 Research context

Multinationals within the food sector are setting themselves ambitious carbon reduction targets to make the transition towards low-carbon supply networks. This context allows the analysis of carbon reduction strategies beyond a single firm to explore multilevel collaboration (Carter et al., 2015a) and unveil the competing tensions at each level.

The choice of a single case study has allowed a multilevel analysis (Barratt et al., 2011; Alvarez et al., 2010; Dyer and Wilkins, 1991) that encompasses the consortium level, the firm/supply network level (both the buyer and farmers’ perspectives) and the level of individuals (Figure 2).

For the purposes of anonymity, the focal firm will be referred to as FoodDrinkCo (FDC) and the consortium as sustainable farming tool (SFT) throughout the paper. FDC is a multinational firm employing over 250,000 globally and over 5,000 within the UK. The company has been recognised and rewarded for its proactive sustainability engagement over the past six years. It is ranked in the Dow Jones Sustainability Index, participates in the United Nations Global Compact and is an active member of the Sustainable Agriculture Initiative Platform. The company has set carbon reduction as a top priority. FDC has extended its sustainability strategy to include its agricultural suppliers in Western and Eastern Europe with a focus on radically reducing its upstream carbon emissions. This research focusses on FDC’s UK supply network for one agricultural product, referred to as Crop A hereafter.

4.3 Data collection

We use a combination of different methods (Eisenhardt and Graebner, 2007; Shah and Corley, 2006), including collection of documents from the case company, participant observations and semi-structured interviews with key stakeholders. One of the researchers was involved in researching the focal company and its supply network over more than five years and regularly attended meetings and other events. Such longitudinal approach allows gathering rich insights. As Van de Ven and Johnson (2006) accurately note, traditional research designs tend to only capture the information that people are willing to share through formal and shallow interviews. They argue that research over an extended period of time will provide greater penetration into the subject matter as a result of the mutual trust developed.

The primary sources of evidence are notes taken during observations and meetings, interviews (43) and workshops (3) conducted with key informants. Details regarding key informants and various primary and secondary data sources are provided in Tables I – III.

Interviews lasted between 30 min and 2 h and followed a semi-structured format, exploring aspects of the relationships between the different parties (buyer, supplier, and consultants and external parties) and experiences with FDC’s environmental agenda and approach to carbon reduction. The workshops were organised in Year 3 and Year 4 and gathered participants that had taken part in the interviews to provide a space to reflect on interview findings and explore identified issues in more depth, especially around understandings of sustainability and supply network relationships. Interviews and workshops participants were selected based on their level of experience regarding the implementation of the carbon measurement tool. They included purchasing, agriculture and sustainability managers, supplier informants that had implemented the tool and external informants from supporting organisations that were involved alongside FDC (Tables I-III).

We followed two criteria to guide the number of interviews presented in this study. On the one hand, we aimed to gather a wide breadth of perspectives and include relevant stakeholders in both the focal organisations and across the supply network. On the other hand, theoretical saturation helped us decide when to stop interviewing based on the fact that we were not gaining additional insights (Kaufmann and Denk, 2011). Informants’ confidentiality has been protected, thereby ensuring credibility and dependability.

4.4 Data analysis

Our overall focus for conducting the analysis is FDC’s carbon reduction strategy. The data analysis process was based on the principles of abductive reasoning, whereby the researchers engaged in a to-and-from between the empirical and the conceptual to make sense of the phenomena under study (Ketokivi and Choi, 2014). In an abductive approach, a theoretical framework is used to inform the data analysis, unlike in inductive approaches, but the analysis is not confined to...
testing aspects of the theoretical framework as with deductive approaches (Dubois and Gadde, 2002). Instead, the analysis is a process of determining which aspects of the theoretical framework are most salient to the empirical material being analysed (Dubois and Gadde, 2002; Ketokivi and Choi, 2014).

In this case, the CAS concept of “schema” was identified as being one of the most useful for understanding the dynamics of the case. Abductive reasoning is consistent with our theory elaboration approach as it allows us to elaborate those aspects of the theoretical framework that are most relevant to the investigation and use the idiosyncrasies of the case being studied to elaborate upon those concepts (Fisher and Aguinis, 2017; Ketokivi and Choi, 2014).

Data coding consisted of three main cycles (Saldaña, 2009). The first cycle was an initial coding (Saldaña, 2009) used to explore the data and construct initial codes and themes. The researchers paid particular attention to the interactions between agents and how these interactions have influenced the development of the strategy. This has included considering interactions within the supply network and also in terms of involvement in the consortium. This relates to the internal mechanisms, especially connectivity and dimensionality, and the external environment aspects of the CAS framework. More specifically, we have looked at moments when agents’ schema clashed or aligned, and how this has moved the network from an inception phase to an adaptation phase and finally to quasi-equilibrium. We were interested here in the co-evolution aspect of the CAS framework and therefore considered the main changes and events, as well as the challenges encountered and how they were resolved and the impact of these on the development of the carbon reduction strategy. Our analysis was multilevel in the sense that it sought to explore the various levels of analysis of the case study as depicted in Figure 2. The different data sources presented in Section 4.3 were complementary in building a rich picture of the dynamics at various levels. Interviews were central to understanding the micro individual level and the organisational and supply network levels. Workshops and observations provided insights into organisational and supply network levels. Specific meetings at the consortium level provided evidence of the environment level and of the role of boundary-spanning individuals. Secondary data were critical in providing contextual information, mapping key events and exploring FDC’s schema. Within this initial cycle, we first became aware of existing tensions within and between the levels.

In the second cycle, we conducted versus coding. In versus coding, concepts, processes and phenomena are contrasted in binary terms; the resulting analysis often adopts the phrases “on the one hand” and “on the other hand” to spotlight inherent dilemmas identified in the data analysis (Saldaña, 2009). This coding method was useful for developing understanding of the tensions within each level of analysis. Identified themes were attributed a level. It became apparent that some themes were connecting different levels. For example, we identified “conflict” and “conflict resolution” as key multilevel themes, with evidence at the micro and organisational levels (the individuals and teams within FDC) and the network level (between different agents of the network: FDC and farmers). We focussed on teasing out how events at the various levels contributed towards exacerbating or resolving conflict. We also explored the linkages with other themes at the various levels. For instance, we describe later in the paper that a supply network level event – the harvest crisis and its handling – had a strong influence on the development of the carbon reduction strategy.

Table I Details of interviews

<table>
<thead>
<tr>
<th>Stakeholders/Participants</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FoodDrinkCo</strong></td>
<td>22</td>
</tr>
<tr>
<td>Head of sustainability team</td>
<td>2</td>
</tr>
<tr>
<td>Head of UK agricultural sustainability programme</td>
<td>1</td>
</tr>
<tr>
<td>Head of European agricultural sustainability programme</td>
<td>2</td>
</tr>
<tr>
<td>European sustainable procurement manager</td>
<td>1</td>
</tr>
<tr>
<td>Agricultural team manager</td>
<td>1</td>
</tr>
<tr>
<td>Procurement manager for Crop A</td>
<td>1</td>
</tr>
<tr>
<td>Procurement manager for Crops B and C</td>
<td>1</td>
</tr>
<tr>
<td>Agronomist</td>
<td>1</td>
</tr>
<tr>
<td>Global health and agricultural policy manager</td>
<td>1</td>
</tr>
<tr>
<td>European head of agriculture</td>
<td>1</td>
</tr>
<tr>
<td>Manager global sustainable procurement programme</td>
<td>1</td>
</tr>
<tr>
<td>Manager global sustainability programme</td>
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</tr>
<tr>
<td>Procurement manager</td>
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</tr>
<tr>
<td>Supply chain manager</td>
<td>1</td>
</tr>
<tr>
<td>Environmental analyst</td>
<td>1</td>
</tr>
<tr>
<td>Climate change and energy manager</td>
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</tr>
<tr>
<td>Sustainability data and reporting manager</td>
<td>1</td>
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<tr>
<td><strong>Suppliers</strong></td>
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<tr>
<td>Crop A</td>
<td>10</td>
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<tr>
<td>Local merchant and farmer (owner/manager)</td>
<td>1</td>
</tr>
<tr>
<td>Local merchant and farmer (FDC relationship manager)</td>
<td>1</td>
</tr>
<tr>
<td>Local vegetable and cereal farmer 1 (owner/manager)</td>
<td>1</td>
</tr>
<tr>
<td>Vegetable and cereal farming group (operations manager)</td>
<td>1</td>
</tr>
<tr>
<td>Local vegetable and cereal farmer 2 (owner)</td>
<td>1</td>
</tr>
<tr>
<td>Local vegetable and cereal farmer 2 (manager)</td>
<td>1</td>
</tr>
<tr>
<td>Local farming group (owner)</td>
<td>1</td>
</tr>
<tr>
<td>Local farming group (manager)</td>
<td>1</td>
</tr>
<tr>
<td>Local vegetable farmer and packer (owner/manager)</td>
<td>1</td>
</tr>
<tr>
<td>Local vegetable and cereal farmer 3 (owner/manager)</td>
<td>1</td>
</tr>
<tr>
<td>Crop B</td>
<td>2</td>
</tr>
<tr>
<td>Local merchants (owner/manager)</td>
<td>1</td>
</tr>
<tr>
<td>Local producer (owner/manager)</td>
<td>1</td>
</tr>
<tr>
<td>Crop C</td>
<td>3</td>
</tr>
<tr>
<td>Regional agricultural merchant and supplier (owner/manager)</td>
<td>1</td>
</tr>
<tr>
<td>Regional agricultural merchant and supplier (sustainability manager)</td>
<td>1</td>
</tr>
<tr>
<td>Local vegetable and cereal farmer (owner/manager)</td>
<td>1</td>
</tr>
<tr>
<td><strong>External stakeholders</strong></td>
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<tr>
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<tr>
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<td>1</td>
</tr>
<tr>
<td>Agricultural consultancy</td>
<td>1</td>
</tr>
<tr>
<td>SFT (deputy manager)</td>
<td>1</td>
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<tr>
<td>Other SFT member (sustainability manager)</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>43</td>
</tr>
</tbody>
</table>
coding, which is the process of analysing the coding (i.e. first and second cycles methods), to develop theory further, which is hence an appropriate method for qualitative studies that aim toward theory elaboration (Saldaña, 2009). This latter step offered a nuanced perspective of how the multilevel tensions can be explained by the CAS framework, supporting theory elaboration to encompass the idiosyncrasies of the case study.

Beyond ensuring consistency in data reporting (Miles and Huberman, 1994), the combined expertise of the authors regarding SSCM and carbon measurement has ensured a critical analysis of the findings.

Despite the fact that numerous phenomena in SCM involve more than one level of theory and analysis, most SCM research still produces research at a single level (Carter et al., 2015a). This paper offers advancements towards a multi-level perspective by adopting CAS as a framework that serves as a lens with which to investigate multi-actor behaviour and relationships (Mena et al., 2013).

Second, it uses a multi-level analysis to understand levels nested within levels (Carter et al., 2015a). Our study shows how the engagement of the FDC’s Sustainability team at the consortium level granted them access to pre-competitive collaboration. As a result, FDC was able to produce, with the help of a consultancy firm, the needed change at the individual level, i.e. changing suppliers’ negative perception regarding the tool to a more collaborative approach. Moreover, behavioural change at the individual level produced changes at supply network level, enabling data

<table>
<thead>
<tr>
<th>Data type</th>
<th>N</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshops</td>
<td>3</td>
<td>Agricultural team manager, procurement manager for Crop A, head of UK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>agricultural sustainability programme, agricultural team manager, procurement</td>
</tr>
<tr>
<td>FoodDrinkCo workshop</td>
<td>1</td>
<td>manager</td>
</tr>
<tr>
<td>Suppliers of Crop A workshops</td>
<td>2</td>
<td>Local merchant and farmer (owner/manager), Local vegetable and cereal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>farmer 1 (owner/manager), Vegetable and cereal farming group (operations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>manager), Local vegetable and cereal farmer 2 (owner), Local farming group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(owner)</td>
</tr>
<tr>
<td><strong>Observations, meetings and site visits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SFT sponsors’ meeting</td>
<td>1</td>
<td>Representatives of SFT corporate members, SFT managing director, SFT deputy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>manager</td>
</tr>
<tr>
<td>Farmers forum</td>
<td>2</td>
<td>Farmers of Crop A, FDC agricultural team, Procurement managers, Agri-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>consultancy, researcher</td>
</tr>
<tr>
<td>Farmers meeting</td>
<td>2</td>
<td>Farmers of Crop A, FDC agricultural team, Procurement managers, researcher</td>
</tr>
<tr>
<td>FoodDrinkCo European sustainability meeting</td>
<td>1</td>
<td>Members of the sustainability and agricultural teams at FDC, other European</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sustainability team members, researcher</td>
</tr>
<tr>
<td>Sustainability tradeshow</td>
<td>1</td>
<td>Members of the sustainability and agricultural teams at FDC, other European</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sustainability team members, FDC employees, researcher</td>
</tr>
<tr>
<td>SFT meeting</td>
<td>2</td>
<td>Representatives of SFT corporate members, SFT managing director, SFT deputy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>manager, Agri-consultancy members working with FDC</td>
</tr>
<tr>
<td>FoodDrinkCo sustainability strategy milestone event</td>
<td>1</td>
<td>Researcher, members of the sustainability and agricultural teams at FDC, PR</td>
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<tr>
<td></td>
<td></td>
<td>team, journalists, Agri-consultancy members, farmers of Crop A, European</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sustainability team members, policy-makers, MPs</td>
</tr>
<tr>
<td>Farm visits</td>
<td>11</td>
<td>Farm owners/managers and researcher</td>
</tr>
<tr>
<td>Meetings with sustainability and agricultural teams</td>
<td>6</td>
<td>Research and members of the sustainability and agricultural teams at FDC</td>
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</tbody>
</table>

Table III Details of secondary data sources (including both documents published and not publicly available)

<table>
<thead>
<tr>
<th>Document title/type</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFT Leadership Summit Report</td>
<td>Year 3</td>
</tr>
<tr>
<td>Internal FoodDrinkCo Newsletters (4)</td>
<td>Year 1, Year 2, Year 3, Year 4</td>
</tr>
<tr>
<td>Internal corporate sustainability strategy presentation</td>
<td>Year 2</td>
</tr>
<tr>
<td>Internal carbon footprinting progress presentation</td>
<td>Year 2</td>
</tr>
<tr>
<td>FoodDrinkCo agricultural sustainability programme videos (3)</td>
<td>Year 2, Year 4, Year 5</td>
</tr>
<tr>
<td>SFT Sponsors meeting report</td>
<td>Year 1</td>
</tr>
<tr>
<td>FoodDrinkCo Sustainable Farming Reports (2)</td>
<td>Year 1, Year 3</td>
</tr>
<tr>
<td>Internal FoodDrinkCo sustainable farming initiative draft survey</td>
<td>Year 4</td>
</tr>
<tr>
<td>FoodDrinkCo Sustainability Reports (4)</td>
<td>Year 1, Year 2, Year 3, Year 4</td>
</tr>
<tr>
<td>Press release on celebrating achievements of sustainable agriculture strategy</td>
<td>Year 6</td>
</tr>
</tbody>
</table>
sharing, the development of a carbon emission baseline and driving reduction in carbon emissions.

As a result of our analysis, we have obtained a nuanced account on how a carbon reduction strategy emerges, evolves and diffuses in a supply network. From a theory elaboration perspective (Fisher and Aguinis, 2017), our multilevel abductive approach has contributed to unpacking the constructs of CAS and the relationships between these constructs in the context of advancing sustainability in a supply network.

4.5 Research quality
Several mechanisms were used to ensure the overall quality and “trustworthiness” of the research (Shah and Corley, 2006; Lincoln and Guba, 1985). At the research design stage, particular attention was paid to the selection of participants and using previous literature to conceptually ground the research problem under study. During data collection, extensive notes were taken and stored, and interviews and meetings (when possible for the latter) were digitally recorded and transcribed to ensure accuracy. Transcripts were sent back to participants to ensure confirmability. Multiple informants and sources of information were used to ensure credibility, as shown in Tables I-III. The long-term data collection process also ensures the credibility of the research. At the data analysis stage, the experience of several researchers was combined to address dependability and confirmability. The researchers who were not as closely involved in the data collection were able to bring a fresh perspective on the data. The researchers agreed on the approach to coding, as explained in Section 4.4. The analysis was conducted iteratively and independently by the researchers. The researchers compared their respective analysis and themes to reach agreement.

5. Case study analysis
In this section, we present the emergence of FDC’s carbon reduction strategy for its Crop A supply network from Year 1 to Year 5. The agents within FDC’s Crop A supply network are FDC’s Sustainability and Buying teams, FDC’s agricultural suppliers (farmers) and the environmental consultancy, Agri-consultancy. The FDC Sustainability team is also an agent within the SFT consortium. There were three phases to the process of transformation: inception, adaptation and quasi-equilibrium. The process is represented in Figure 3. The inception phase covers the first year of FDC’s five-year strategy, the adaptation phase covers the second, third and beginning of fourth year and the quasi-equilibrium phase was initiated at the end of the fourth year.

5.1 Phase 1: inception (Year 1)
In Year 1, FDC set itself the ambitious target of reducing its carbon emissions by 50 per cent between Year 1 and Year 5. Moreover, FDC extended this target to its supply network, which accounted for over 30 per cent of its carbon footprint. In so doing, FDC has put farmers at the centre of its sustainability agenda. However, FDC faced a number of challenges. They had ambitious targets that required farmers to double their carbon efficiency, which would require a substantial change in their operations. The strategy depended upon their cooperation, but FDC did not have the resources to facilitate this cooperation. Clearly, FDC needed to have a supplier engagement approach that would allow it to deliver its carbon reduction strategy.

To realise its carbon reduction strategy, FDC joined the SFT consortium in Year 1 as one of the first partner firms. From the perspective of CAS, the consortium exists within the environment of FDC’s Crop A supply network. We will show the extent to which FDC shares the schema of the consortium and how it has affected its behaviour.

The consortium was initially founded when a multinational, an NGO and a university formed a partnership to drive emissions reductions on farms. The consortium was launched and included other multinational companies, including FDC. With the inclusion of more corporate members, the consortium became a platform for pre-competitive collaboration. Their philosophy was that “what gets measured gets managed”, and they developed the SFT as a farmer-friendly tool to help farmers measure their carbon footprints, identify carbon

Figure 3 The three-phase transformation process
hotspots and ultimately reduce their emissions through the development and implementation of carbon reduction plans.

The SFT consortium is a way for organisations within food supply networks to share learning on carbon reduction in a non-competitive environment. One of their basic principles is that organisations would all benefit from the development of the SFT but would be able to reap individual benefits when implementing it in their own supply networks. Members do not share raw data. Instead, members share their learning in relation to using the tool through case studies (specific crops) and sharing stories of implementation (mostly the challenges).

Although the consortium aimed to develop and roll-out a farm-friendly tool, the boundaries of the consortium did not and do not extend to farmers. The schema of the consortium is very much that of the large multinational companies (consortium members), who view environmental sustainability in terms of measurable progress, scientific methodologies and impact reduction. The schema is very much in line with the strategic (top management) agendas of the multinationals – most of which have made pledges around impact reduction (FDC being one of the most ambitious). Their schema also assumes that the data from farming operations were already available or at least easily accessible through the farmers. Initially, the consortium had not considered how their members would engage their farmers to take ownership of the tool to support the members’ carbon reduction strategies. A cooperative schema underpins the philosophy of the consortium. It is assumed that farmers will be willing to openly share the data collected through the SFT with other participants. The success of the SFT depends upon these assumptions about farmer behaviour being correct. In the case study, they were shown not to be. A comment by the only farmer present at the initial SFT meeting gave hint of the dynamics at play in the supply network:

So really with this (referring to the SFT) they (referring to large companies) have found a new way of exploiting their farmers. (Only farmer participating in SFT meeting)

While membership of the consortium gave FDC legitimacy, it was unable to give them actual guidance on how the tool could be used to support their carbon reduction strategy. The success of FDC’s strategy would depend heavily upon their farmers taking ownership of the SFT, but FDC did not know how to engage their suppliers in the project initially. It took the first round of data collection through the tool to realise that a strategy had to be developed to engage farmers more effectively.

5.1.1 Lack of unified sustainability schema within FoodDrinkCo
During the case-study period, two teams were responsible for managing the carbon reduction strategy with the farmers: FDC’s Sustainability and Buying teams. The Sustainability team was responsible for all aspects related to agricultural sustainability, including the introduction of new sustainability tools for suppliers. The Buying team was responsible for negotiating and monitoring contracts with suppliers. Initially, there was a conflict between the schemas of the two teams on how to implement FDC’s carbon reduction strategy within the supply network.

The Sustainability team had a more eco-centric orientation focussed on reducing carbon emissions. The Buying team had a more commercial perspective, treating the carbon reduction strategy as an add-on to their role. They initially had a fairly instrumental orientation towards the carbon reduction strategy and were only interested in those emissions reductions initiatives that also delivered cost reductions (“we aren’t doing it because we want to save the planet”, “as long as it makes business sense”). Such instrumental orientation was driven, at least in part, by the performance measures by which the Buying team were evaluated. While the Buying team was required to recommend inclusion of the environmental agenda in the farmers’ contracts, this element was not part of the buyers’ key performance indicators. Instead, their performance was evaluated in terms of their ability to deliver cost reductions.

The commercial perspective of the Buying team was also reflected through the farmers’ accounts of the Buying team’s approach:

- It has become much more an American ethos about goals and KPIs and price and everything like that [...] (Farmer, Year 1)

- Thinking this is 50 years or something we’ve been growing for you, and it’s just gone, just like that, because you are so pig headed and not understanding the economic situation that you’re putting us in, not just us, but everybody. (Farmer, Year 1)

Initially, the conflicting schema of the two teams undermined their ability to collaborate on the carbon reduction strategy as they each assigned a different priority to the carbon reduction strategy. This is evidence of the key role of the interaction between agents in the deployment of the carbon reduction strategy. Further, the tensions between the teams were apparent to some farmers, with negative effects upon their willingness to engage in FDC’s carbon reduction strategy.

The area of difficulty as with any supply chain is the commercial aspect. And certainly, there are 2 parallel activities if you like. There is the work that FDC are doing on sustainability and then there is also the commercial and procurement theme alongside where there is a difficult relationship between the 2. And every year there are trading discussions in terms of how much FDC will pay for return of [Crop A] and what the farmers expect to be paid. Now and again, for example in Year 1, those discussions can be quite tense and quite difficult. (Agri-consultancy team member, Year 2)

The relationship between the Sustainability and Buying teams was not entirely negative. The participation of the Sustainability team in the SFT consortium had a positive impact on the Buying team, helping them realize that carbon reduction was a legitimate activity. The Sustainability team members who attended the consortium meetings also had the opportunity to discuss the issues they were facing within their organisations with other like-minded individuals who were facing the same challenges, notably around engaging commercial teams and suppliers. The consortium served a motivational purpose in this regard.

FDC’s carbon reduction strategy was a means for them to reduce dimensionality within their Crop A supply network. It was intended that the SFT would become the means through which farmers would take ownership of FDC’s carbon reduction strategy. The top-down schema of the SFT consortium was incorporated into FDC’s carbon reduction strategy through the Sustainability team, which was an agent in both the SFT consortium and FDC. The top-down approach took the form of making it mandatory for their farmers to collect data and develop carbon reduction plans using the SFT. From the end of Year 1, this
mandate was included in the supply contracts for Crop A farmers.

And it is contractualised around those elements now. That is where we have got to go. We have delivered a consistent message to them and now we are getting to the point where we are contractualising some of the requirements for ongoing carbon reduction and water management. (FDC Buying team member, Year 1)

5.1.2 Conflicting sustainability schemas between the FoodDrinkCo teams and farmers

The two FDC teams assumed that the farmers would either share their commitment to reducing carbon emissions or that emissions could be reduced through fiat, i.e. through inclusion within supply contracts. However, few farmers initially shared FDC’s commitment to carbon reduction, and the majority failed to see what they would gain from using the SFT. This perceived “failure” of the farmers to understand and commit to the strategy was a source of continual frustration for the Sustainability team.

I think that the farmers feel that there are lots of different things coming under the sustainability umbrella and then there are the other things like the commercial contract and also legislative programs. (FDC Sustainability team member, Year 1)

The cause of these difficulties lay in the significant clashes between the schema of the two FDC teams and the farmers and FDC’s initial failure to engage their farmers. The tensions are explored in detail below.

The farmers felt they had a more holistic view of the relationship between agriculture and the natural environment than FDC. The farmers talked about the farming tradition and the more tacit way of knowing about how to deal with agriculture. To them, FDCs focus on carbon reductions, and data collection seemed a reductionist approach to sustainability. They viewed sustainability as a more holistic concept that included their role with nature and the community:

We have a moral compass. As a farmer you can’t run away from your farm, so your reputation is paramount. You can’t decamp and set up a new business in a different city, you can’t do that. You’re living as part of the community. (Farmer, Year 1)

In the most extreme cases, the clash between the sustainability schemas of FDC and its farmers resulted in some farmers not being able to see the connection between carbon reduction and sustainability:

Carbon is very alien, carbon is just something that they know they have got to reduce and then they know that FDC want to reduce it. (FDC Buying team member, Year 1)

An important part of FDC’s sustainability schema was the urgency with which carbon emissions needed to be reduced within their Crop A supply network and the scale of the changes required. As FDCs were looking to reduce emissions by 50 per cent within a five-year period, this dictated that the pace of change needed be quick. Farmers would need to learn how to use the SFT, set a baseline of current carbon emissions and then develop and implement a plan for carbon reduction within a five-year period. This conflicted with the farmers’ view of change, which tended to be less radical. Arguably, this is in line with the nature of the farmers’ businesses. Most of the farmers are third- or fourth-generation farmers and are often reluctant to radically change their practices, especially if they do not understand the reasons for the change being requested:

Our farmers in the UK are very conservative, they don’t want to change. They’ve inherited a system from their fathers and their fathers’ fathers – their generation and the supplier’s generation, and benefited on their farm, not just with us, with huge subsidies. (FDC Buying team member, Year 1)

The above issues resulted in many farmers not being able to understand FDC’s emissions reductions strategy and their role within it. Many farmers had difficulties capturing the data that FDC needed. For example, it was unclear to many whether all of their emissions counted or solely those related to the crops produced for FDC.

Cooperation is a core principle within the sustainability schema of the SFT consortium, and it is assumed that farmers will engage in the desired cooperative behaviour needed to drive down emissions. By putting the SFT at the heart of FDC’s carbon reduction strategy, they became dependent on the willingness of farmers to share data information with FDC and with other farmers. However, majority of farmers did not share the cooperative schema of the SFT consortium and Sustainability team. There was a shared feeling amongst farmers that the data collected through the SFT would be used against them:

What do they want to do with this data? Is it going to be used to negotiate harder? (Farmer, Year 1)

The farmers had two concerns about using the SFT to collect and share data. Many farmers had doubts about how the information they shared would be used by the Buying team. For example, some farmers were expecting FDC to rank all their suppliers according to how well they performed on emissions and stimulate competition between them to increase or decrease the price paid per ton of Crop A supplied. As a result, there was considerable uncertainty when the SFT was first rolled-out.

Many farmers saw the data related to the carbon emissions as proprietary information and as a possible means to gain a competitive advantage over other farmers supplying to FDC. Consequently, they were reluctant to share it with other suppliers.

The factors presented above contributed to farmers’ lack of engagement in FDC’s carbon reduction strategy and made them reluctant to take ownership of the SFT. Instead, farmers saw the SFT as just “another form” to fill in, i.e. a non-value adding activity that would consume valuable resources. Rather than engaging farmers around carbon reduction, FDC’s strategy had instead led to many farmers perceiving that their relationship with FDC had become more formal and bureaucratic. The result was that the data collected in the first year of FDC’s initiative were not accurate. Because the farmers saw the SFT as a box ticking exercise and an additional burden, many filled in the SFT with data that were inaccurate and simply complied with their contractual obligations. This undermined FDC’s attempt to establish an accurate emissions’ baseline in the first year of their strategy.

Findings from the inception phase are summarised in Table IV with illustrative quotes and corresponding CAS constructs.

5.2 Phase 2: adaptation (Years 2–4)

FDC had not anticipated that the farmers would respond so negatively to their strategy in general and the SFT in particular, and that it would put such a strain on farmers. There was a
Table IV: Evidence of the emergence of the carbon strategy in the network: inception phase

<table>
<thead>
<tr>
<th>CAS dimensions</th>
<th>Key themes</th>
<th>Level of analysis</th>
<th>Exemplary events and actions</th>
<th>Illustrative quotes and evidence from the case</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal mechanisms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agents and schema</td>
<td>Dominant buying firm translates greening strategy into specific goals (i.e. carbon)</td>
<td>Firm/supply network</td>
<td>Articulation of sustainability strategy around priority areas in Year 1 with carbon reduction at the core</td>
<td>“Working with the Carbon Trust, we discovered that the amount of carbon emitted in growing crops such as Crop A ... was equal to all the carbon used by our manufacturing sites. In fact, growing Crop A and sunflowers accounts for 34% of the carbon footprint of our product” FDC Sustainable Farming Report</td>
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<td></td>
<td>Dominant buying firm initiates diffusion of carbon reduction strategy in network</td>
<td>Firm/supply network</td>
<td>Life-cycle assessments conducted prior to Year 1 used to support focus on emissions reduction in upstream network Inclusion of carbon reduction strategy as appendix to contracts</td>
<td>“It’s mandated because they wrote it in the contract” (Farmer)</td>
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<tr>
<td>Dimentionality (initially low)</td>
<td>Lack of unified sustainability schema within dominant buying firm</td>
<td>Individual</td>
<td>Differences in schemas within FDC between sustainability and commercial teams</td>
<td>“We aren’t doing it because we want to save the planet” “As long as it makes business sense” (Members of agricultural procurement team)</td>
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<tr>
<td><strong>Environment</strong></td>
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<tr>
<td>Dynamism (rules and norms, new connections)</td>
<td>Development of consortium and tool</td>
<td>Consortium</td>
<td>Partnership between large multinationals, university and NGO to provide evidence-based approach to carbon management in food supply chains FDC becomes founding sponsor of the SFT consortium</td>
<td>The purpose of the SFT is “taking stock of our personal and organisational journeys and setting a common agenda: 1 Sharing common challenges and lessons learned about operationalising sustainability 2 Identifying needed Tools and approaches that could be developed more efficiently in a pre-competitive space” (SFT documentation)</td>
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<td><strong>Co-Evolution</strong></td>
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<tr>
<td>Non-linear changes</td>
<td>Tensions between the buying firm’s teams and suppliers a) Conflicting sustainability schemas b) Lack of cooperative schemas among suppliers</td>
<td>Individual</td>
<td>Commercial and sustainability KPIs not aligned within FDC Sustainability team focussed on carbon reduction and buying team focussed on contract negotiation Inclusion of SFT carbon measurement tool adoption in the contracts Low number of responses/ inaccurate responses to the tool returned by farmers in the first year Perceived tension between commercial pressures (competition between farmers) and request to share carbon data (cooperation)</td>
<td>“Sustainability is part and parcel of what we do. We deal with nature, we are custodians of the countryside” “It is 50% in five years you know and the clocks keep running. We haven’t got the luxury ... And that is another barrier that we come up against. It is that farmers will always want to be 99.99% sure of something before making the change, maybe see it happen over 8 or 10 crop years but we haven’t got the luxury of waiting that long to start affecting changes for things that affect the environment. It’s kind of 50% in 5 years, one year is gone we have got 4 left so we have to take the learnings we have got and we have got to make some changes” (Farmer) “And also, there are some tensions between the different farmer groups so it means there are things that they consider as intellectual property and they don’t wish to share with people outside of their particular group” (Buyer)</td>
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perception among many farmers that FDC had managed the process of transformation poorly and had attempted to manage the process through fiat rather than through engagement. The irony of a farmer-friendly tool that the farmers had not been consulted on being imposed on them by fiat was not lost on many of the farmers:

The fundamental problem was the process, the way they went about it was totally wrong, you know. It’s a grower’s tool. And they didn’t just impose it, they went away and did their own work without engaging with people who understand it and do it and would ultimately be investing in it, they just did their own thing, bought it and then looked around to see who was going to use it. That’s not a way of engaging. (Farmer, Year 2)

5.2.1 Supplier engagement strategy
FDC’s challenge was to engage their suppliers on the issue of carbon reduction and to make the SFT more farmer-friendly. In the second year of the case study, FDC changed their approach. While the SFT remained at the centre of their strategy and its use by farmers was still mandated in contracts, FDC launched a supplier development plan to engage and support its farmers. Forums would be established to hear farmers’ concerns and to better explain FDC’s strategy. Training would be provided to farmers on how to collect accurate data and develop plans for reducing their emissions. These were organized as workshops given to groups of farmers on their farms.

The Sustainability team did not have the resources to support the scale of the supplier development that was required and turned to a third party, Agri-consultancy. Originally, Agri-consultancy had been engaged by FDC to help refine measures for carbon reduction, but their brief was expanded significantly in the second year in response to the challenges of implementation. They became responsible not only for rolling out the tool more widely but also for running a number of training sessions/workshops with the farmers:

And, although something actually was completed and returned last year, they felt much more comfortable having been given more training on it. You know making sure that people fully understanding these tools. So that the data that they give is correct and therefore the information that they are getting back is appropriate and helpful. (Agri-consultancy team member, Year 2)

5.2.2 Supplier learning
There were a number of elements that contributed positively to making the suppliers more engaged with the SFT and FDC’s strategy in general. Clearly, the iterative approach to data collection for the SFT was an important learning curve for the farmers who became more acutely aware of the link between carbon measurement and the commercial viability of their business. In this sense, the schemas of the farmers became progressively more aligned with those of FDC. The role of Agri-consultancy was pivotal in supporting suppliers’ learning. This is clear evidence of how the introduction of a new agent and the relationships with existing agents have influenced the development of the initiative.

There were also external pressures that contributed towards supplier learning. For example, in Year 3, the farmers were facing an upcoming reform of the European Union’s Common Agricultural Policy that put a strong emphasis on environmental sustainability. They were also facing requirements to reduce carbon from other customers and could therefore use their experience with FDC as a competitive advantage. This meant that the farmers became more attuned to FDC’s sustainability agenda and to the importance of carbon reduction.

5.2.3 Greater connectivity between FoodDrinkCo buying team and farmers
An initial barrier to farmers engaging with FDC’s carbon reduction strategy was their growing distrust of the Buying team. Farmers perceived the team to be aggressive in its negotiations and assumed that the data would be used by the Buying team to strengthen their negotiating position relative to the farmers. However, the trust between farmers and FDC improved considerably in the period of the case study because of the response of the Buying team to a crisis that affected the supply network in the fourth year of FDC’s carbon reduction strategy.

Heavy rain in the UK in Year 3 resulted in poor harvests for many farmers, including FDC’s Crop A farmers. The Buying team responded to the crisis by listening to the farmers’ concerns, providing support in dealing with adverse weather conditions and the impact this had on the crop’s quality and in adjusting their buying price. This was viewed positively by farmers, who extended these positive feelings to FDC’s carbon reduction strategy and became more willing to engage in data sharing and carbon reduction.

5.2.4 Greater connectivity between FoodDrinkCo teams
FDC is a “data hungry” organisation, and as the SFT realised its potential to gather and process data, the relationship between the Sustainability and Buying teams improved. The carbon agenda gained legitimacy in the eyes of the Buying team. Thanks to the supplier engagement activities and the results achieved through the SFT, the Buying team was able to see measurable progress in terms of reaching the carbon reduction targets. They could discuss carbon measurement in a more concrete manner as the data were coming in, and this was an important learning point. The Buying team began absorbing a lot of information from the work conducted on the ground by the Sustainability team.

Findings from the adaptation phase are summarised in Table V with illustrative quotes and corresponding CAS constructs.

5.3 Phase 3: quasi-equilibrium (Years 4 and 5)
By the end of the case study, FDC’s Crop A supply network had made the adaptations required, reaching a new state of quasi-equilibrium. FDC’s strategy had raised awareness about carbon reduction among its farmers, created an accurate baseline for suppliers’ emissions and reduced emissions by 50 per cent within five years. Further, FDC was able to deepen its relationship with its Crop A farmers. Although many of them are considered heritage farmers, integrating environmental concerns within the context of the commercial relationship has resulted in an increase of shared information, communication and the development of a more collaborative relationship.

The consortium acted as a bridge for individuals from FDC between the macro concept of sustainability and the micro reality of implementing practices on the ground. It stopped individuals from becoming too focussed on the minutia and allowed them to keep seeing the bigger picture. Discussions at the consortium were as much about “global learning” and the
<table>
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<td>Agents and schemas</td>
<td>Supplier development</td>
<td>Firm/supply network</td>
<td>Forums established to discuss environmental strategy with farmers</td>
<td>“And, although something actually was completed and returned last year, they felt much more comfortable having been given more training on it. You know making sure that people were fully understanding these tools. So that the data that they give is correct and therefore the information that they are getting back is appropriate and helpful” (Agronomist)</td>
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<td></td>
<td>a) Supplier engagement</td>
<td>Individual</td>
<td>FDC delegated rolling out of the tool to agri-consultancy</td>
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<td>b) Supplier learning</td>
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<td>Agri-consultancy delivered training sessions and workshops to farmers</td>
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<td>Iterative data collection supported supplier learning</td>
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<td>Dimensionality</td>
<td>Carbon-measurement tool as a control-scheme</td>
<td>Firm/supply network</td>
<td>SFT tool deployed in the network in search of increased control by FDC</td>
<td>“We are now rolling out the SFT to all our suppliers and it links industry recognised measures of CO2 to what we are doing” (Head of sustainable agriculture)</td>
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<td>“The SFT helps support conversations with people on why carbon is important and how measuring it can bring business benefits” (Manager at Agri-consultancy)</td>
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<td>“In order for carbon reduction to be implemented on farm, it is not sufficient for changes to realise carbon savings alone, they must also make financial sense and fit in with the overall farm business plan. Over the past five years we have been finding ways to achieve this. To date, this has included fitting invertors to in-store fans; increasing store insulation; switching to GPS for all tractor and sprayer operations; replacing irrigation pumps with more fuel-efficient models; and changing the tractor fleet to a more fuel efficient make. Using the SFT has confirmed the carbon saving impact of these changes and has highlighted carbon emission hotspots” (Farmer)</td>
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<td><strong>Self-organisation and emergence</strong></td>
<td>Central role of bridging agents in facilitating progression of environmental strategy in the network</td>
<td>Firm/supply network</td>
<td>Agri-consultancy became fully responsible for delivering farmers’ training and managing the data collection process</td>
<td>“I think as the project as evolved it became apparent that it’s not just about methodology and science and it’s actually an agricultural development type of project. And therefore, I think one of the challenges has been to ensure that the project is fully inclusive with a collaborative approach” (Manager at Agri-consultancy)</td>
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<td><strong>Environment</strong></td>
<td>Formalisation of consortium and tool based on members’ experiences</td>
<td>Consortium</td>
<td>Data being gathered through pilots by participating members</td>
<td>SFT website and publicly available documents</td>
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<tr>
<td>Dynamics – rules and norms from external agents</td>
<td></td>
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<td>Case studies developed and compiled as publicly available resources</td>
<td>Presentations at SFT meeting</td>
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<td>Sharing the learning events organised to discuss progress and next steps</td>
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<td>Increased membership to SFT</td>
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<td>Agri-consultancy started taking part in the SFT meetings</td>
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<td><strong>Dynamics – changes and changes and institutional norms</strong></td>
<td>Legal and institutional network</td>
<td>Firm/supply network</td>
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"journey to sustainability" as they were about farm-level analysis.

FDC has made a number of contributions towards the consortium. First, its successes in engaging its suppliers on the issue of carbon reduction has encouraged other corporations to join the SFT consortium. Second, FDC has shared its experiences with the other members of the consortium through meetings and the production of a case study. As a result, the consortium has more resources to support the supplier engagement strategies of its members and more effectively drive emissions reductions. FDC’s successful engagement in the consortium also means that the head of the Sustainability team is regularly invited to speak at various industry events on environmental sustainability and supplier engagement.

Findings from the quasi-equilibrium phase are summarised in Table VI with illustrative quotes and corresponding CAS constructs.

### 6. Discussion

Figure 4 provides a synthesis of the match between CAS elements and the case study.

This study provides a theoretically grounded perspective of the complexity inherent to the implementation of SSCM strategies. Van Bommel (2011, p. 899) points out that “only limited frameworks in the literature analyse and describe the process of implementing sustainability in supply networks”. Through the lens of CAS, we provide a multilevel exploration of the processes at play in moving towards more environmentally sustainable supply networks. We have gained detailed longitudinal insights into both the agentic and environmental mechanisms that affect the transition for carbon reduction and have provided evidence for the criticality of contextual variables in making supply networks more environmentally sustainable. While the majority of previous research has often assumed linear and controlled views of greening strategies, this research offers an emergent and somewhat “messier” perspective to such strategies. This perspective enriches previous findings on the influence of institutional pressures on emergent SSCM practices (Zhu and Sarkis, 2007), but is also in line with the view that SSCM is fundamentally about change (Matthews et al., 2016).

We have used elements of CAS theory to make sense of the change process of making supply networks more environmentally sustainable, have offered relevant explanations for the captured insights and have also elaborated on aspects of the CAS framework. This has enabled to formulate a number of propositions.

The notion of dimensionality proposed in CAS was particularly useful to understand the ways in which the focal firm as an agent member of the consortium was using the carbon reduction tool as a way to control the behaviour of the
supplier agents. When the tool was first introduced, a relative degree of freedom was given to the suppliers who had the prime responsibility to fill in the data onto the tool. Because of a poor farmer response in the first year, FDC’s approach evolved to include more supplier engagement through the involvement of the consultants to support the implementation (delivering training sessions and sitting down with the farmers to fill in the questionnaire), which was an attempt for them to maintain

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<th>Table VI</th>
<th>Evidence of the emergence of the carbon strategy in the network: quasi-equilibrium phase</th>
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<td><strong>Phase 3: quasi-equilibrium</strong></td>
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<td><strong>Environment</strong></td>
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<tr>
<td><strong>Co-Evolution</strong></td>
<td><strong>Quasi-equilibrium</strong></td>
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higher levels of control over the transition process. Despite these control aspects, the carbon reduction strategy was characterised by self-organisation and emergence. The nature of the relationships between the different agents meant that the implementation of the tool was not as straightforward as anticipated and new approaches emerged, as well as new and stronger relationships, for instance, between the suppliers and the consultants and between FDC and the consultants.

Different schemas are noticeable in such a system. The SFT consortium and tool represented the dominant schema around carbon reduction in the food supply network, which is not that of the farmers/suppliers but of the large buying firms. Different schemas about the relationships were also held by individuals; suppliers had a fairly negative perception of the relationship at the beginning of the introduction of the SFT, which negatively affected their receptiveness to the tool and they became suspicious of FDC's intentions. The difference in understanding that resulted from the different schemas held by agents in the supply network was one of the most critical factors undermining the carbon reduction strategy initiated by the focal firm and leads us to the development of our first proposition below:

P1. The emergence of environmental strategies within supply networks is a non-linear evolutionary process, and if the sustainability schemas of agents within those networks are not aligned, the less likely it is that the intended environmental strategy will be realised.

The case study complements previous research that suggests that transitioning to more sustainable practices with legacy suppliers may not be as smooth as one would expect and actually presents a number of challenges (Hoejmose and Adrien-Kirby, 2012). CAS as a framework appears, however, to underplay the power dynamics underlying internal mechanisms and co-evolution. In this research, the SFT was included as part of the contracts for suppliers, who because of their dependence on the buyer had limited choice but to implement it. The control exerted by the focal firm on the overall environmental strategy cannot be fully understood without considerations of both power and trust in the relationships between network agents. It also appears that because the consortium solely involves large players in their role of buyers, it reinforces the existing top-down approach to SSCM rather than stimulate a change in relational dynamics. We therefore echo previous research, in particular in the food industry, which has found that power dynamics need to be taken into account to understand how to best advance sustainability practices (Touboulic et al., 2014; Hoejmose et al., 2013). Hence, to fully make sense of non-linear changes in supply networks, we must account for existing dependencies and power relations between the network agents. It is interesting to note that our findings confirm the idea that relying on a position of power in attempts to shape the environmental strategy of the supply network is insufficient to drive meaningful change.

While the exercise of power by the buying firm (FDC) had a negative effect upon the evolution of the carbon reduction strategy within the supply network, it was able to build goodwill with its suppliers through its response to an external event, the poor weather that negatively affected its farmers. Agents in the network may create goodwill with other members through their response to such events and change the attitudes and behaviours of other agents as a result, potentially facilitating the progression towards more sustainable practices. Our case suggests that goodwill may be able to better compensate for conflicting sustainability schema than the exercise of power by the buying firm.

The following propositions are based on the discussion of the contrasting roles that power and goodwill can play in facilitating the cooperation of agents within a supply network when there is a conflict between their sustainability schemas.
P2a. The power of buying firms will have limited capacity to change the behaviour of the supply network in the absence of shared sustainability schema.

P2b. Goodwill demonstrated by participating agents in the supply network may compensate for the lack of alignment between the sustainability schema of agents and thus facilitate the diffusion of environmental strategies.

Cooperative buyer–supplier relationships have been examined extensively within the SSCM literature as a means to drive change in supply networks (Gimenez and Sierra, 2013; Tachizawa et al., 2015; Gimenez and Tachizawa, 2012; Vachon and Klassen, 2006; Vachon and Klassen, 2007; Vachon and Klassen, 2008). Relationships with non-traditional network partners such as NGOs have been recognised as an important aspect of making supply networks sustainable (Gold et al., 2013; Pagell et al., 2010; Hartmann and Moeller, 2014; Wolf, 2011). While useful work has been conducted in exploring collaboration between firms and NGOs (most notably Pagell and Wu, 2009), it needs to be recognised that such initiatives do not always take the form of simple dyadic relationships. Many firms are finding it useful to participate in consortia to drive action on particular sustainability issues, such as climate change (Xu et al., 2016). As in our case study, participation in such consortia often takes the form of pre-competitive collaboration, where competitors share research during the early stages of the innovation process (Ritala and Hurmelinna-Laukkanen, 2009; Gnyawali and Park, 2011).

The case study elaborates that other CASs in the external environment of the supply network, such as consortia, can play in the development and emergence of SSCM strategies. Further, the research showed that consortia can have a bridging and catalyst function for agents in supply networks. Consortia can help focal firms address the uncertainties of implementing sustainability in supply networks (Matos and Hall, 2007) by providing a platform to share experiences. The consortium in the case study ensured that agents did not lose sight of the bigger sustainability picture. It therefore bridged the micro means – the carbon reduction tool – with the macro idea of sustainability. In addition, the consortium played a motivational and legitimising role for individual agents who were often faced with difficulties in their own organisations. While much research has acknowledged the value of pre-competitive collaboration, their more intangible value needs to be recognised.

In a CAS, the role of external environmental factors is crucial in determining the evolution of the system. In this study, the boundaries of the system evolved in different ways, for example, through the inclusion of Agri-consultancy as a critical agent. The role played by Agri-consultancy in this study was that of a key boundary spanning agent. Our findings in this respect resonate with the process model phases proposed by Nair et al. (2016). Agri-consultancy’s role and responsibilities were initially defined by FDC’s structuring process, whereby the dominant buying firms recognised that its limited resources and the conflicting schemas with suppliers constituted important barriers in the diffusion of its carbon reduction strategy. Agri-consultancy’s role became pivotal in the diffusion and amplification of the carbon reduction strategy in the supply network through the developmental activities it ran with the suppliers and through its contribution and participation in the SFT consortia. Agri-consultancy has become a fundamental agent in the network, developing strong inter-organisational links with the suppliers and FDC and equally supporting the existing links between FDC and its suppliers by acting as a boundary spanner. It contributed to the institutionalisation of new practices as routines (SFT tool annual data collection) and to the synchronisation around carbon reduction in the supply network.

The preceding discussion leads us the development of our final propositions below:

P3a. Consortia are critical boundary-spanning agents serving to bridge the micro practices in supply networks with the macro concept of sustainability and provide access to both tangible and intangible resources that can support the emergence and sustaining of a cohesive environmental strategy in the longer term.

P3b. Boundary-spanning agents, comprising internal and external agents in the network, can help overcome existing conflicts between the schemas of agents and facilitate the proliferation of environmental strategies in the network.

7. Conclusion, implications and future research

In this study, we have focussed on the implementation of an SFT as a means to achieve carbon reduction in supply networks. We sought to understand how a carbon reduction strategy emerges in a supply network.

We have addressed our research question by offering insights into the emergent nature of a carbon reduction strategy across a supply network, drawing on a longitudinal case study and CAS as a theoretical framework. Findings from our study shed light on the multilevel, emergent and complexity aspects of driving carbon reduction in supply networks, therefore offering novel insights in the field of SSCM. Though SSCM strategies are generally reported as being top-down and rational, we explored the emergent aspects of such strategies and showed that individual and firm agents within the supply network, as well as agents and factors in the external environment, play a critical role in shaping the direction of such environmental strategy.

This paper contributes to SSCM research in three ways. First, we use the CAS framework (Pathak et al., 2007; Nair et al., 2009; Choi et al., 2001; Surana et al., 2005) to make sense of the process through which supply networks adapt in response to the challenges of environmental sustainability and the complexity inherent to this process of adaptation. Through an embedded case study, we provide an in-depth exploration of context, which in turn is used through abduction to confirm elements of the CAS framework and elaborate on others, enabling us to formulate a number of propositions. Second, the focus on complexity has allowed us to explore the multilevel factors that influence the emergence of a carbon reduction strategy in a food supply network context, hence responding to recent calls for more multilevel research in the field (Carter et al., 2015a). Third, we contribute towards the incipient
literature on consortia within SSCM by exploring the way in which buying firms use consortia to gain access to unique resources that can help initiate and sustain SSCM strategies. Specifically, we show how a consortium may act as a facilitator for change for sustainability in supply networks by providing platforms for non-competitive interaction.

The research yields several lessons for organisations and managers looking to adopt environmental strategies within their supply networks. Alignment of values, understandings and visions around sustainability and ways of working are crucial at two main levels. First, it cannot be assumed that suppliers will adopt a particular tool or change their behaviour if they do not see their values and beliefs integrated or represented in the strategy. Second, when multiple teams within the same organisation are working with suppliers, they need to be sharing similar views and values about sustainability to communicate a coherent message and ultimately facilitate supplier engagement. There can also be an important role for intermediaries in this context to offer guidance in a neutral way, e.g., through independent agronomists, unions and consultants.

Another important lesson from this research is that SSCM strategies are organic processes and ultimately emerge because of cooperation and adjustments. This may suggest that transitioning towards more environmentally sustainable practices cannot be controlled or mandated and is not a top-down process. Sustainable supply networks are in constant flux and cannot be viewed as machines. Central to this is also the fact that managers should assume that their environment is dynamic. External factors such as the harvest crisis described in our case, while having disastrous consequences for the farmers, had a positive impact upon the carbon reduction strategy, as FDC’s supportive response to the crisis increased the farmers’ willingness to engage in the strategy.

Our research seeks to sensitise managers to the dynamic and complex nature of the transition towards more sustainable practices in supply networks. It is crucial for managers to appreciate that the diffusion of environmental practices outside the boundaries of their organisation may not be entirely within their direct control. Our case illustrated the value of working with boundary spanning actors in this context, such as the consortium that included consultancies and NGOs. The research therefore offers a more nuanced view of the role that dominant firms may play in supporting the transition to more sustainable supply networks. Indeed, rather than directing and controlling, they may become orchestrators (Dhanaraj and Parkhe, 2006).

There are also societal implications that have emerged from our project. In particular, as discussed above, consortia appear as central in promoting forums for horizontal collaboration and supporting the development and implementation of sustainability initiatives in supply networks. There are important roles to be played in these forums by societal agents such as universities and NGOs, notably in providing access to the latest scientific developments and research around a particular sustainability issue. Individuals from these organisations also seem to be well placed to act as dialogue facilitators not only between competitors within the context of the consortium but also between agents in a supply network. Hence, the project is evidence of the value of promoting industry–university collaboration.

Finally, our research has shown the value of taking part in consortia both for individuals and organisations seeking to become more sustainable. People or teams within an organisation working on sustainability projects can not only gain access to innovative tools and ideas but also will be able to share the learning and experiences with like-minded individuals, which can sustain and inspire them, especially in difficult times. At an organisational level, contributing to consortia can be a source of reputation.

The choice of a single case study was important to allow a multilevel analysis that encompasses the consortium level, the supply network level and the level of individuals. Yet, we acknowledge that there are limitations to using a single case study. The first limitation of single-case studies relates to control variables. Single cases do not allow researchers to control for variables such as environmental variations, firm size and other aspects as in multiple-case research (Eisenhardt, 1989). Further, multiple-case research allows researchers to select categories or dimensions for analysis and then look for within-group similarities coupled with intergroup differences to expand understanding (Eisenhardt, 1989).

A second limitation of single-case research is the risk of placing too much emphasis on a single problem. When taking a single-case approach, researchers are often tempted to try to build theory that captures everything. The outcome can be a theory that is very rich in detail, but lacks the simplicity of an overall perspective (Eisenhardt, 1989). The idiosyncratic boundaries of a single setting can often lead to narrow and overly complex theoretical developments (Yin, 1994).

A third limitation is that the research considers the emergence of a carbon reduction strategy in the food sector driven by a dominant buying firm. This concern with carbon reduction reflected the concern of the buying firm within the case but is clearly a reductionist construction of environmental sustainability – as was identified by the farmers in the case. Future research should seek to investigate the diffusion of environmental strategies more broadly and in other contexts. It would be interesting to explore the emergence and diffusion processes of environmental or social strategies initiated by suppliers or not-for-profit actors in their networks.

Another interesting avenue for future research would be to examine and test our propositions in similar and different contexts. Further studies could potentially seek to offer comparative evidence of other carbon decision support systems and tools. A logical step would be to explore how the other companies involved in the consortium have applied the tool. Comparative evidence from other sectors and other initiatives would also be useful. Finally, opportunities exist for the systemic application and exploration of theories that would complement CAS, such as social network theory and ecological modernisation theory. In particular, the latter would be relevant when seeking to understand the decision-making aspects of innovation diffusion and the interplay between bottom-up and top-down factors, while the former would enable refining the conceptualisation of linkages and relationships between agents and their influence on the evolution of the system.
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Carbon reduction

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Key risks in the supply chain of large scale engineering and construction projects

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Abstract
Purpose – Large-scale projects are the typical delivery model in the engineering and construction industry, with their very own characteristics. Even though well established, only 1 in 1,000 large-scale projects is successful (Flyvbjerg, 2011). A lack of effective supply chain risk management (SCRM) has repeatedly been identified as one of the main causes. While the SCRM body of knowledge seems increasingly well established, a lack of effective methods meeting the specific requirements of large-scale projects can be observed.

Design/methodology/approach – This paper presents a structured and prioritized view on the supply chain risk portfolio in this sector: first, the authors identified and categorized the key supply chain risks in the recent literature. Next, the authors surveyed large-scale project managers across multiple industries, mainly coming from the domains of supply chain management and project management. Finally, the authors provide a contextualized risk taxonomy for engineering, procurement and construction (EPC) projects.

Findings – The identified risk portfolio deviates from generic projects significantly and shows a very high inherent risk exposure of large-scale projects. In particular, behavioral risks are identified as crucial. Additionally, a bias to considerably underestimate risks at project beginning is found.

Originality/value – The contextualized SCRM taxonomy offers a systematic and structured view on the key supply chain risks in EPC large-scale projects. The identified risks are considerably different in their characteristics compared to generic projects or classical SCRM approaches. The authors thus provide a new perspective on SCRM in this specific setting and complement traditional risk and project risk management techniques.

Keywords Project management, Risk management, Construction industry, Supply chain disruptions, Supply risk, SCM project evaluation

Paper type Research paper

1. Introduction
Every human endeavor involves risk. The past decade taught us that large risks occur frequently and with severe impact: a global financial crisis, environmental disasters, product failures, commodity price spikes and unexpected regulatory changes. While traditionally, risks were seen as undesirable, companies more and more realize that they can create significant competitive advantages through managing risk properly.

Especially, the level of corporate exposure to supply chain risks increased considerably over the past years (Blackhurst et al., 2005). Besides this universal surge, it has been shown that the recent generic drive toward leaner supply chains resulted in further growth of vulnerabilities (Christopher and Lee, 2004). As of 2015, for the third year in a row, supply risks are the number one risk affecting companies according to the Allianz Risk Barometer (Allianz, 2015).

This issue is even more evident in the field of large-scale projects, where companies form a temporary coalition to build something new (Cox et al., 2006). The entire large-scale project sector has a poor reputation for coping with risk as many major projects fail to meet deadlines, cost targets or specifications (e.g. Stuttgart 21, the Elbphilharmonie Hamburg or the Sydney Opera House). Their outcomes create huge financial losses for businesses and severe damages to the surrounding economies (Flyvbjerg, 2011, 2014).

Generally, large-scale projects in this sector can be characterized as being performed in an engineering-to-order environment with high complexity and high values associated with supplies (Rolstadás et al., 2011). Consequently, the risks in the supply chain must be seen as key driver for the overall risk exposure (Chen et al., 2004; Hendricks and Singhal, 2005), and supply chain risk management (SCRM) needs to be regarded as a central activity in any large-scale project (Krane et al., 2010).

Though traditional SCRM methods are not simply transferable to the specific setting of large-scale projects (Xie and Yang, 2011; Flyvbjerg, 2014; Dey and Ogunlana, 2004) and despite rich literature on both risk and SCRM (Colicchia and Strozzi, 2012; Jüttner et al., 2003; Kleindorfer and Saad, 2005), no published contributions address the specific issues of large-scale projects. Previous research has revealed a particular need to identify those key supply chain risks that the respective large-scale projects are most sensitive to (Lee et al., 2009; Micheli et al., 2008).

The objective of this paper is to identify the specific supply chain risk portfolio of large-scale projects executed in the engineering and construction sector. We thus aim to develop
and contextualize SCRM, making it more useful for the application in large-scale projects and support improved management practices, potentially leading to a higher success rate of large-scale projects.

This study is organized as follows: Section 2 provides a brief introduction to large-scale projects, while in Section 3, the methods of our research are laid out. In Section 4, we analyze the current status of research in the intersection of project, risk and supply chain management (SCM) in the context of large-scale projects to identify a broad base of applicable key risks. We then evaluate and structure these risks to build a taxonomy for EPC projects. Based on a survey among industry experts, mainly from SCM and project management, we provide an empirical analysis of the specific supply chain risk portfolio in large-scale projects. We conclude in Section 5 with a brief summary and discussion of our results and future research topics.

2. Large-scale projects in the engineering and construction industry

Since the 1980s, large-scale projects became an increasingly popular delivery model in the engineering and construction industry (Xie and Yang, 2011). The size and importance are described to be steadily growing. The McKinsey Global Institute (2013) estimates for example an average growth of 1.5–2.5 per cent per year. Even as it is undoubtedly a relevant segment of the world-wide economy, large-scale projects are often complex and underperforming endeavors: cost overruns and massive delays seem to be rather the norm than the exception (Flyvbjerg, 2014).

Large-scale projects are characterized by the following distinctive features:

- financial values ranging from several million up to billions of US dollars;
- projects being usually executed under an engineering, procurement and construction (EPC) contract;
- a complex technical nature with long timelines and many interfaces;
- a high level of influence of regulatory authorities;
- customers that exercise a strong influence on the final product and often change requirements during project execution;
- a high number and diverse types of stakeholders (e.g. authorities, owners, designers and constructors);
- short-term thinking as of the temporary configuration; and
- a high number of unplanned changes during the project lifetime.

Consequently, EPC large-scale projects must be seen as endeavors particularly exposed to risk (Burtonshaw-Gunn, 2009; Flyvbjerg, 2014; Krane et al., 2010; Cox et al., 2006).

The need for significant improvements in these types of projects emerged over recent years (Bankvall et al., 2010). Hendricks and Singhal (2005) argue that in developing supply chain strategies focusing solely on cost reduction, organizations have often ignored the resulting increased risk exposure, particularly with regard to EPC large-scale projects. The main reasons are the essential need to form value networks to achieve competitive advantages, the large number of interrelated processes where disruptions spread rapidly and chain reactions easily occur and the severe impact of materializing risks (Wan et al., 2013). In combination with a steadily growing dependency on suppliers, this leads to a particular high risk exposure. Aloini et al. (2012) stated there is a clear need to further develop SCM methods for the application in this sector.

3. Methods

3.1 Deriving an initial risk taxonomy based on pertinent research

Risk factor identification and prioritization is a critical process for helping management to make informed decisions (Sodhi and Tang, 2012; PMI, 2009). A comprehensive description of all the possible risks in a supply chain is infeasible as the risk situation is strongly influenced by the specific context (Giunipero and Eltantawy, 2004) and a nearly infinite number of potential supply and sourcing risks exists (Sheffi, 2005). Various studies note that neither a universally accepted approach for structuring and classifying risk factors nor a fixed number and type of risk categories have yet been introduced (Dey and Ogunlana, 2004).

Addressing this issue and attempting to differentiate supply chain risks from other business risks, many scholars have suggested classifications in the form of risk taxonomies (Chopra and Sodhi, 2004; Christopher and Peck, 2004; Hallikas et al., 2004; Jüttner, 2005; Svensson, 2000). However, there is a broad range of viewpoints on the suggested number of categories, the structure and the importance of individual risk factors with none considering the context of large-scale projects.

To develop our contextualized portfolio and taxonomy of supply chain risks in engineering and construction large-scale projects, we applied a two-phased approach:

1. we first create an initial taxonomy based on an extant literature review and then refine; and
2. validate it by empirical data obtained through a survey across large-scale project subject matter experts.

Using the principles of grounded theory, theoretical structure was therefore extended using empirical data in a systematic method (Glaser and Strauss, 2012; Partington, 2000). During the first phase, the applicable literature is analyzed and combined with insightful anecdotal evidence from conversations with practitioners. This represents the baseline for understanding the concepts involved, which is necessary for theory construction (Yin, 2011).

The sources come primarily from the categories of business review, operations and project management, as well as management science. A total of seven keyword sets was identified by the authors by means of a brainstorming process:

1. risk;
2. risk management;
3. supply chain, sourcing, procurement or purchasing;
4. SCRM;
5. project;
6. large-scale project or mega project; and
7. construction or engineering.

These sets are combined to constitute a series of strings to be applied in the search on the database. As the focus of our research is SCRM in large-scale projects and the engineering and construction industry, the strings were specifically designed to select relevant papers for the overlap between risk management and SCM in the specific context. By combining
keywords through simple operators and Boolean logic, complex searches were constructed to avoid too generic and wide results. These search strings were brainstormed, tested and refined until a reasonable list of terms was deemed sufficient, resulting in eight relevant research strings.

To obtain and include relevant documents to concentrate on, a series of inclusion and exclusion criteria was defined. The following criteria, based on the ones proposed by Newbert (2007), were considered to include or exclude papers:

- Search for papers published in peer-reviewed scientific journals.
- Search for papers either in English or German language.
- Search for papers published in the past 35 years.
- Limit search to literature published in the field of management and organization studies.
- Ensure substantive relevance by requiring that selected articles contain all keywords either in their title or abstract.
- Eliminate substantively irrelevant articles by excluding papers related to very narrow aspects or contexts.

The literature search was performed with the Scopus database. The rationale for this choice is that it is the largest abstract and citation database of peer-reviewed literature, offering the broadest coverage available of scientific, technical and social sciences literature. It is deemed that by restricting the search to peer-reviewed journals, the quality control of search results can be enhanced because of the rigorous process the articles published in such journals are subject prior to publication (Newbert, 2007). Furthermore, the results retrieved can easily be organized and analyzed directly in the tool itself.

The collected bibliographic data were analyzed directly through Scopus. The initial search led to 563 potentially relevant contributions. Following substantive and empirical study, relevance was ensured by reading all abstracts and validating whether the literature retrieved helps to address the research questions and fits for purpose (Boaz and Ashby, 2003). Moreover, articles were not included in the final list if they had either a lack of references or a missing sound methodological research approach. After removing and selecting the material of interest, the sample consisted of 70 contributions with a total of 1,018 citations, 499 out of the primary domain of project risk management, 60 from enterprise risk management and 459 from SCRM.

Building on these results, a thorough systematic literature review (SLR) was conducted to retrieve potentially relevant key risk factors. According to Colicchia and Strozzi (2012), this method offers a solid and reliable technique that can easily be applied to a broad field of research for selecting the most relevant contributions. The approach is evidence-based and aims to identify, select and analyze secondary data. SLR differs from other review methods because of its principles such as transparency, inclusivity, explanatory and heuristic nature. It allows a more objective overview on the search results and the elimination of any bias and error issues (Denyer and Tranfield, 2009). During the SLR, each citation was linked to a risk factor and then classified in the course of an iterative process into a risk category and a risk class. As a result, the major classes and class hierarchy of a contextualized SCRM taxonomy were defined. The resulting structure is used as the underlying concept for the present research.

3.2 Approach for validating and advancing the initial taxonomy

Previous studies suggested that both the classification and the balance between depth and coverage could change the development results (Dey and Ogunlana, 2004). Yet, there is no specific standard for the validation of taxonomies. Thus, we used domain expertise in the ensuing explorative phase to validate our results and further refine the taxonomy.

As risk identification in general depends on subjective judgment from experienced experts, historical information and objective statistical data about risk factors are hard to obtain. Therefore, quantitative evidence is often missing. Likewise, it is usually impossible to conduct longitudinal studies on most risk categories. Consequently, the available information on risks is usually incomplete, non-representative or with low accuracy. The judgement of experts can hence be seen as a more suitable approach for evaluating risk in engineering and construction large-scale projects (Xie and Yang, 2011). After reviewing the SCRM taxonomy identified in the first phase with several researchers and management executives, we thus decided to conduct an online survey across respondents with subject matter expertise in the field.

According to the described specific characteristics of risks in projects and to tap the mental maps and experiences of the subject matter experts, a discovery-oriented approach was applied to assess the key supply chain risks. Similar approaches were previously used for investigating risk-related research questions (Ellram et al., 2002; Jüttner, 2005; Sitkin and Weingart, 1995). The target population for the survey consisted of subject matter experts working in engineering or construction large-scale projects, preferably under an EPC contract. As the purpose of the study is to shape existing knowledge and gain new insights, it was deemed as crucial to capture a wide range of experience from diverse perspectives. Therefore, we aimed at a preferably large sample with respondents of different functional backgrounds and responsibilities.

“Validity is not a commodity that can be purchased with techniques” (Brinberg and McGrath, 1985, p. 13). However, the ideal state can be pursued through sound research methods built into each stage of the research process (Ellram, 1996). Construct validity, ensuring that operational measures are suitable for the concepts being studied (Miles and Huberman, 1994), was controlled using multiple respondents from each of several functional areas and multiple hierarchical levels to measure the overall level of supply chain risk exposure in EPC large-scale projects.

External validity, the extent to which the results accurately represent the phenomenon studied to establish generalizability, was designed into the study through a sample including multiple subject matter experts from different companies, countries and industrial sectors. Reliability, demonstrating that the operations of a study can be repeated with the same results (Yin, 2011), was controlled through a pretest of the survey with a convenience sample of seven subject matter experts by using the collaborative participant pretesting method described by Cooper et al. (2006).

3.3 Structure and design of the subject matter expert survey

Based on feedback from the initial reviews and pretesting, the survey consequently was structured to first ask attendees to
preselect category by category out of the list of risk classes identified in the literature analysis as the main ones in which significant risks occurred during one of their projects. The reason for this nonstandard approach is to attract a broad audience by allowing especially a time-efficient survey completion through limiting the number of risk factors that needed to be assessed and by offering a familiar method for the assessment. This follows the suggestion of Krosnick and Presser (2010) to closely align the order and grouping of items with the survey objective. Moreover, we aimed with this design to avoid potential biases such as satisficing (Bogner and Landrock, 2015; Krosnick et al., 1996) driven by a too comprehensive list of risks classes that have to be assessed in detail (Holbrook et al., 2007; Krosnick and Fabrigar, 1997). Additionally, this approach allows to specifically identify for each category risk classes that are perceived as most significant by the subject matter experts.

Likewise, this approach of branching questions saves time and allows respondents to avoid irrelevant or redundant risk assessments (Cummings et al., 2013; Slovic, 1995). Additionally, Armstrong et al. (1975) showed that people make more accurate judgments when a complex decision task is decomposed into a series of subcomponent constituent decision tasks. As it is deemed necessary to generate a coherent information flow throughout the questionnaire, items on related topics had to be grouped. This coherent grouping facilitates the respondents’ cognitive processing and increases data quality (Knowles and Byers, 1996; Malhotra et al., 2009). While Smith (1983) reported inconsistent results and negative effects on the data validity through this approach, others did not find those negative effects (Metzner and Mann, 1953; Martin, 1980; Baehr, 1953).

Cummings et al. (2013) suggest that existing and familiar measures and scales should be used for questionnaires if suitable. Thus, in a second step, the selected risk classes were assessed more in detail based on a proven practitioner-oriented semi-quantitative risk estimation approach (PMI, 2009; Hillson and Simon, 2012; Smith et al., 2009). Therefore, every chosen risk class was scored on four five-point scales, each the probability and the impact from two perspectives:

1. historical: how the risk class was assessed at the beginning of the project; and
2. from the perspective of increased knowledge at the end of the project.

For the assessment of the probability of occurrence, we choose a combination of standard ordinal terms in combination with numerical range definitions as scale. Thus, we aim to avoid ambiguity and the issue of semantics when the same phrase could be interpreted subjectively with different meanings by different persons. This combination is the preferred solution recommended by several risk standards (PMI, 2013, 2009; British Standards Institute, 1996) and previous research (Hillson, 2004; Hillson and Hulett, 2004; Conrow and Pohlmann, 2004). The used scale for the probability was very improbable (0-10 per cent); improbable (11-30 per cent); possible (31-50 per cent); probable (51-70 per cent) and very probable (71-99 per cent).

Because of the various project sizes and possible wide spread of financial impacts, we used a qualitative ordinal scale for the assessment of the risk impact. This qualitative approach allows identifying efficiently the most relevant risk classes (Brünger, 2011). The used scale for the impact was insignificant; marginal; significant; serious and severe. All used scales are further proven both in practice and research (PMI, 2009; Hillson and Simon, 2012; Brünger, 2011).

4. Results

4.1 Applicable supply chain risk factors in pertinent research

We build our analysis on a thorough examination of the various supply chain risk factors, risk taxonomies and risk management practices proposed in the current literature. Table I depicts the initial SCRM taxonomy with subclasses.

In a first step, the literature was analyzed, risk factors were derived and the number of occurrences in the literature were noted. To translate the list of risks into a practicable

Table I Initial list of supply chain risk management strategies derived from literature

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>No. of occurrences (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td>[RC-E] Economical</td>
<td>48 4.7</td>
</tr>
<tr>
<td>[RC-SE] Social environment</td>
<td>47 4.6</td>
</tr>
<tr>
<td>[RC-LR] Law and regulations</td>
<td>39 3.8</td>
</tr>
<tr>
<td>[RC-NE] Natural events</td>
<td>28 2.8</td>
</tr>
<tr>
<td>[RC-PG] Political and governmental</td>
<td>21 2.1</td>
</tr>
<tr>
<td>[RC-EHS] Environmental, health and safety</td>
<td>17 1.7</td>
</tr>
<tr>
<td>[RC-SC] Sociocultural</td>
<td>10 1.0</td>
</tr>
<tr>
<td>[RC-STC] Standards and codes</td>
<td>1 0.1</td>
</tr>
<tr>
<td>Supply chain coordination and management</td>
<td>362 35.6</td>
</tr>
<tr>
<td>[RC-MSC] Management of the supply chain</td>
<td>107 10.5</td>
</tr>
<tr>
<td>[RC-SCC] Supply chain configuration</td>
<td>65 6.4</td>
</tr>
<tr>
<td>[RC-DSC] Demand and scope changes</td>
<td>41 4.0</td>
</tr>
<tr>
<td>[RC-PC] Planning and forecasting</td>
<td>34 3.3</td>
</tr>
<tr>
<td>[RC-L] Logistics</td>
<td>24 2.4</td>
</tr>
<tr>
<td>[RC-SBS] Scope and baseline specification</td>
<td>21 2.1</td>
</tr>
<tr>
<td>[RC-CSR] Corporate social responsibility</td>
<td>21 2.1</td>
</tr>
<tr>
<td>[RC-C] Communication</td>
<td>20 2.0</td>
</tr>
<tr>
<td>[RC-I] Inventory</td>
<td>15 1.5</td>
</tr>
<tr>
<td>[RC-CFM] Cash flow management</td>
<td>14 1.4</td>
</tr>
<tr>
<td>Supplier</td>
<td></td>
</tr>
<tr>
<td>[RC-SPO] Performance and operations</td>
<td>128 12.6</td>
</tr>
<tr>
<td>[RC-SEM] Supplier environment and market</td>
<td>103 9.9</td>
</tr>
<tr>
<td>[RC-CTC] Contractual terms and conditions</td>
<td>50 4.9</td>
</tr>
<tr>
<td>[RC-FS] Financial stability</td>
<td>41 4.0</td>
</tr>
<tr>
<td>[RC-SIR] Infrastructure and resources</td>
<td>36 3.5</td>
</tr>
<tr>
<td>[RC-SS] Sub-suppliers</td>
<td>25 2.5</td>
</tr>
<tr>
<td>[RC-EE] Experience and expertise</td>
<td>19 1.9</td>
</tr>
<tr>
<td>Behaviour and cooperation</td>
<td>86 8.4</td>
</tr>
<tr>
<td>[RC-CT] Collaboration and teaming</td>
<td>31 3.0</td>
</tr>
<tr>
<td>[RC-CPS] Mutual commitment to project success</td>
<td>21 2.1</td>
</tr>
<tr>
<td>[RC-T] Trust issues</td>
<td>16 1.6</td>
</tr>
<tr>
<td>[RC-PGS] No mindset of &quot;pain/gain sharing&quot;</td>
<td>10 1.0</td>
</tr>
<tr>
<td>[RC-FCC] Misfit of corporate cultures</td>
<td>8 0.8</td>
</tr>
</tbody>
</table>

339
measurable set, each of the initially identified 114 factors was refined, grouped into 1 of 30 classes, prioritized based on the number of citations and then grouped into one of four main categories. Figure 1 provides a graphical representation of the contextualized supply chain risk taxonomy for EPC large-scale projects.

4.2 Survey context and demography
An internet-based survey was conducted in 2015. It was sent directly to appropriate candidates in the network of the authors and was advertised in 42 discussion groups at the platforms LinkedIn and Xing, primarily focusing on project, risk, supply chain, supply chain risk and construction management. The initial sample included 131 replies. Only responses with less than 5 per cent of missing item values were accepted. The final realized sample includes a total of 117 usable questionnaires.

Replies were obtained from a multitude of sectors, project volumes, hierarchy levels and years of experience. Hence, the respondents provide a reasonably representative and well-balanced profile of experienced subject matter experts working in large-scale projects and across the targeted population. Those appear well qualified to provide valuable information based on their practical experience. Figure 2 gives an overview of the obtained demography.

4.3 General insights on risk and supply chain risk management
Our research shows that although the application of generic risk management in large-scale projects is high, risk management focusing specifically on the supply chain is currently applied only to a lesser extent: 82 per cent of the participants of our survey state that they perform risk management consistently, while only 64 per cent make use of SCRM. The standard process for managing risk (PMI, 2009) is seen by only 23 per cent of the respondents as applicable for managing supply chain risks in large-scale projects; 72 per cent see a need for process modification to reflect the specific requirements. This maturity level is in particular surprising as SCRM’s potential impact to project success is graded as fairly high (μ = 7.2; scale from 1 [low] to 10 [very high]; σ = 1.93). By contrast, the current process efficiency is seen only as mediocre (μ = 4.9; σ = 1.81), emphasizing on a need for further development.

When analyzing supply chain risks, majority of respondents state a need to look at either the entire supply chain in depth (52 per cent) or at least on a case-related base (34 per cent); only a minority limits the evaluation to Tier 1 or 2 suppliers (13 per cent). This need to anticipate and manage risk across the entire chain from the outset thus represents a particular challenge in large-scale projects. Further, the risk portfolio of large-scale projects contains many hard-to-predict but high consequence type of supply chain risks: 37 per cent are graded as totally unpredictable with either a significant (56 per cent) serious (36 per cent) or severe (5 per cent) impact, stressing on a particular high intrinsic risk exposure. These types of risks are particularly hard to manage (Taleb et al., 2009; Rolstadás et al., 2011).

4.4 The overall taxonomy and portfolios of supply chain risks
Figure 3 exhibits an overview of the investigated key supply chain risk classes for large-scale engineering and construction
projects. The results are grouped by category and class, showing the times selected as key risk class (A), impact (B) and probability (C), both as mean values from the perspective of the project beginning, as well as from the perspective at the end of the project (D and E). In addition, a comparison between both perspectives is shown in F and G. Each risk class is then ranked within the entire set under each of those views.

The average rating from the perspective of project start is for the impact $\mu = 3.0$ ($\sigma: 0.27$) and for the probability $\mu = 2.3$ ($\sigma: 0.35$), respectively; from the perspective of the completed project $\mu = 3.9$ ($\sigma: 0.37$) for the impact and $\mu = 3.7$ ($\sigma: 0.35$) for the probability. The preselection of key risk factors in the literature analysis and the survey process, asking participants to first select key risk classes and then rate only those might partially explain the medium to high ratings as consequently only occurred key risks got rated. However, in summary a fairly consistent picture of large-scale projects being above average exposed to supply chain risks can be observed. This finding is in line with previous research (Xie and Yang, 2011; Turner and Zolin, 2012; Krane et al., 2010; Rolstadås et al., 2011).

Overall, the initial taxonomy derived from the literature was confirmed through the survey in regard to the relevant key risks. For Question 56 “Do you see any other key supply chain risks not mentioned in the lists before?”, only ten respondents provided suggestions. However, these ten replies could be matched into one of the existing risk classes, and no new ones could be identified.

When comparing the literature analysis with the survey results in terms of ranking by being named as key risk, only a moderate correlation ($r = 0.351$) can be observed. The overall average deviation in ranking positions (ADRP) is 7.6. In particular, in the category of behavior and cooperation, a strong underestimation in the literature versus survey results can be observed (ADRP: 12.6). This indicates that the survey respondents value the key risk classes differently as compared to the current research, which is not primarily focused on large-scale projects. An explanation for this could be the strong dependency on collaboration in projects and the specific characteristics of large-scale projects (Cruz, 2009; Smith, 2009; Seiter, 2009).

A standard method to gain a differentiated view of various risks and derive a prioritization, i.e. determining the risk magnitude by multiplying the impact with the probability (PMI, 2009; Hillson and Simon, 2012), is rarely meaningful for the given sample because of the low variation in both values in the obtained data set. Further, the priorities and weightings are always highly driven by the specific project. However, we deem this with regard to the objective of the paper as not crucial and instead cluster risks by impact and probability to provide a view of the risk portfolio in the format of heat maps (PMI, 2013) by risk category. Figures 4-7 provide a differentiated view of the supply chain risk portfolio in large-scale projects based on the two mean scores for probability and impact and the perspectives of project beginning and project end. The diameter of the bubble in the charts indicates the count of being selected as key risk class.

4.5 Most frequently named key risks

Our study shows that a number of supply chain risks deviate in terms of probability, impact, frequency and magnitude of occurrence significantly from generic-sized projects. As the identification of an absolute and universal set of key risks for EPC large-scale projects is not possible because of the highly unique character of each of those projects, we focus for the following discussion on the during our survey most as key risk class identified ones as shown in Table II.

Behavioral risks are found to be highly important for large-scale projects (Cox et al., 2006), which is particularly interesting as those risks have largely been neglected in previous studies (Seiter, 2009). As the number of suppliers increases in a supply chain, the level of visibility and control decreases. Christopher and Lee (2004) argue that this may induce harmful and destructive behavior. Because of the large number of suppliers and the sums of money involved in large-scale projects, principal-agent problems and opportunistic behavior are common. Even though parties need to rely heavily on a mutual commitment to project success (78 times selected as key risk class), collaboration and teaming (65) as well as solidarity and flexibility in sharing pain and gain (80).
Figure 3  Determined key supply chain risks for large-scale projects

<table>
<thead>
<tr>
<th>Category</th>
<th>Class</th>
<th>A) times selected as Key Risk</th>
<th>Mean - perspective: ◊ beginning</th>
<th>Mean - perspective: ◊ end</th>
<th>Δ Perspective ◊ vs ◊</th>
<th>Rank by</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPPLIER</td>
<td>[RG-SPX] Performance &amp; Operations</td>
<td>77</td>
<td>3.4 ± 0.1</td>
<td>2.9 ± 0.7</td>
<td>3.9 ± 0.7</td>
<td>3.6 ± 0.3</td>
</tr>
<tr>
<td></td>
<td>[RG-CTC] Contractual Terms &amp; Conditions</td>
<td>60</td>
<td>3.3 ± 0.1</td>
<td>2.3 ± 1.0</td>
<td>4.2 ± 0.2</td>
<td>4.0 ± 1.7</td>
</tr>
<tr>
<td></td>
<td>[RG-EE] Experience &amp; Expertise</td>
<td>52</td>
<td>3.0 ± 0.7</td>
<td>2.5 ± 1.1</td>
<td>4.0 ± 0.6</td>
<td>3.7 ± 1.7</td>
</tr>
<tr>
<td></td>
<td>[RG-PS] Financial Stability</td>
<td>43</td>
<td>3.0 ± 0.8</td>
<td>2.9 ± 1.0</td>
<td>4.0 ± 0.7</td>
<td>3.9 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>[RG-SS] Sub-Suppliers</td>
<td>40</td>
<td>2.9 ± 0.7</td>
<td>2.2 ± 1.0</td>
<td>4.1 ± 0.8</td>
<td>4.0 ± 1.1</td>
</tr>
<tr>
<td></td>
<td>[RG-SIR] Infrastructure &amp; Resources</td>
<td>36</td>
<td>2.7 ± 0.8</td>
<td>2.3 ± 0.9</td>
<td>4.2 ± 0.8</td>
<td>3.9 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>[RG-SEM] Supplier Environment &amp; Market</td>
<td>33</td>
<td>2.6 ± 0.6</td>
<td>2.2 ± 0.4</td>
<td>4.0 ± 0.7</td>
<td>4.1 ± 1.0</td>
</tr>
<tr>
<td>SUPPLY CHAIN MANAGEMENT</td>
<td>[RG-SBSS] Scope &amp; Baseline Specification</td>
<td>64</td>
<td>3.3 ± 0.6</td>
<td>2.3 ± 0.9</td>
<td>4.3 ± 0.7</td>
<td>3.9 ± 0.9</td>
</tr>
<tr>
<td></td>
<td>[RG-SCC] Supply Chain Configuration</td>
<td>61</td>
<td>3.3 ± 0.7</td>
<td>2.3 ± 0.5</td>
<td>4.1 ± 0.4</td>
<td>3.9 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>[RG-MSC] Management of the Supply Chain</td>
<td>60</td>
<td>3.3 ± 0.7</td>
<td>2.7 ± 0.6</td>
<td>3.9 ± 0.5</td>
<td>3.8 ± 0.6</td>
</tr>
<tr>
<td></td>
<td>[RG-DSG] Demand &amp; Scope Changes</td>
<td>54</td>
<td>3.1 ± 0.7</td>
<td>2.6 ± 0.9</td>
<td>4.3 ± 0.7</td>
<td>4.0 ± 1.2</td>
</tr>
<tr>
<td></td>
<td>[RG-PC] Planning &amp; Forecasting</td>
<td>30</td>
<td>2.8 ± 0.9</td>
<td>2.1 ± 1.0</td>
<td>4.6 ± 0.4</td>
<td>4.3 ± 1.2</td>
</tr>
<tr>
<td></td>
<td>[RG-C] Communication</td>
<td>24</td>
<td>3.0 ± 0.8</td>
<td>3.1 ± 1.0</td>
<td>3.6 ± 0.7</td>
<td>3.9 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>[RG-CPM] Cash Flow Management</td>
<td>17</td>
<td>3.0 ± 1.1</td>
<td>2.3 ± 0.8</td>
<td>3.7 ± 1.2</td>
<td>3.7 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>[RG-LU] Logistics</td>
<td>7</td>
<td>3.0 ± 0.9</td>
<td>2.5 ± 1.0</td>
<td>3.9 ± 0.9</td>
<td>3.9 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>[RG-I] Inventory</td>
<td>3</td>
<td>3.0 ± 1.1</td>
<td>2.4 ± 0.8</td>
<td>3.9 ± 1.1</td>
<td>3.8 ± 0.8</td>
</tr>
<tr>
<td></td>
<td>[RG-CSR] Corporate Social Responsibility</td>
<td>2</td>
<td>2.6 ± 0.0</td>
<td>1.8 ± 0.0</td>
<td>3.8 ± 0.0</td>
<td>3.6 ± 0.1</td>
</tr>
<tr>
<td>ENVIRONMENT</td>
<td>[RG-UL] Law &amp; Regulations</td>
<td>63</td>
<td>2.9 ± 0.9</td>
<td>2.3 ± 1.0</td>
<td>3.6 ± 0.5</td>
<td>3.6 ± 0.6</td>
</tr>
<tr>
<td></td>
<td>[RG-Sd] Standards &amp; Codes</td>
<td>59</td>
<td>3.2 ± 0.7</td>
<td>2.4 ± 0.8</td>
<td>3.4 ± 0.7</td>
<td>2.9 ± 0.9</td>
</tr>
<tr>
<td></td>
<td>[RG-E] Economical</td>
<td>52</td>
<td>3.0 ± 0.7</td>
<td>2.0 ± 0.8</td>
<td>3.8 ± 0.2</td>
<td>3.5 ± 0.7</td>
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<tr>
<td></td>
<td>[RG-P] Political &amp; Governmental</td>
<td>50</td>
<td>3.7 ± 0.9</td>
<td>1.4 ± 1.0</td>
<td>4.6 ± 0.4</td>
<td>3.6 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>[RG-N] Natural Events</td>
<td>26</td>
<td>3.1 ± 0.0</td>
<td>2.9 ± 0.5</td>
<td>4.0 ± 0.7</td>
<td>3.6 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>[RG-HE] Environmental, health &amp; Safety</td>
<td>21</td>
<td>2.8 ± 0.9</td>
<td>1.9 ± 1.0</td>
<td>3.2 ± 1.0</td>
<td>2.9 ± 1.3</td>
</tr>
<tr>
<td></td>
<td>[RG-SE] Social Environment</td>
<td>19</td>
<td>2.9 ± 0.8</td>
<td>2.6 ± 1.0</td>
<td>2.0 ± 0.8</td>
<td>2.8 ± 0.9</td>
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<tr>
<td></td>
<td>[RG-SC] Sociocultural</td>
<td>14</td>
<td>3.0 ± 0.9</td>
<td>2.7 ± 0.5</td>
<td>4.0 ± 0.6</td>
<td>3.7 ± 0.6</td>
</tr>
<tr>
<td>OBSERVATION &amp; CO-OPERATION</td>
<td>[RG-POS] No Mindset of “Pain/Gain sharing”</td>
<td>80</td>
<td>3.1 ± 0.8</td>
<td>2.5 ± 0.8</td>
<td>3.9 ± 0.8</td>
<td>3.7 ± 0.8</td>
</tr>
<tr>
<td></td>
<td>[RG-PCS] Mutual Commitment to Project Success</td>
<td>78</td>
<td>2.8 ± 0.7</td>
<td>2.2 ± 0.8</td>
<td>3.6 ± 0.7</td>
<td>3.6 ± 0.8</td>
</tr>
<tr>
<td></td>
<td>[RG-CT] Collaboration &amp; Teamning</td>
<td>65</td>
<td>3.0 ± 0.4</td>
<td>2.4 ± 0.5</td>
<td>3.7 ± 0.7</td>
<td>3.8 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>[RG-F] Misfit of Corporate Cultures</td>
<td>26</td>
<td>2.7 ± 0.9</td>
<td>2.2 ± 0.8</td>
<td>3.9 ± 0.7</td>
<td>3.9 ± 0.7</td>
</tr>
<tr>
<td></td>
<td>[RG-J] Trust Issues</td>
<td>30</td>
<td>2.5 ± 0.8</td>
<td>2.5 ± 1.0</td>
<td>3.3 ± 0.7</td>
<td>3.4 ± 0.8</td>
</tr>
</tbody>
</table>

SD: 0.27  0.35  0.37  0.35
Marked items: top 5
The predominantly volatile and changing customer expectations, as well as external influences in large-scale projects, often cause changes during project execution and mandate scope modifications. Further, technical specifications are often unclear, designs poor, special local requirements or conditions not considered and a precisely defined baseline missing. Thus, large-scale projects usually have an incomplete and unfixed scope of work and consequently an incomplete contractual baseline. This leads, in particular, to expensive changes during project execution and provides the rationale why the risk classes scope and baseline specification (64) and contractual terms and conditions (60) are identified as critical.

The presence of frequent changes mandates, moreover, a rigid change management process to control contract adjustments and effectively communicate changes within the supply chain. Often, those changes are driven by new laws and regulations (63) or revised standards and codes (59) that need to be adhered to. Because of the related high cost, suppliers often demonstrate a lack of flexibility or willingness to adjust terms if conditions change. While comprehensive contractual documentation and a solid definition of the scope of work are
essential for large-scale projects, those can rarely be achieved (Tirole, 1999).

As for supply chain complexity, a further key risk class is the configuration of the supply chain (61) and its management (60). The risks class performance and operations (77) is closely related, even though it is more focused on the individual supplier. Those risks are fairly nonspecific to large-scale projects and apply to projects in general. Thus, they are represented fairly well in the current body of knowledge (Thamhain, 2013; Krane et al., 2010; Fiksel et al., 2015).

4.6 Risks significantly underestimated at project beginning
A general pattern can be observed that most risk classes are significantly underestimated at the beginning of a project, both in terms of probability (ADRP of 1.4) and impact (ADRP of 0.9) as shown in Sections F and G in Figure 3. Especially, the probability of planning and forecasting risks occurring is underestimated at the project beginning (1.7 scoring points lower at project start versus end). This is expressed, e.g. in incorrect cost estimates or schedules, and leads often to demand and scope changes (1.2), which is also a considerably misjudged risk class. Risks related to infrastructure and
resources (1.5) and supplier environment and market (1.4) are further underrated classes, encompassing risks such as raw material cost fluctuation or volatile sourcing markets. Moreover, the likelihood of not fitting corporate cultures (1.2) is usually not foreseen sufficiently.

The biggest deviation in the assessment of the impact can be found in the risk classes political and governmental (2.2), as well as planning and forecasting (2.2). This is, in particular, interesting as the latter one is also found to be considerably underestimated in terms of probability. Likewise, the class supplier environment and market (1.9) is underrated at the project beginning, both for its chance of occurrence and its impact. Additionally, sociocultural (1.9) and financial stability (1.9) are typically under-evaluated risk classes.

Similar to many other subjective activities, risk identification is prone to several forms of biases (Seiter, 2009; Carter et al., 2007; Jap and Anderson, 2003). The underlying reasons can according to Kavallo and Kahneman (2003) be grouped into three categories:

1. delusions or honest mistakes;
2. deceptions or strategic manipulation of information or processes; or
3. bad luck.

Flyvbjerg et al. (2009) confirm this for large-scale projects and state further a generic tendency that managers make decisions based on delusional optimism rather than on rational weightings, influenced by planning fallacy, strategic misrepresentation and principal-agent behavior. Thus, in large-scale projects, benefits in the early project stage are usually overestimated and cost and time are usually underestimated.

This behavior directly impacts risk assessment. Suggested approaches for de-biasing to increase the assessment quality include a rigid and peer-reviewed risk evaluation process, collective forecasting, incentivization of realistic estimates and strict external audits (Oliva and Watson, 2009; Flyvbjerg et al., 2009), as well as reference class forecasting (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992). Our results can be used as a benchmark to compare own risk assessments and generate the awareness for this bias and the need to implement counteracting activities.

## 5. Discussion

### 5.1 Summary of the key findings

Risk is both a reality and significant challenge for organizations. The presence of risk creates surprises throughout the project life cycle, impacting a wide area of objectives, ranging from technical feasibility to cost, schedules and financial performance. The increasing number of studies on SCRM underlines that risk issues are becoming the new norm in supply chain operations and implies that supply chains themselves might never reach a stable state, making a sound SCRM program indispensable. This is true especially for engineering and construction large-scale projects, as the involvement of a magnitude of people, processes and technologies spanning different organizations, support groups, sub-suppliers, government agencies and authorities compounds to the level of risk.

Successful and effective SCRM requires above all a clear understanding of the risks faced by the project and business. Based on an initial taxonomy and an empirical survey, we compiled and validated the importance of various risks in the supply chains of EPC large-scale projects. The results of this study present the risk classes relevant to large-scale projects, grouped into four main categories:

1. supplier;
2. supply chain coordination and management;
3. environment; and
4. behavior and cooperation.

Key risk classes include well-known areas such as scope and baseline specification or supply chain configuration, but we further found that the previous studies have largely neglected behavioral risks as a crucial risk source for large-scale projects. Moreover, we observe a clear need to include the entire supply chain to the risk identification and analysis process. Overall, the identified risk portfolio deviates from generic projects in terms of probability, impact, frequency and magnitude of occurrence significantly and shows a very high inherent risk exposure of large-scale projects.

### 5.2 Contribution and managerial implications

Although the literature offers a wide range of methods for managing risks and specifically risks in supply chains, those are not adapted sufficiently for the specific setting of engineering and construction large-scale projects. The identified key risks as shown in Figure 3 are considerably different in their characteristics compared to generic projects or classical SCRM approaches. To our knowledge, this is the first study addressing this issue in the specific context and at the intersection of project, risk and SCM.

The contextualized SCRM taxonomy offers a systematic and structured view on the key supply chain risks in EPC large-scale projects. With that, we provide a new perspective on the specifics of SCRM in engineering and construction large-scale projects and complement traditional risk and project risk management techniques (Zsidisin et al., 2000; Pettit et al., 2010; Rolstadás et al., 2011; Krane et al., 2010; Wu and Blackhurst, 2009; Sodhi et al., 2012; Tang and Tomlin, 2009).

Given the provided standardization of risk factors and classes, it is now more efficient to perform risk assessments and to develop a body of knowledge to draw on in future. Further,
this taxonomy can be used as vehicle to promote communication, team work and risk response planning among multidisciplinary project team members. This contributes, in particular, to reduce the behavioral risks that were identified as significant. Further, the provided results can generate the necessary awareness for the bias of optimistically underestimating risk at the beginning of a large-scale project, drawing the attention of practitioners to counteract by challenging initially made risk assessments and taking a more realistic perspective.

Overall, proper supply chain risk identification can help to screen out financially unsound projects and get minds working together early enough to overcome foreseen difficulties. This is pivotal throughout the initial project phases of large-scale projects as too many projects proceed that should not and vice versa (Flyvbjerg, 2014). An increased understanding of the key supply chain risks will lead to the formulation of more realistic plans and expectations. Knowing the magnitude of the possible impacts that may be caused, organizations can strive for a better allocation of the risks through the entire supply chain with suitable contracts, insurances or other risk management strategies.

6. Conclusion and future research

While activities can be outsourced, responsibility cannot. Therefore, organizations are required to actively manage risk along the supply chain effectively to turn good risk management into a true competitive advantage. While the first work on sourcing risk stretches back to the 1960s and various cases since then demonstrated the high vulnerability of supply chains and the vast impact on a company’s performance, SCRM started only relatively recently to be seen as an essential topic for research and practitioners. Given the specific environment of engineering and construction large-scale projects and the importance of supplies in this context, sound SCRM must be seen as an indispensable activity. Our study shows that especially, the previously understudied behavioral risks represent a severe issue for large-scale projects. Further, successful large-scale projects require a high management quality to coordinate and provide the necessary oversight to the complex supply chains.

Some limitations of our study might apply and be related to the structure of the survey. The preselection and grouping of key risks before the detailed risk assessment could lead to sequence effects and limit the validity of the data. However, this approach was deemed as necessary to attract a sufficiently broad audience. Thus, the selected approach delivers adequate data to give the essence of which supply chain risks of EPC large-scale project are in general most sensitive to.

These recognized shortcomings could inspire scholars to define their future research agendas, such as the confidence in our results could be strengthened by a more in-depth case study within a single project. By including all involved stakeholders, the different perspectives on the various risk factors along the entire supply chain and their predictability could be reflected on and further valuable insights could be delivered. As a supply chain is a complex network combined with the adaptive capability of various organizations, cross-organizational teaming is essential for risk identification, assessment and management. Gaining a deeper understanding of the processes and dynamics in those networks, including, in particular, behavioral and cognitive biases aspects, presents an interesting field for additional research. Further methods to evaluate the quality of teaming and the inherent risk in this setting need to be developed. Likewise, an efficient process for managing risks across such a complex, multi-tiered supply chain presents an interesting opportunity for exploration.

Moreover, comparative research indicates that the problems, causes and cures identified for engineering and construction large-scale projects might apply to a wide range of other project types, including large-scale IT, aerospace, defense or oil and gas projects (Charette, 1996; Wallace et al., 2004; Flyvbjerg, 2009, 2006). Further research should therefore take a closer look at shared common dilemmas and evaluate how and if the presented taxonomy might be applicable to smaller types of projects.

Although firms arguably are getting more and more efficient in identifying and analyzing known risk factors, it is obvious that they are still fairly weak in dealing with unpredictable risks. This is in particular challenging for large-scale projects, as disproportionately, many previously unknown risks may cause massive performance issues. Taleb (2010) titled those situations as “black swans,” highlighting a key weakness of current risk management: the inability to adequately characterize low-probability, disastrous-consequence events. This implies a need for future research on methods to address this issue, in particular, in the specific context.

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Further reading


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Reading on and between the lines: risk identification in collaborative and adversarial buyer–supplier relationships

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Abstract
Purpose – This paper aims to investigate how supply chain risks can be identified in both collaborative and adversarial buyer–supplier relationships (BSRs).

Design/methodology/approach – This research includes a multiple-case study involving ten Chinese manufacturers with two informants per organisation. Data have been interpreted from a multi-level social capital perspective (i.e. from both an individual and organisational level), supplemented by signalling theory.

Findings – Buyers use different risk identification strategies or apply the same strategy in different ways according to the BSR type. The impact of individual and organisational social capital on risk identification is contingent upon the degree to which individual social capital is deployed in a way that benefits an individual’s own agenda versus that of the organisation. Signalling theory generally complements social capital theory and helps further understand how buyers can identify risks, especially in adversarial BSRs, e.g. by using indirect signals from suppliers or other supply chain actors to “read between the lines” and anticipate risks.

Research limitations/implications – Data collection is focussed on China and is from the buyer side only. Future research could explore other contexts and include the supplier perspective.

Practical implications – The types of relationships that are developed by buyers with their supply chain partners at an organisational and an individual level have implications for risk exposure and how risks can be identified. The multi-level analysis highlights how strategies such as employee rotation and retention can be deployed to support risk identification.

Originality/value – Much of the extant literature on supply chain risk management is focussed on risk mitigation, whereas risk identification is under-represented. A unique case-based insight is provided into risk identification in different types of BSRs by using a multi-level social capital approach complemented by signalling theory.

Keywords Social capital, Risk management, Case studies, Supplier-manufacturer relationships, Supply risk

Paper type Research paper

1. Introduction

Supply chain risk management (SCRM) is aimed at developing strategies for the identification, assessment, mitigation and monitoring of supply chain risks (SCRs) (Tummala and Schoenherr, 2011). SCR can be understood as the probability of an incident associated with a supply chain from, e.g. individual supplier failures, leading to operational, tactical or strategic-level failures or irregularities (Zsidisin, 2003; Ho et al., 2015). The importance and challenge of dealing with SCRs makes SCRM a key topic. Risk identification is a crucial first stage of SCRM (Neiger et al., 2009; Kern et al., 2012). If this stage is mismanaged, it can undermine the rest of the SCRM process (Kern et al., 2012). Thus, it is important that organisations find effective ways of quickly and accurately identifying risks; and the importance of this has been acknowledged by leading manufacturers such as Dell, Toyota and Motorola (Chopra and Sodhi, 2004). Many sophisticated approaches have been presented for identifying risks, e.g. the value-focussed process engineering methodology (Neiger et al., 2009) and the knowledge-based SCR identification system (Kayis and Karningsih, 2012). But developing and implementing these methods is costly and time-consuming (Chen et al., 2016), and SCRM budgets and resources are often limited. Therefore, firms often seek other ways of effectively identify risks.

It has been argued that building collaborative supply chain relationships, referring to “two or more autonomous firms working jointly to plan and execute supply chain operations” (Cao and Zhang, 2011, p. 163), can aid risk identification (Scholten and Schilder, 2015; Chen et al., 2016). Such relationships can help to share information about risks and identify risks sooner, potentially before they affect the supply chain. Yet, although prior research has examined how collaborative buyer–supplier relationships (BSRs) can facilitate

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SCRM in general (Lavastre et al., 2014), aid in (Li et al., 2015) or potentially hinder (Nishiguchi and Beaudet, 1998; Villena et al., 2011) risk mitigation, their influence on risk identification remains empirically unexplored. Moreover, not all BSRs will be collaborative – and there may be good reasons why a more adversarial relationship exists – but the ability to identify risks remains important. The literature currently offers no insight into how to effectively identify SCRs in non-collaborative BSRs.

Much of the limited prior empirical work on risk identification has been conducted in a developed country context, e.g. the UK (Roehrich et al., 2014) or USA (Lockamy and McCormack, 2010). There is a need to extend this work to developing countries such as China, which is an important Eastern destination for manufacturing, where guanxi, which has been referred to as both a social practice for building and using interpersonal relationships (Chen et al., 2004; Chen et al., 2013) and as a strategy for firms to gain competitive advantage (Peng and Luo, 2000; Gu et al., 2008; Opper et al., 2017), plays a critical role in business and SCRM activities (Jia and Zsidisin, 2014). Expanding research in this direction may complement the extant literature on risk identification and provide new insights for practice.

In this paper, we present empirical evidence from ten manufacturing firms in China, examining how buyers identify risks in different types of BSRs. The dyadic BSR represents the smallest unit of analysis for studying important supply chain phenomena. We seek to address the following research question:

RQ. How does the nature of the buyer–supplier relationship affect supply chain risk identification?

Our analysis is aided first by social capital theory and second by signalling theory. Social capital theory is our primary a-priori theoretical lens. It can be defined as “the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit” (Nahapiet and Ghoshal, 1998, p. 243). This definition acknowledges that social capital may reside at both an individual and an organisational level. Indeed, inter-firm relationships almost always depend on individuals connecting people affiliated with other firms. The owners of organisations therefore do not always control these connections and consequently cannot always profit from them (Sorenson and Rogan, 2014). Thus, it is necessary to consider social capital at both an individual and an organisational level to understand how BSRs influence risk identification. The context (i.e. China) chosen for this study also necessitates the application of social capital from a multi-level theoretical perspective. Guanxi, which is closely related to individual social capital, is cultivated by managers in their personal relationships (Park and Luo, 2001). This is in contrast to organisational-level social capital, which is often not easily transferable or traded (Nahapiet and Ghoshal, 1998). Yet, there are also negative aspects of guanxi (Gu et al., 2008) that relate to the dark side of social capital in BSRs (Villena et al., 2011). The prior supply chain management (SCM) literature, however, has focussed on a single level of social capital analysis – using data to capture and measure the construct at the organisation level only.

Although social capital theory is of high utility for understanding collaborative BSRs, we find that it does not adequately enhance our understanding of how risks can be identified in adversarial BSRs. We therefore supplement social capital theory with signalling theory (Spence, 1973), which helps us to understand how buyers can overcome the information asymmetry that often exists in an adversarial BSR to identify potential risks that the supplier may not otherwise disclose to the buyer.

The remainder of this paper is organised as follows. Section 2 reviews literature relating to risk identification and BSRs before explaining our rationale for using social capital theory, demonstrating its fit with SCR research and outlining why it is necessary to apply it at both an organisational and individual level. Section 3 discusses the research method adopted before an overview of SCRs and risk identification strategies is presented in Section 4, together with an analysis of the case study evidence from a multi-level social capital perspective. Signalling theory is then used to complement social capital theory in Section 5, before we discuss our overall findings and present five propositions in Section 6. The paper concludes in Section 7, where we highlight key theoretical and managerial implications.

2. Literature review

2.1 Supply chain risk identification

Risk identification aims to discover all relevant risks (Kern et al., 2012), to reveal different risk types and to develop an understanding of the events and conditions driving risks (Narasimhan and Talluri, 2009). Kern et al. (2012) demonstrated that a company’s risk identification endeavours can augment the level of risk analysis, which in turn enhances risk mitigation. This implies that an early judgement in risk identification is needed to determine whether a risk is relevant and thus should be further assessed (Faisal et al., 2006) and/or mitigated (Enyinda et al., 2010).

Much of the literature on SCR identification has sought to:

- identify drivers (Peck, 2005; Roehrich et al., 2014), sources (Ritchie and Brindley, 2007) and consequences of SCRs (Ceryno et al., 2015);
- classify SCRs (Rangel et al., 2015); or
- propose risk identification strategies/approaches (Neiger et al., 2009).

Researchers have also applied these risk identification strategies in specific industries, such as automotive (Xie et al., 2009) and pharmaceuticals (Kayis and Karningsih, 2012; Elleuch et al., 2014), especially in a developed country context (Lockamy and McCormack, 2010; Roehrich et al., 2014). This line of work includes complex approaches, e.g. the analytical hierarchy process (Gaudenzi and Borghesi, 2006), the value-focussed process engineering methodology (Neiger et al., 2009), and the knowledge-based supply chain risk identification system (Kayis and Karningsih, 2012); and the use of technology, e.g. label-card systems (Xie et al., 2009) and supply network decision support systems (Basole and Bellamy, 2014). Adopting these approaches, however, is time-consuming and resource-intensive, making them infeasible for many firms. Although simpler approaches exist, e.g. the Ishikawa diagram and value stream mapping (Lavastre et al., 2012), firms may need to find...
other cost-effective ways (Chopra and Sodhi, 2014) of identifying risks. One such approach is by building trusting relationships with suppliers, allowing information and knowledge about risks to be shared (Scholten and Schilder, 2015; Chen et al., 2016).

Building collaborative relationships with suppliers could aid risk identification (Badurdeen et al., 2014), but empirical evidence is needed to fully unpack how the nature of the BSR affects risk identification. Although it seems logical that buyer–supplier collaboration would be beneficial, it remains unclear how it aids risk identification and whether it always has a positive effect. For example, is it possible to be too collaborative? Moreover, given that not all BSRs will be collaborative, there is a need to understand how buyers can cost-effectively identify risks in non-collaborative relationships.

2.2 Buyer–supplier relationships and supply chain risk identification

There are various typologies of BSRs in the literature, including those based on power-dependence (Cox, 2004), relational attributes (James and Faizul, 2000) and both relational and power-dependence (Tangpong et al., 2015). We follow the approach adopted in most prior studies on BSRs and SCRM, which is to focus on relational attributes, e.g. trust and collaboration (Li et al., 2015; Scholten and Schilder, 2015). Thus, we use the prevailing bipolar BSR typology of collaborative-adversarial relationships (Carr and Pearson, 1999), where a collaborative relationship is characterised by closely tied actors (Carr and Pearson, 1999) and an adversarial relationship by arm’s-length actors (James and Faizul, 2000).

There is some literature that advocates developing collaborative BSRs to effectively identify SCRs (Khan et al., 2008; Badurdeen et al., 2014) and enhancing warning capabilities (Riley et al., 2016). It has been suggested that various supplier performance indicators can be used to identify potential risks concerning, for example, inventory levels, production throughput, capacity utilisation, delivery lead times (Giannakis and Louis, 2011), infrastructure status and financial stability (Schoenherr et al., 2008). Indeed, picking up on these cues or early warning signs may help identify potential disruptive events before they occur (Blackhurst et al., 2008; Bode et al., 2014; Bühler et al., 2016), thereby improving the proactiveness and effectiveness of risk identification. There remains, however, limited empirical evidence; and, to the best of our knowledge, no prior studies have empirically investigated how to identify risks in both collaborative and adversarial BSRs.

2.3 Theoretical lens: social capital theory and its relevance to risk identification

Social capital theory, with its three dimensions of structural, relational and cognitive capital (Nahapiet and Ghoshal, 1998), can be used to explore how networking relationships bring value to actors such as individuals or organisations (Leenders and Gabbay, 1999) by enabling them to access resources embedded in those relationships (Bourdieu and Wacquant, 1992) and by facilitating actions (Adler and Kwon, 2002). For example, Toyota develops social capital by creating and fostering social relations between personnel from within Toyota and from its suppliers to improve performance (Liker and Choi, 2004). It is therefore the theory frame adopted in this study. Social capital theory has recently been used to view BSRs in SCR research to:

- explain the relationship between buyer and supplier (Cheng et al., 2012);
- bridge from inter-organisational relationships to resilience (Johnson et al., 2013); and
- study the antecedents of opportunism (Hartmann and Herb, 2014).

None of these studies, however, explored how social capital influences SCR identification.

Social capital theory has been increasingly adopted in SCM research during the past decade (Krause et al., 2007; Villena et al., 2011; Roden and Lawson, 2014), but the use of social capital as a multi-level construct is rather limited (Payne et al., 2011; Kwon and Adler, 2014). Prior studies have implicitly imported the individual-level mechanism for social capital to the organisational level by collecting data from individuals whilst treating the organisation as the unitary actor – with the same sets of motivations, cognitions and emotions as individuals, such as the ability to trust one another (Sorensen and Rogan, 2014); instead of the individual as the unit of observation but treating the organisation as the unit of analysis. Undoubtedly, such importation has contributed to an improved understanding of BSRs and performance outcomes. But the link between social capital and performance has been theorised in general terms only. There is a need to look closer at the precise nature of how social capital influences risk identification in a multi-level context.

Within a BSR, we use the term individual social capital to refer to an individual’s personal connections with his/her counterpart in the partner organisation and the information, influence and solidarity derived from these connections (Figure 1). We note that social capital as represented by the three dimensions – structural, cognitive and relational – resides at both the individual and organisational levels.

The following subsections specify the meaning of each social capital dimension for risk identification. It is, however, noted that there are also interactions between the dimensions (Li et al., 2014), e.g. social interaction (i.e. structural dimension) is viewed as a prerequisite for creating trust (i.e. relational capital), which promotes common interests and mutual understanding (i.e. cognitive capital). It should also be noted that the following uses a broad interpretation of social capital as prior SCM research has not tended to differentiate between organisational and individual level social capital.

2.3.1 Structural capital and supply chain risk identification

Structural capital refers to the “properties of the social system and of the network of relations as a whole” (Nahapiet and Ghoshal, 1998, p. 244). Burt (2004) explained that it deals with who you reach and how you reach them; and it encompasses the structural configuration, diversity, centrality and boundary-spanning roles of network participants (Krause et al., 2007). In BSRs, practices of building structural capital may range from general sharing of codified information to sharing tacit knowledge (Krause et al., 2007; Li et al., 2014). It also incorporates supplier evaluations and supplier development activities, such as visits to suppliers’ facilities and supplier training (Krause et al., 2007). A higher level of structural capital is therefore likely in collaborative BSRs than
in adversarial BSRs. For example, information exchanges are expected to be more detailed, intricate and proprietary when the relationship is collaborative (Krause et al., 2007; Lawson et al., 2008).

Information and knowledge sharing is generally seen as critical to identifying SCRs (Kleindorfer and Saad, 2005) and to enhancing early warning capabilities (Riley et al., 2016). For example, sharing risk-related information can allow the buyer to identify possible threats before they become actual risk events (Li et al., 2015). Without information, or if suppliers hold back information (Li et al., 2015), buyers may hesitate to act on SCRs (Riley et al., 2016). But sharing information could also be a source of vulnerability (Sharma and Routroy, 2016). For example, a supplier may decide to use proprietary information against the buyer for their own gain. This suggests that one strategy for identifying risks (information sharing) could potentially induce other, new risks (e.g. information risk or intellectual property risk). Therefore, it is expected that different levels of structural capital in different BSRs will affect the outcomes of risk identification initiatives.

2.3.2 Cognitive capital and supply chain risk identification
Cognitive capital refers to “those resources providing shared representations, interpretations, and systems of meaning among parties” (Nahapiet and Ghoshal, 1998, p. 244). Tsai and Ghoshal (1998) suggested that cognitive capital is embodied by shared visions and collective goals among partners. Thus, a higher level of cognitive capital is expected in collaborative than in adversarial BSRs. For example, collaborative BSRs are likely to develop shared norms and values (Moran, 2005) and have a common understanding of what constitutes improvement and how to accomplish it (Krause et al., 2007). In contrast, if goals and values are incongruent, buyer–supplier interactions could lead to misinterpretation and conflict (Inkpen and Tsang, 2005).

Cognitive capital could improve understanding of SCRM between buyer and supplier, which could reduce errors, conflicts and confusions (Li et al., 2015), enabling SCRs to be identified sooner (Faisal et al., 2006). By developing a shared understanding of SCRM, firms can improve their learning capabilities (Braunscheidel and Suresh, 2009) and have a better understanding of the knowledge and information specific to SCRs that is available to share with partners (Cao and Zhang, 2011; Li et al., 2015). It has, however, been suggested that a groupthink mentality can emerge that produces forms of collective blindness (Villena et al., 2011). Actors become too homogenous in their thinking, leaving the buyer less likely to critically evaluate risk-related information. Thus, there is the potential for too much cognitive capital, which could hinder proactive risk identification.

2.3.3 Relational capital and supply chain risk identification
Relational capital refers to “the kind of personal relationships people have developed with each other through a history of interactions” (Nahapiet and Ghoshal, 1998, p. 244). This dimension often concerns the characteristics and qualities of individual relationships, and the identity that a particular individual has within a network (Inkpen and Tsang, 2005). Relational capital comprises trust, cooperation, buyer dependence, supplier dependence, expectations and obligations (Nahapiet and Ghoshal, 1998; Krause et al., 2007). Thus, there is the potential for major differences in relational capital between collaborative and adversarial BSRs (Krause et al., 2007). The high level of relational capital likely in collaborative BSRs can help reduce transaction costs (Ojala and Hallikas, 2006), enhance cooperation (Villena et al., 2011) and reduce opportunistic behaviour (Faisal et al., 2007; Hartmann and Herb, 2014) even if short-term incentives exist (Li et al., 2015). The lower level of relational capital likely in adversarial BSRs, where buyers have limited information concerning a supplier’s behaviour, technology and costs, may lead to the supplier taking advantage of their private knowledge (Camuffo et al., 2007).

A lack of trust is considered a major contributor to SCR (Faisal et al., 2006; Lavastre et al., 2012). Thus, a higher level of relational capital has been associated with lower perceived risk (Cheng et al., 2012; Mishra et al., 2016). Moreover, trust can be considered a predictor of risk-sharing behaviour between supply chain parties (Jüttner, 2005; Li et al., 2015), thereby simplifying the complex decision-making process (Chen et al., 2016) in risk identification (Barker et al., 2010). But trust is also a fragile asset and is subjected to numerous
stresses in a business environment (Spekman and Davis, 2004). Moreover, there is the potential for heightened risk if the buyer becomes over-dependent on a supplier (Govindan and Chaudhuri, 2016) and the supplier abuses the buyers’ trust. Few studies, however, have recognised this problem (Villena et al., 2011).

2.4 Assessment of the literature
Most prior studies concerning the role of BSRs in SCRM have focussed on how collaboration may enable or hinder risk mitigation in the context of developed countries. Further research is needed to investigate the role of BSRs in risk identification, particularly in developing countries such as China, e.g. to understand the role of country-specific practices (e.g. guanxi) in risk identification. Moreover, not all BSRs will be collaborative – and there may be good reasons why a more adversarial relationship exists – but the ability to identify risks remains important. Empirical research is therefore required to examine how both collaborative and non-collaborative BSRs influence risk identification. Moreover, few prior studies on SCRM have made use of theory. Greater use of established theory frames would deepen understanding and add external validity. Although prior studies have examined the social capital–performance link in general terms, further research is needed to study social capital at both an individual and organisational level. In response, we adopt a multi-case study approach to explore the role of BSRs in shaping risk identification in China. We begin by using social capital theory as a multi-level theoretical lens and later supplement this with signalling theory to further our understanding.

3. Research method
3.1 Research design
The case study method (Meredith, 1998; Eisenhardt and Graebner, 2007) adopted in this study is appropriate given the nascent state of the literature on the phenomenon (Edmondson and McManus, 2007). A multiple-case study approach is applied to help guard against observer bias, augment external validity (Voss et al., 2002; Yin, 2014) and support theory building (Barratt et al., 2011). Four key measures for establishing the validity and reliability of case research (McCutcheon and Meredith, 1993; Stuart et al., 2002; Yin, 2014) are summarised in Table I with a description of how each has been addressed. The remainder of this section outlines the case selection process, data collection procedure and data analysis approach.

3.2 Case selection
A case is defined as the buyer firm. We are interested in their experiences of SCR identification and in their upstream relationships with suppliers. Case selection is guided by theoretical interests rather than statistical sampling logic (Eisenhardt, 1989; Stuart et al., 2002; Yin, 2014). Four criteria for selection were specified:
- Organisations should be based in China.
- Access to multiple suitable interviewees must be available to aid triangulation.
- Organisations should have a number of upstream suppliers.
- Firms should have experiences of identifying SCRs.

In addition, the focus was on manufacturers, i.e. the focal firms in product supply chains, making them a good starting point for theory development (Manuj and Mentzer, 2008).

We selected ten cases, as summarised in Table II, which met the above criteria. This number of cases works well according to Eisenhardt (1989) and Barratt et al. (2011) and allowed us to reach theoretical saturation (Eisenhardt, 1989).

3.3 Data collection
The main data collection method has been semi-structured interviews. This approach provides a relatively open format, yet is still focussed on specific issues, allowing the researcher to guide the interviewee through the areas to be discussed (Easterby-Smith, 1991; Saunders et al., 2016). Interviews were conducted via telephone or video telephony for logistical reasons, where the latter still allows the non-verbal behaviour of participants to be observed. Interviews were audio-recorded (and video-recorded), contributing towards an accurate, unbiased record and allowing for direct quotations (Voss et al., 2002; Saunders et al., 2016).

The interview questions (Appendix), which were sent to participants in advance, covered two main themes: first, the major SCRs that manufacturers in China have encountered or anticipate and the risk identification strategies used (Appendix, Section 2), and second, the linkages between BSRs, SCR and risk identification (Appendix, Section 3). The interview protocol was piloted with two interviewees. This led, for example, to using a sample list of SCRs to aid interviewees. Secondary data, e.g. from corporate reports, were used to triangulate the interviewees while websites provided background knowledge prior to an interview.

3.4 Data analysis
Interviews were conducted in Chinese and fully transcribed using the translation-back-translation method (Brislin, 1970). Data analysis followed a three-step process of data reduction, data display and conclusions (Miles and Huberman, 1994), supported by the use of qualitative data analysis software NVivo, which facilitates the coding process and data management. We started by assigning codes to extracts that were truly relevant to the research question. The transcripts were read several times to increase familiarity with the data, reduce the data and refine the codes. The relevant data were coded to create new or apply existing nodes by the first author; a second author was also involved in coding development to reduce subjective bias. First-order codes were descriptive and close to the SCRM literature, e.g. SCR types and risk identification strategies. Second-order analysis involved moving back-and-forth between the theory and data to reveal new constructs, including factors that support (enablers) and hinder (barriers) each dimension of social capital. The content of the nodes was continuously reviewed and discussed until final agreement was reached to ensure consistency. The data analysis process continued until a point of saturation (Robson, 2011).
Table I  Summary of research credibility

<table>
<thead>
<tr>
<th>Evaluation criteria</th>
<th>Research design</th>
<th>Case selection</th>
<th>Data collection</th>
<th>Data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct validity (establishes correct operational measures for the concepts being studied)</td>
<td>Developed a protocol based on the extant literature and a priori theoretical lens</td>
<td>N/A</td>
<td>Piloted the protocol with two interviewees; multiple sources of evidence and interviewees</td>
<td>Informants’ validation of case study report; obtained feedback from fellow researchers on case analysis Pattern matching</td>
</tr>
<tr>
<td>Internal validity (establishes a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished by spurious relationships)</td>
<td>Established the evidence from the literature</td>
<td>Case included leading manufacturers from various industries</td>
<td>Two interviewees per company; triangulation supported by secondary data largely from websites and corporate reports (or equivalent)</td>
<td>N/A</td>
</tr>
<tr>
<td>External validity (establishes a domain in which the study’s findings can be generalised)</td>
<td>Used replication logic (i.e. replicate on analytical rather than statistical generalisation); multiple case study design</td>
<td>Carefully selected interview participants, including referrals from the first to the second interviewee</td>
<td>Provided the (semi-structured) questions to all interviewees before the interview; developed a case study database (transcripts, quotations, matrix, codes, memos, etc.) in NVivo</td>
<td>N/A</td>
</tr>
<tr>
<td>Reliability (demonstrates that the operations of a study can be repeated with the same results)</td>
<td>Developed a case study protocol</td>
<td>Selected cases based on theoretical sampling</td>
<td>N/A</td>
<td>Involved another researcher who did not collect the data; two scholars were involved in the development of coding</td>
</tr>
</tbody>
</table>

Source: Adapted from Yin (2014)

Table II  Overview of case study companies

<table>
<thead>
<tr>
<th>Company</th>
<th>Interviewee position</th>
<th>Main products</th>
<th>No. employees (approx.)</th>
<th>Annual sales (in million RMB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candy</td>
<td>Lean Manager</td>
<td>Candy and other confectionery products</td>
<td>1,500-2,000</td>
<td>8,000</td>
</tr>
<tr>
<td></td>
<td>Site Quality Manager</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PetPro</td>
<td>Supplier Quality Assurance (SQA) Manager</td>
<td>Pet care products</td>
<td>1,000-1,500</td>
<td>1,500</td>
</tr>
<tr>
<td></td>
<td>Senior Lean Manager</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alum</td>
<td>Finance Manager</td>
<td>Aluminium extruded products</td>
<td>1,000-1,500</td>
<td>16,000</td>
</tr>
<tr>
<td></td>
<td>Supply Chain Manager</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furniture</td>
<td>Supply Chain Manager</td>
<td>Furniture</td>
<td>1,000-1,500</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Sales &amp; Marketing Manager</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tyre</td>
<td>Quotation Manager</td>
<td>Tyres and inner tubes</td>
<td>7,000-7,500</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>Purchasing Assistant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resin</td>
<td>Quality Engineer</td>
<td>Synthetic resin materials</td>
<td>500-1,000</td>
<td>1,400</td>
</tr>
<tr>
<td></td>
<td>Purchasing Manager</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthcare</td>
<td>Sourcing Leader</td>
<td>Medical equipment</td>
<td>6,000-6,500</td>
<td>50,000</td>
</tr>
<tr>
<td>Alcohol</td>
<td>General Manager</td>
<td>Alcohol</td>
<td>100-150</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Purchasing Manager</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicine</td>
<td>Purchasing Director</td>
<td>Pharmaceutical products</td>
<td>200-300</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Senior Purchasing Manager</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto</td>
<td>Regional Business Development (RBD) Manager</td>
<td>Automobiles and other motor vehicles</td>
<td>4,000-4,500</td>
<td>8,500</td>
</tr>
<tr>
<td></td>
<td>Brand Manager</td>
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</tbody>
</table>
Table III  Summary of SCRs and risk identification strategies

<table>
<thead>
<tr>
<th>SCR/identification strategy</th>
<th>Description (number of case companies out of ten)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External to the supply chain (ESC)</strong></td>
<td></td>
</tr>
<tr>
<td>ESC1 Natural disasters (three)</td>
<td></td>
</tr>
<tr>
<td>ESC2 Political risk (one)</td>
<td></td>
</tr>
<tr>
<td>ESC3 Regulation and policy risk (five)</td>
<td></td>
</tr>
<tr>
<td>ESC4 Other irregular events (one)</td>
<td></td>
</tr>
<tr>
<td><strong>(External to the organisation but) internal to the supply chain (ISC)</strong></td>
<td></td>
</tr>
<tr>
<td>ISC1 Failure to supply required quantity (one)</td>
<td></td>
</tr>
<tr>
<td>ISC2 Interrupted supply or supply shortage (three)</td>
<td></td>
</tr>
<tr>
<td>ISC3 Lack of sufficient capacity (two)</td>
<td></td>
</tr>
<tr>
<td>ISC4 Logistics related risks (eight)</td>
<td></td>
</tr>
<tr>
<td>ISC5 Packaging risk (two)</td>
<td></td>
</tr>
<tr>
<td>ISC6 Price risk (nine)</td>
<td></td>
</tr>
<tr>
<td>ISC7 Financial instability including bankruptcy (five)</td>
<td></td>
</tr>
<tr>
<td>ISC8 Technological risk (four)</td>
<td></td>
</tr>
<tr>
<td>ISC9 Quality risk (ten)</td>
<td></td>
</tr>
<tr>
<td>ISC10 Single source of supply (five)</td>
<td></td>
</tr>
<tr>
<td>ISC11 Sustainability-related risk (six)</td>
<td></td>
</tr>
<tr>
<td>ISC12 Contract breach (four)</td>
<td></td>
</tr>
<tr>
<td>ISC13 Moral hazard (seven)</td>
<td></td>
</tr>
<tr>
<td>ISC14 Service risk (two)</td>
<td></td>
</tr>
<tr>
<td>ISC15 Lack of supplier involvement (four)</td>
<td></td>
</tr>
<tr>
<td>ISC16 Supplier opportunism including intellectual property risk (five)</td>
<td></td>
</tr>
<tr>
<td>ISC17 Corruption reporting from other suppliers (one)</td>
<td></td>
</tr>
<tr>
<td>ISC18 Product redesign (two)</td>
<td></td>
</tr>
<tr>
<td>ISC19 Supplier labour procurement (one)</td>
<td></td>
</tr>
<tr>
<td>ISC20 Unavailable or limited local sourcing (three)</td>
<td></td>
</tr>
<tr>
<td>ISC21 Wrong choice of supplier (three)</td>
<td></td>
</tr>
<tr>
<td>ISC22 Reputation risk (two)</td>
<td></td>
</tr>
<tr>
<td><strong>Supply-side</strong></td>
<td></td>
</tr>
<tr>
<td>ISC23 Changes in customer requirements (one)</td>
<td></td>
</tr>
<tr>
<td>ISC24 Market price fluctuation (three)</td>
<td></td>
</tr>
<tr>
<td>ISC25 Seasonal demand (two)</td>
<td></td>
</tr>
<tr>
<td>ISC26 Single customer (strong power) (two)</td>
<td></td>
</tr>
<tr>
<td><strong>Demand-side</strong></td>
<td></td>
</tr>
<tr>
<td>ISC27 Collusion (two)</td>
<td></td>
</tr>
<tr>
<td>ISC28 Hoarding and price gouging (two)</td>
<td></td>
</tr>
<tr>
<td><strong>Network-related</strong></td>
<td></td>
</tr>
<tr>
<td>ISC29 Behavioural issues (one)</td>
<td></td>
</tr>
<tr>
<td>ISC30 Corruption (two)</td>
<td></td>
</tr>
<tr>
<td>ISC31 Delayed payments to suppliers (one)</td>
<td></td>
</tr>
<tr>
<td>ISC32 Exploiting suppliers (one)</td>
<td></td>
</tr>
<tr>
<td>ISC33 Internal coordination problems (one)</td>
<td></td>
</tr>
<tr>
<td>ISC34 Power cut (one)</td>
<td></td>
</tr>
<tr>
<td>ISC35 Lack of purchasing skills (one)</td>
<td></td>
</tr>
<tr>
<td>ISC36 Unbalanced power between departments (one)</td>
<td></td>
</tr>
<tr>
<td>ISC37 Unsound purchasing system (one)</td>
<td></td>
</tr>
<tr>
<td>ISC38 Production stoppage (one)</td>
<td></td>
</tr>
<tr>
<td>ISC39 Lack of risk awareness (one)</td>
<td></td>
</tr>
<tr>
<td><strong>Internal to the organisation (ORG)</strong></td>
<td></td>
</tr>
<tr>
<td>ORG1 Behavioural issues (one)</td>
<td></td>
</tr>
<tr>
<td>ORG2 Corruption (two)</td>
<td></td>
</tr>
<tr>
<td>ORG3 Delayed payments to suppliers (one)</td>
<td></td>
</tr>
<tr>
<td>ORG4 Exploiting suppliers (one)</td>
<td></td>
</tr>
<tr>
<td>ORG5 Internal coordination problems (one)</td>
<td></td>
</tr>
<tr>
<td>ORG6 Power cut (one)</td>
<td></td>
</tr>
<tr>
<td>ORG7 Lack of purchasing skills (one)</td>
<td></td>
</tr>
<tr>
<td>ORG8 Unbalanced power between departments (one)</td>
<td></td>
</tr>
<tr>
<td>ORG9 Unsound purchasing system (one)</td>
<td></td>
</tr>
<tr>
<td>ORG10 Production stoppage (one)</td>
<td></td>
</tr>
<tr>
<td>ORG11 Lack of risk awareness (one)</td>
<td></td>
</tr>
<tr>
<td><strong>Risk identification strategies</strong></td>
<td></td>
</tr>
<tr>
<td>RIS1 Observed supplier’s abnormal behaviour (nine)</td>
<td></td>
</tr>
<tr>
<td>RIS2 Unannounced inspections (one)</td>
<td></td>
</tr>
<tr>
<td>RIS3 Buyer performs cause-effect analysis (one)</td>
<td></td>
</tr>
<tr>
<td>RIS4 Scenario analysis (two)</td>
<td></td>
</tr>
<tr>
<td>RIS5 Site inspection at supplier’s factory (incl. co-location of employees) (five)</td>
<td></td>
</tr>
<tr>
<td>RIS6 SWOT analysis (one)</td>
<td></td>
</tr>
<tr>
<td>RIS7 Supplier performs cause-effect analysis (one)</td>
<td></td>
</tr>
<tr>
<td>RIS8 Supplier evaluation (three)</td>
<td></td>
</tr>
<tr>
<td>RIS9 Historical events (two)</td>
<td></td>
</tr>
<tr>
<td>RIS10 Sampling check during supplier selection (one)</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
4. Findings: a multi-level social capital perspective

Before interpreting the data using social capital theory, we first provide an overview of the SCRs and identification strategies, as shown in Table III. If one or more interviewee from a given firm identified a risk or strategy, it was considered relevant to that firm. The data contain 43 SCRs categorised into three broad types given by Christopher and Peck (2004). More specifically, 4 SCRs are external to the supply chain; 28 are internal to the supply chain but external to the organisation, which further broken down into supply-side risks (22), demand-side risks (4) and network-related risks (2); and 11 were internal to the organisation. The most frequently mentioned SCRs were quality, price and logistics-related. In addition, 16 risk identification strategies are included in the table. Most strategies were initiated and adopted by buyers, particularly supplier evaluations and auditing. But other parties, including suppliers, customers and third-party organisations, also play a role in identifying SCRs.

Enablers and barriers to the three dimensions of social capital at both an organisational and individual levels are summarised in Table IV, while example quotations are given in Tables V-VII. Enablers of organisational-level social capital support the formalisation and accumulation of organisational social capital and are particularly evident in collaborative BSRs, while barriers to organisational social capital work against the formalisation and accumulation of organisational social capital and explain why organisational social capital is typically low in adversarial BSRs.

We differentiate between enablers and barriers of individual and organisational social capital in terms of who – the organisation or employee – has the ability to exercise control over the relationship and to experience any accrued benefits. Following this line of reasoning, factors such as personal guanxi, enabling employees in the buyer firm to overcome institutional barriers and instability in the face of regulatory changes and to exchange favours, can be classified into enablers of individual social capital. Other factors, such as multiple points of contact in the supplier firm, which weaken an employee’s ability to exercise control over a relationship and mean he/she cannot enjoy the potential benefits for themselves, can be classified as barriers to individual social capital. Note that personal guanxi enables all three dimensions of individual social capital and therefore appears in Tables V-VII. We recognise that guanxi is a potential double-edged sword and that a dark side can exist, e.g. in the form of collusion. However, we identify the latter, rather than guanxi itself, as the barrier to individual social capital.

4.1 Structural dimension of social capital

Table IV identifies six enablers and seven barriers to organisational structural capital and two enablers and three barriers to individual structural capital. Example quotes from the interviews can be found in Table V.

<table>
<thead>
<tr>
<th>Table III</th>
<th>SCR/identification strategy</th>
<th>Description (number of case companies out of ten)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIS11</td>
<td>Inspection of goods at buyer’s factory (five)</td>
<td></td>
</tr>
<tr>
<td>RIS12</td>
<td>Customer complaints (four)</td>
<td></td>
</tr>
<tr>
<td>RIS13</td>
<td>Customs inspection (one)</td>
<td></td>
</tr>
<tr>
<td>RIS14</td>
<td>Feedback from downstream supply chain (one)</td>
<td></td>
</tr>
<tr>
<td>RIS15</td>
<td>Feedback from other buyers (one)</td>
<td></td>
</tr>
<tr>
<td>RIS16</td>
<td>Third-party inspection (three)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table IV</th>
<th>Enablers and barriers to social capital at the organisational and individual levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions of social capital</td>
<td>Organisational level</td>
</tr>
<tr>
<td>Structural capital</td>
<td>Enablers</td>
</tr>
<tr>
<td>Adoption of IT systems and software; corporate communication; local sourcing (including supplier transfer); regular meetings and forums; supplier directory; supplier’s contacts (or network)</td>
<td>Lack of timely communication; Lack of top management support; lack of participation; long distance; lack of visibility; supplier’s competitors; conflicts among departments (organisation chaos)</td>
</tr>
<tr>
<td>Cognitive capital</td>
<td>Enablers</td>
</tr>
<tr>
<td>Shared codes and language; shared culture; standardisation; training</td>
<td>Lack of standards; miscommunication Supplier staff turnover; lack of firm-level trust; exposure to supplier opportunism; reduced monitoring</td>
</tr>
<tr>
<td>Relational capital</td>
<td></td>
</tr>
<tr>
<td>Relationship history/length; firm-level loyalty; firm-level reciprocity</td>
<td></td>
</tr>
</tbody>
</table>
Table V  Enablers and barriers to organisational and individual structural capital

<table>
<thead>
<tr>
<th>Structural capital (information sharing; supplier development; supplier evaluation)</th>
<th>Illustrative quotes (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enablers</strong></td>
<td></td>
</tr>
<tr>
<td>Adoption of IT systems and software (O)</td>
<td>HealthCare’s Supplier Quality Engineer: “We have an online information system to monitor supplier performance such as on-time delivery.”</td>
</tr>
<tr>
<td></td>
<td>Tyre’s Quotation Manager: “We use SRM [supplier relationship management] software to manage and evaluate our suppliers.”</td>
</tr>
<tr>
<td>Corporate communication (O)</td>
<td>Alcohol’s General Manager: “We try our best to solve problems through negotiation and communication. There is always a way for us to deal with these risks and both of us [buyer and supplier] can make some sort of concession.”</td>
</tr>
<tr>
<td>Local sourcing (including supplier transfer) (O)</td>
<td>HealthCare’s Sourcing Leader: “It is much easier to manage local suppliers compared to overseas suppliers. We can go and visit local suppliers whenever they have problems. Besides, there is no time difference and no need to have telephone conferences every day.”</td>
</tr>
<tr>
<td>Regular meetings and forums (O)</td>
<td>Furniture’s Supply Chain Manager: “We have a regular meeting forum with our key suppliers once or twice a month. Suppliers share their predictions and forecasts about the market, including price fluctuation for the raw materials.”</td>
</tr>
<tr>
<td>Supplier directory (O)</td>
<td>Medicine’s Senior Purchasing Manager: “…it is beneficial to establish our supplier database so that we can track their performance.”</td>
</tr>
<tr>
<td>Supplier’s contacts (or network) (O)</td>
<td>Furniture’s Sales &amp; Marketing Manager: “…our suppliers will find alternative scarce raw materials for us through either their suppliers or their peer companies. Their peer companies will help each other in most cases.”</td>
</tr>
<tr>
<td>Interpersonal communication (I)</td>
<td>Furniture’s Sales &amp; Marketing Manager: “We don’t actually rely on the contracts unless there are issues. Even though there are some contractual issues in very rare situations, we try to communicate and solve all kinds of risks and problems.”</td>
</tr>
<tr>
<td>Personal contacts (guanxi) (I)</td>
<td>Alum’s Finance Manager: “Some suppliers in a good guanxi [relationship] with us may just call us directly and ask for a favour. They may have a recent problem with capital turnover and wonder if we can support them. We will shorten the accounts payable payment terms or pay cash on delivery.”</td>
</tr>
<tr>
<td><strong>Barriers</strong></td>
<td></td>
</tr>
<tr>
<td>Lack of timely communicate (O)</td>
<td>Resin’s Quality Engineer: “Some suppliers should have informed us earlier before the risk events occurred. They might not have the awareness to inform us in advance.”</td>
</tr>
<tr>
<td>Lack of top management support (O)</td>
<td>Resin’s Quality Engineer: “To be honest, no one will remind their line manager that this supplier is risky until some risks occur, unless this manager is the ‘big boss’ and fully supports in managing supplier risks.”</td>
</tr>
<tr>
<td>Lack of participation (O)</td>
<td>Auto’s Brand Manager: “Our strategic suppliers would take part and cooperate in our audit and evaluation. They are willing to share information with us. However, other suppliers in a difficult relationship are not willing to share information, especially about their financial performance. Then we have to investigate using a [anonymised] third-party organisation to know their financial status.”</td>
</tr>
<tr>
<td>Long distance (O)</td>
<td>Alcohol’s General Manager: “We don’t have single sourcing in case the single supplier is unable to supply us. We also have concerns when a supplier is too far from us.”</td>
</tr>
<tr>
<td>Lack of visibility (O)</td>
<td>HealthCare’s Sourcing Leader: “Part of the reason why we transfer suppliers to China is to try to reduce the upstream risks… it is very difficult to know what’s happening on their sites [when the supplier is outside of China].”</td>
</tr>
<tr>
<td></td>
<td>Auto’s Brand Manager: “We are now thinking to integrate and optimise our supplier base as the current suppliers are fragmented.”</td>
</tr>
<tr>
<td>Supplier’s competitors (O)</td>
<td>Resin’s Purchasing Manager: “The competition for contracts between suppliers can also cause us problems. For example, one of our purchasing managers once bought equipment at a lower price from Supplier A [than had been quoted by Supplier B]. Afterwards, Supplier B [a competitor to Supplier A] reported collusion [i.e. price fixing] between this purchasing manager and Supplier A to our boss.”</td>
</tr>
<tr>
<td></td>
<td>Alum’s Supply Chain Manager: “In the purchasing process, organisation chaos causes a series of purchasing problems. For example, the finance department was given too much power and authority. As a result, they made many doubts on items bought in the purchasing department. They have the right to deny purchasing orders, but by that time the purchased item was already used and we need to pay the suppliers. The finance department would not process the payments. This is a very serious problem. In a word, it is about the unbalanced power between the purchasing department and finance department. And of course there is no visibility. It is not very clear on the ownership and responsibility of each department. This can cause us many risks.”</td>
</tr>
</tbody>
</table>

(continued)
4.1.1 Organisational structural capital and risk identification

Some risk identification strategies are more likely to be used in collaborative BSRs because they rely, e.g. on detailed and timely information. For example, enablers of organisational structural capital, including corporate communication and regular meetings, illustrate why supplier development activities such as co-location of employees are mainly adopted in collaborative BSRs. HealthCare’s Sourcing Leader noted: “We maintain strict standards to monitor and control the raw materials provided by key suppliers. For instance, we house our supplier quality engineers at the suppliers’ factory”. Such strategies enable regular information sharing and facilitate buyer–supplier interactions, thereby identifying risks earlier, i.e. at a supplier’s site. The shared information can help the buyer anticipate the types, likelihood and consequences of potential risks. For example, Furniture’s Supply Chain Manager explained: “We have a regular meeting forum with our key suppliers once or twice a month. Suppliers share their predictions and forecasts about the market, including price fluctuations for raw materials”.

When integrated practices such as the above cannot be used, the buyer may rely on other strategies, e.g. inspecting goods at the buyer’s site, to reactively identify risks. As the buyer will be embedded in a wider network, it can also use connections with other firms, e.g. a supplier’s competitors, to identify potential SCRs. These practices, however, are not always effective, meaning problems are only identified after the product reaches the market. For example, PetPro’s Supplier Quality Assurance (SQA) Manager stated: “We did not realise there was a printing error with dates [i.e. incorrect ‘used by’ dates] on our products until we received complaints from customers”.

Barriers to organisational structural capital can expose firms to certain risks. For example, the barrier – a lack of participation – was found to expose a buyer in an adversarial relationship to financial risk. Auto’s Brand Manager explained: “Suppliers in a difficult relationship are not willing to share information, especially about their financial performance”, which limited the buyer’s options and pushed it to rely on other strategies, e.g. “using a third-party organisation” to identify potential risks. Barriers, such as a supplier’s competitors and organisational chaos, were also found to distort information flow and assimilation, impairing the proactiveness and effectiveness of risk identification.

4.1.2 Individual structural capital and risk identification

Like organisational structural capital, individual structural capital enabled by interpersonal communication and guanxi can positively affect risk identification. It can provide an alternative mechanism that enables firms to bypass institutional hurdles and contractual control. Resin’s Quality Engineer noted: “If we and the supplier need to deal with a risk incident through contracts, this implies that we do not really have good guanxi [relationship]”. Instead, interpersonal communication allows for more flexible conversations and joint problem-solving activities, as explained by Furniture’s Sales and Marketing Manager: “We don’t actually rely on the contracts unless there are issues. Even though there are some contractual issues in very rare situations, we try to communicate and solve all kinds of risks and problems”. Consequently, these enablers of individual structural capital can help reduce a firm’s exposure to certain risks. For example, financial risk may occur in collaborative BSRs but is less likely due to the openness of the guanxi. Alum’s Finance Manager stated:

Table V

<table>
<thead>
<tr>
<th>Structural capital (information sharing; supplier development; supplier evaluation)</th>
<th>Illustrative quotes (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different points of contact (I)</td>
<td>HealthCare’s Sourcing Leader: “Actually, there are different contact windows from this supplier company. Their sales team are more likely to care about our attitudes when buying their materials. However, when I need to talk to their production department to add a new requirement on this material, their production manager does not care and seems like they do not want to talk with me. Who knows how his bad attitude influences his company.”</td>
</tr>
<tr>
<td>Collusion (between an internal actor and prospective supplier) (I)</td>
<td>Resin’s Quality Engineer: “One old supplier has been replaced by our new senior technology manager. This manager informed the purchasing department that the old supplier is not qualified anymore and a new supplier with a lower price has been identified. He asked to do business with this supplier. You can see the power of selecting suppliers is not within the control of the purchasing department.”</td>
</tr>
<tr>
<td>Limited capacity to process information (I)</td>
<td>HealthCare’s Sourcing Leader: “One of our collaborative suppliers suddenly shut down their factory with no reason. I really doubt how our finance department evaluated that suppliers’ financial status several months ago. How come they didn’t find out any warning signs in the supplier’s financial statements? The supplier provided all of the statements we needed, we cannot blame anyone else because we failed to recognise any problems in the evaluation process.”</td>
</tr>
</tbody>
</table>

Notes: (0 = organisational; 1 = individual)
Table VI Enablers and barriers to organisational and individual cognitive capital (O = organisational; I = individual)

<table>
<thead>
<tr>
<th>Cognitive capital (shared paradigm; collective goals)</th>
<th>Illustrative quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enablers</strong></td>
<td></td>
</tr>
<tr>
<td>Shared codes and language (O)</td>
<td>HealthCare’s Sourcing Leader: “… doing business with Chinese [local] suppliers is much easier. You know, there is no time difference and the same language.”</td>
</tr>
<tr>
<td>Shared culture (O)</td>
<td>Candy’s Lean Manager: “We encourage our suppliers to manage risks according to our requirements. For example, in order to increase their awareness on quality management, we encourage them to learn our corporate culture and principles.”</td>
</tr>
<tr>
<td>Standardisation (O)</td>
<td>Candy’s Site Quality Manager: “We have many standard documents for managing our suppliers.”</td>
</tr>
<tr>
<td>Training (O)</td>
<td>PetPro_1: “We manage our suppliers according to our ‘working bible’, material quality management standard.”</td>
</tr>
<tr>
<td>Personal contacts (guanxi) (I)</td>
<td>Candy’s Site Quality Manager: “We provide regular training to our suppliers to help them establish a quality management culture. We also invite them to visit our factories to understand our requirements better.”</td>
</tr>
<tr>
<td>Tacit understanding or agreement (I)</td>
<td>Medicine’s Senior Purchasing Manager: “Of course, good established guanxi is essential in the risk management process as we both [buyer and supplier] are willing to build long-term collaboration.”</td>
</tr>
<tr>
<td><strong>Barriers</strong></td>
<td></td>
</tr>
<tr>
<td>Lack of standards (O)</td>
<td>HealthCare’s Sourcing Leader: “We check if our suppliers have a standard process. If they do have, we will check if they have any updates and if they are actually following the standard.”</td>
</tr>
<tr>
<td>Miscommunication (O)</td>
<td>Resin’s Quality Engineer: “Because the supplier didn’t communicate properly, we didn’t realise the risk until it happened.”</td>
</tr>
<tr>
<td>Lack of absorptive capacity (I)</td>
<td>Candy’s Lean Manager: “Some suppliers might not really understand our quality requirements or why we have such requirements.”</td>
</tr>
<tr>
<td>Collective blindness (I)</td>
<td>Auto’s Brand Manager: “If guanxi is not managed properly, it can cause us many problems, especially when both parties [buyer and supplier] turn a blind eye.”</td>
</tr>
<tr>
<td></td>
<td>Tyre’s Quotation Manager: “One common risk is delivery risk. We [buyer and supplier] know each other well. We both know we will not go to court even if the supplier does not comply with the delivery agreements in the contract.”</td>
</tr>
</tbody>
</table>

Some suppliers in a good guanxi with us may just call us directly and ask for a favour. They may have a recent problem with capital turnover and wonder if we can support them. We will shorten the accounts payable payment terms or pay cash on delivery.

Barriers to individual structural capital were found to damage risk identification performance. For example, different points of contact in the supplier firm lead to limited information sharing with buyer representatives, making it difficult to develop individual structural capital and effectively identify potential risks. Some barriers, including collusion and limited capacity to process information, illustrate why collaborative BSRs may not always have a positive influence on risk identification. HealthCare’s Sourcing Leader explained:

One of our collaborative suppliers suddenly shut down their factory […] the supplier provided all of the statements we needed, we cannot blame anyone else because we failed to recognise any problems in the evaluation process.

Information was being shared, but the sourcing leader did not have the capacity to process it, meaning the risk was not anticipated.

4.2 Cognitive dimension of social capital

Table IV identifies four enablers and one barrier to organisational cognitive capital and two enablers and three barriers to individual cognitive capital. Example quotes can be found in Table VI.

4.2.1 Organisational cognitive capital and risk identification

A high level of organisational cognitive capital is supported by an increased tacit understanding, which can help limit unexpected behaviour and misunderstanding. In particular, shared cognition can help reduce the cognitive load and calculative effort involved in risk identification tasks that, to some extent, require a degree of shared understanding (e.g. shared language, culture and mutual awareness). Consequently, a shared understanding helps the buyer to predict and anticipate potential risks. The data suggest that although risks concerning, for example, quality, price and logistics exist in collaborative BSRs, buyers in collaborative BSRs may perceive there to be a lower likelihood of them occurring than in adversarial BSRs due in part to the development of joint understanding and shared goals. Resin’s Purchasing Manager explained: “Some trustworthy suppliers have been working with us for more than ten years. Risks in price, quality, and delivery exist but are much lower”. Collaborative BSRs also tend to feature more of the enabling factors of organisational cognitive capital, e.g. providing training to suppliers. Candy’s Site Quality Manager explained: “We provide regular training to our suppliers to help them
Enablers and barriers to organisational and individual relational capital

Table VII  Enablers and barriers to organisational and individual relational capital

<table>
<thead>
<tr>
<th>Relational capital (trust; friendship; mutual obligation; identification)</th>
<th>Illustrative quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enablers</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Relationship history/length (O) | Alcohol’s General Manager: “After a long time, suppliers become our friends and will keep the same price, even under seasonal demand.”  
Resin’s Purchasing Manager: “Some trustworthy suppliers have been working with us for more than ten years.” |
| Firm-level loyalty (O) | Furniture’s Sales & Marketing Manager: “Many suppliers have limited capabilities. It is useless to force them. We have requirements, such as that the supplier needs to prioritise to supply and deliver to us when the material is scarce in the market. If they cannot make it, we can choose not to work with this supplier when we have sufficient supply. So it is important for us to evaluate whether this supplier is loyal to us.” |
| Firm-level reciprocity (O) | Alcohol’s Senior Purchasing Manager: “Some suppliers are in a rapport relationship with us. We are nice to them in the same way that they are nice to us.” |
| Personal contacts (guanxi) (I) | Medicine’s Senior Purchasing Manager: “Good guanxi with suppliers allows you to do many things, of course, including risk management.” |
| Commitment (I) | Furniture’s Sales & Marketing Manager: “Some suppliers made commitments to us that they would hold stocks of raw materials for us. Therefore, they were able to keep the same price when the market price increased.” |
| Goodwill (I) | Alcohol’s Senior Purchasing Manager: “We know that they [the supplier] didn’t mean to cause quality risks on purpose.”  
Medicine’s Senior Purchasing Manager: “We both [buyer and supplier] rely on each other with very good intentions.” |
| **Barriers** | |
| Supplier staff turnover (O) | Auto’s RBD Manager: “High turnover of supplier’s staff on the production line would result in quality risk. Because the new employees may not have experienced skills and knowledge or they don’t really understand our requirements for the parts supplied.” |
| Lack of firm-level trust (O) | Resin’s Purchasing Manager: “Some suppliers with a good reputation have worked with us for a very long time. We are more like friends now. However, they now seem like they do not want to continue our business. This is not because they do not trust me anymore. In fact, they don’t trust our company and worry that our company is not able to pay them on time.” |
| Exposure to supplier opportunism (O) | Auto’s Brand Manager: “We have a supplier who makes air-conditioner compressors for us. We have a specific requirement on the failure rate. In other words, if the failure rate of this product reaches a certain level, we will lodge a claim to this supplier. If the claim ratio is too high, then we will disqualify and eliminate this supplier because this affects the quality. However, this supplier sent people to different places like service stations and urged them not to report failure rates back to our factory. Rather, they will return the compressor to them. You know, they are worried about the claim ratio. This is the common case in China.”  
HealthCare’s Sourcing Leader: “We do have a potential risk when doing early supplier involvement. As they [the supplier] are involved in the very early design stage, it is very likely that they take away our technology and other confidential information.” |
| Reduced monitoring (O) | Alcohol’s Senior Purchasing Manager: “Some suppliers have been working with us for many years. We trust each other and gradually reduce the efforts of monitoring.” |
| Change in personnel (purchasing managers) (I) | Alum’s Supply Chain Manager: “To solve lots of problems in the purchasing department, our boss normally would rely on the organisation tools, e.g. change the purchasing managers and the vice president, and so on.” |
| (Lack of) motivation to switch supplier (I) | Auto’s Brand Manager: “Even if quality cannot be assured, Chinese guanxi will mean we are reluctant to switch to a better supplier for fear of losing current relationships or because we prefer to keep working with friends we have already known for many years.” |
| Lack of purchasing skills or experience (I) | Alum’s Supply Chain Manager: “Some of our purchasing staff are quite inexperienced. They are not yet capable of establishing business relationships with big suppliers, of communicating with suppliers’ top management, or of improving relationship etc. Within our company, these young purchasers cannot keep balanced relationship with internal customers like R&D, planning, and sales staff. Many problems and risks are emerging due to ill-managed internal and external relationships.” |

Notes: (O = organisational; I = individual)
establish a quality management culture. We also invite them to visit our factories to understand our requirements better”.

Data on organisational cognitive capital suggest that buyers may use the same risk identification strategy in different ways according to the BSR type. Many of the buyers interviewed used strategies such as supplier evaluations and auditing across all of their suppliers, but the level of cognitive capital affected how this strategy was implemented and its impact on risk identification performance. PetPro’s SQA Manager explained: “For assured suppliers in strategic partnerships with us, we evaluate and audit once every three years. It’s two years for approved suppliers and one year for in-development suppliers”. Enablers such as training and standardisation facilitate the formalisation of shared goals and values creating expected norms of behaviour, resulting in less reliance on regular supplier evaluations and auditing in collaborative than in adversarial BSRs.

The actor taking responsibility for risk identification can shift from buyer to supplier when the two parties are cognitively aligned. For example, suppliers may initiate activities or inform buyers about anticipated risks. PetPro’s SQA Manager stated: “Our strategic suppliers do root cause analysis on their own and use tools like fishbone analysis”. In these situations, both the buyer and supplier form a shared understanding of the actions required to maintain their business relationship. But barriers that hinder cognitive capital and alignment, including miscommunication, can affect risk identification performance, meaning that buyers are unable to identify risks before an event occurs. Resin’s Quality Engineer recalled: “Because the supplier didn’t communicate properly, we didn’t realise the risk until it happened”. Such a low level of organisational cognitive capital is often found in adversarial BSRs.

4.2.2 Individual cognitive capital and risk identification
Individual cognitive capital is also supported by personal guanxi. Medicine’s Senior Purchasing Manager stated: “Of course, good established guanxi is essential in the risk management process as we both (buyer and supplier representative) are willing to build long-term collaboration”. These shared cognitions increase the tendency to interact with similar individuals in supplier firms. In collaborative BSRs, individual cognitive capital, enabled by tacit understanding and agreement, can make buyers predict a lower likelihood of certain risks occurring, including quality risk. When these risks, however, do occur, they can have a severe impact (e.g. on order fulfilment), as explained by HealthCare’s Sourcing Leader: “We have to stop our production line because there are quality issues in one part provided by the key supplier X […] They either have no issues at all or have huge impacts”.

The barriers to individual cognitive capital in the data took the form of collective blindness and a lack of absorptive capacity. Barriers lead to misunderstandings, confusion and conflicts, which could explain why certain risks such as quality problems are more likely in adversarial BSRs where cognitive capital is typically low. Candy’s Lean Manager explained:

Some suppliers might not really understand our requirements or why we have such quality requirements. We explain everything to them in detail. After we reach the agreement, problems are quickly resolved.

As adversarial BSRs tend to be characterised by low purchasing spend and multi-sourcing, the buyer can also switch to alternative sources of supply, meaning that the impact can also be relatively low.

A higher level of individual cognitive capital may not always be beneficial to risk identification. This is because individuals think alike and can become less likely to critically evaluate potential risks, which inhibits risk identification performance. Tyre’s Quotation Manager explained: “We often turn a blind eye in most cases, e.g., when the supplier cannot meet the on-time delivery targets. Of course, I know this would bring loss to our company”.

4.3 Relational dimension of social capital
Table VII identifies three enablers and four barriers to organisational relational capital and three enablers and three barriers to individual relational capital. Example quotes can be found in Table VII.

4.3.1 Organisational relational capital and risk identification
Due to a high level of organisational relational capital, shared cooperation norms can lead to a buyer perception that some risk types are less likely in collaborative BSRs than in adversarial BSRs. Indeed, trust in collaborative BSRs can facilitate joint efforts in identifying risk. Meanwhile, the buyer may anticipate that quality risk and opportunism risk appear more likely in adversarial BSRs where trust is lower and suppliers may behave unethically. For example, Alcohol’s General Manager stated: “Some suppliers opportunistically plot to do something to us, such as increase the price or mix impurities”.

The data on organisational relational capital also suggest that different risk identification strategies are used by buyers in different BSRs. For example, a lack of inter-firm trust in adversarial suppliers leads buyers to adopt certain strategies that they would not use with collaborative suppliers, e.g. an unannounced inspection. Candy’s Lean Manager explained:

For those suppliers in ‘transactional’ relationships, we sometimes perform unannounced inspections. We go directly to their sites without informing them to get to know their actual performance and identify risks.

Auto adopts similar practices, but uses a third-party auditor because the supplier also does not trust the buyer and is not willing to disclose its financial performance to them directly. This shows that relational and structural dimensions of social capital can be used together to understand the adoption of risk identification strategies in different BSRs.

Barriers to organisational relational capital, such as exposure to opportunism, can help to understand how opportunism (including intellectual property theft) can occur in collaborative BSRs. HealthCare’s Sourcing Leader explained: “As they [the supplier] are involved in the very early design stage, it is very likely that they take away our technology and other confidential information”. This is a negative consequence of using early supplier involvement to encourage interaction during the design and planning phase. Further, it demonstrates that a barrier of organisational relational capital (i.e. exposure to opportunism) together with an enabler of organisational structural capital (i.e. corporate communication) can explain why an unexpected opportunism risk may occur in collaborative BSRs. Other barriers, such as a lack of firm-level trust (particularly in adversarial BSRs) and reduced monitoring
(specifically in collaborative BSRs), can reduce the proactiveness and effectiveness of risk identification.

4.3.2 Individual relational capital and risk identification

Individual relational capital is shaped by affective commitment based on notions of doing favours, reciprocity and emotional attachment. A high level of individual relational capital enabled by factors such as personal guanxi can lead to a buyer’s perception that supply shortage risk appears less likely in collaborative BSRs. Alcohol’s General Manager claimed: “We have good guanxi with [Supplier X]. If they know that our order is very urgent, they will unload the moulding tools of other buyers to prioritise our production plans”. A higher level of interpersonal trust in relationships, enabling higher individual relational capital, promotes information sharing as part of the formalisation of individual structural capital. Moreover, information sharing reinforces the buyer’s ability to foresee and identify possible risks. Resin’s Quality Engineer explained:

A supplier in a good guanxi would inform us in advance that they might deliver late, and they would offer us options like “wait until the full order is ready” or “deliver part of the order on time”.

Thus, such good guanxi enables the buyer to become aware of risks earlier.

Barriers to individual relational capital, such as a lack of motivation to switch supplier because of the fear of potential loss of guanxi, can help to further understand why buyers in collaborative BSRs may become more likely to expose themselves to some risks such as quality risk. Auto’s Brand Manager argued:

Even if quality cannot be assured, Chinese guanxi will mean we are reluctant to switch to a better supplier for fear of losing current relationships or because we prefer to keep working with friends we have known for many years […] this lowers standards.

Other barriers, such as a lack of skills and experience, can make it difficult to use certain strategies to identify risks, e.g. analysing historical events. Alum’s Supply Chain Manager claimed:

Some of our purchasing staff are quite inexperienced. They are not yet capable of establishing business relationships with big suppliers, of communicating with suppliers’ top management, or of improving relationships.

Together with another barrier, changing purchasing managers, these factors can lead to the loss of guanxi, making it more difficult to identify risks effectively.

4.4 Cross-level effects of social capital on risk identification

Social capital in a buyer-supplier dyad is created through a micro-macro process that crosses two distinct levels (i.e. individual and organisational) and generates cross-level effects on risk identification. We now identify the following mechanisms relating to these cross-level effects: convergent effects, whereby the aims and incentives of individuals within the buyer firm are congruent with the aims and incentives of the buyer firm, meaning that even if there is a low level of social capital between organisations, a high level of social capital between individuals can still lead to positive effects for the buyer firm; and divergent effects, whereby the aims and incentives of the individuals within the buyer firm are incongruent with the aims and incentives of the buyer firm, meaning that individuals may pursue their own agenda and this may be against the interests of the buyer firm, thus undermining any organisational impact. These two mechanisms are based upon the assumption that the owners of the firms are motivated to pursue organisational interests, whereas the individuals that are employed by the firms may or may not always act in the organisational best interests, resulting in convergent and divergent effects on risk identification.

These two mechanisms were found in both types of BSRs, thus creating four quadrants, as shown in Figure 2. Quadrant 1 refers to convergent effects in an adversarial BSR. This happens when an individual in the buyer firm approaches their correspondent in the supplier firm, with whom he/she has interpersonal ties, for a favour in a business exchange. Such

**Figure 2** Characteristics of cross-level effects of organisational and individual social capital on risk identification in adversarial and collaborative BSRs

<table>
<thead>
<tr>
<th>Quadrant 1: Convergent Effects in an Adversarial BSR</th>
<th>Quadrant 2: Convergent Effects in a Collaborative BSR (Best Case Scenario for Risk Identification)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Assets and resources made available through individual social capital that an individual can use to produce benefits for organisational purposes in an adversarial BSR, indicating why the buyer is able to effectively identify risks in an adversarial relationship.</td>
<td>Description: Assets and resources made available through individual social capital that an individual can use to produce benefits for organisational purposes in a collaborative BSR, indicating why the buyer can effectively identify risks in a collaborative relationship.</td>
</tr>
<tr>
<td><strong>Convergent Effects</strong></td>
<td><strong>Divergent Effects</strong></td>
</tr>
<tr>
<td>Quadrant 3: Divergent Effects in an Adversarial BSR (Worst Case Scenario for Risk Identification)</td>
<td>Quadrant 4: Divergent Effects in a Collaborative BSR</td>
</tr>
<tr>
<td>Description: Assets and resources made available through individual social capital that an individual can use to pursue their own gain against organisational interests in an adversarial BSR, indicating why the buyer cannot effectively identify risks in an adversarial relationship.</td>
<td>Description: Assets and resources made available through individual social capital that an individual can use to pursue their own gain against organisational interests in a collaborative BSR, indicating why the buyer cannot always effectively identify risks in a collaborative relationship.</td>
</tr>
</tbody>
</table>

**Adversarial BSRs** | **Collaborative BSRs**
positive effects brought about by individual social capital can help firms maintain inter-firm exchanges even if the supplier lacks firm-level trust with the buyer firm, thereby facilitating risk identification activities in adversarial BSRs. This case reflects individual social capital complementing organisational social capital in a positive way. Quadrant 2 refers to convergent effects in a collaborative BSR. This can be seen from, for example, how personal guanxi can enable supplier firms to prioritise the production and delivery needs of the buyer over those of other buyers in collaborative BSRs. This scenario is considered the best case for the buyer firm in terms of risk identification as the individual social capital reinforces the positive effects of organisational-level social capital. Quadrant 3 refers to divergent effects in an adversarial BSR, where the negative effects of individual social capital, such as caused by collusion, can hurt risk identification in adversarial BSRs. We describe this as the worst case for the buyer firm in terms of risk identification as the buyer appears to lose the initiative and control of the relationship. Finally, Quadrant 4 refers to divergent effects in a collaborative BSR. This indicates that individual social capital is not always reciprocal with organisational social capital, meaning individuals can use their personal ties to pursue their own agenda against organisational interests. The organisation cannot profit from these personal ties and therefore cannot benefit in terms of risk identification.

4.5 Assessment based on the multi-level social capital perspective
Overall, the findings suggest there are enablers and barriers that influence the formalisation and accumulation of both organisational and individual social capital within BSRs. The level of organisational social capital is a strong indicator of the type of BSR, with implications for SCR and risk identification. A buyer may perceive there to be differing degrees of likelihood and consequence of certain SCRs depending on the BSR type. For example, a buyer may expect quality risk to be very likely in an adversarial BSR (e.g. due to a lack of involvement), and that although it is expected to be less likely to occur in a collaborative BSR, when it does occur, the consequences can be severe, e.g. due to the volume of business or degree of integration. In terms of risk identification, buyers may use different strategies or apply the same strategy in different ways according to the BSR type.

It should also be noted that although the three dimensions of social capital at an organisational and individual level are theoretically different, they can be difficult to separate empirically in relation to risk identification. In fact, there are cross-level effects (i.e. convergent and divergent effects) of organisational and individual social capital on risk identification. Convergent effects appear more likely in collaborative relationships, allowing buyers to identify risks earlier than in adversarial BSRs, leading to more proactive and effective risk identification. It was also found that buyers in adversarial BSRs may still be able to effectively identify risks when the convergent effects are in place. Divergent effects that unexpectedly occur in collaborative BSRs can have a negative impact on risk identification, e.g. resulting from collusion and collective blindness.

Social capital theory has utility here but has provided arguably only limited insight into how buyers can identify risks in adversarial BSRs. Given that not all BSRs will be collaborative, it is important that buyers can also identify risks in non-collaborative BSRs. We therefore introduce a second theoretical lens, signalling theory, which allows us to understand how buyers can overcome the information asymmetry that particularly exists in adversarial relationships to identify risks; it can also be used to further examine information sharing in collaborative relationships, meaning that it complements social capital theory.

5. Findings: signalling theory perspective
Signalling theory is best known for its application to labour markets where education (i.e. qualifications) is considered a signal of an employee’s (or applicant’s) qualities that overcomes information asymmetry in the employer–employee relationship (Spence, 1973). The use of signalling theory has also gained recent attention in the field of operations and SCM (e.g. Stevenson and Busby, 2015; Jayasinghe, 2016). In signalling theory, the two key parties are the sender and receiver of signals. In general, the sender must choose the frequency and method of sending information, while the receiver must interpret the signal (Connelly et al., 2011).

The supplier is likely to know much more about supply-side risks to the buyer unless they disclose information. We classify signals into:

- direct signals, i.e. where a supplier voluntarily and deliberately discloses information about risk to the buyer; and
- indirect signals, i.e. where the suppliers’ actions or communications contain information about risk but where this disclosure is not the purpose of the action or communication.

Our choice of signalling theory, and this classification, partly emerged from the data. For example, Medicine’s Purchasing Director explained:

> We use strong [direct] and weak [indirect] signals to evaluate if the supplier has any risks in our evaluations and auditing process or during usual communication.

5.1 Supply chain risk from a signalling perspective
Table VIII provides an overview of signals identified in the data, indicating the signal type (direct vs indirect), the BSR type where a signal was observed (collaborative vs adversarial) and the implied risk type. An example direct signal is a supplier promising not to increase prices even though market prices are rising, which is a direct indication to the buyer that price risk is low. Meanwhile, a high staff turnover at a supplier may be an indirect signal to the buyer of imminent quality problems due to a loss of expertise. The table identifies 13 direct and 10 indirect signal types from supplier to buyer; 12 of the direct signals were evident in collaborative BSRs and only 2 in adversarial BSRs, while all 10 indirect signals were only identified in adversarial BSRs. Thus, the dominant signal type appears to be related to the form of BSR.

Direct signals about risks are mainly emitted by suppliers in collaborative BSRs, which is logical given that we would expect information to be openly shared here. In contrast, buyers must mainly rely on indirect signals in more adversarial BSRs. For example, a supplier may request early payment on an invoice,
Table VIII  Signals (direct and indirect) and potential risks in adversarial and collaborative BSRs

<table>
<thead>
<tr>
<th>Signal description</th>
<th>Adversarial BSR</th>
<th>Collaborative BSR</th>
<th>Potential risk(s)</th>
<th>Illustrative quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking for a favour</td>
<td>Direct (Less)</td>
<td></td>
<td>financial risk</td>
<td>Alum’s Finance Manager: “Some suppliers in a good guanxi [relationship] with us may just call us directly and ask for a favour. They may have a recent problem with capital turnover and wonder if we can support them. We will shorten the accounts payable payment terms or pay cash on delivery.”</td>
</tr>
<tr>
<td>Cash holding or good cash flow performance in a good</td>
<td>Direct (Less)</td>
<td></td>
<td>price risk</td>
<td>Furniture’s Sales &amp; Marketing Manager: “Some suppliers made a commitment to us that they would hold stocks of raw materials for us. Therefore, they were able to keep the same price when the market price increased . . . so these suppliers (in good guanxi) who are willing to hold more cash for us are our key suppliers. They can support us in hard times.”</td>
</tr>
<tr>
<td>relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier warns the buyer that they may not able to</td>
<td>Direct</td>
<td></td>
<td>supply shortage risk; Quality risk</td>
<td>Alcohol’s Senior Purchasing Manager: “When there is a shortage of raw materials, we are in a passive position. Suppliers start to demand favourable requirements for them such as cash on delivery, reduce the transactions that they sell on credit, or reduce the accounts payable payment terms and so on. Because they have much more power, they will implicitly threaten that they cannot supply to you or they will rather lower the quality.”</td>
</tr>
<tr>
<td>Certification (e.g. ISO certification)</td>
<td>Direct</td>
<td></td>
<td>(Less) sustainability risk; Quality</td>
<td>Resin’s Quality Engineer: “For example, things like whether our suppliers have certifications like ISO and can meet the local requirements of sustainability or not etc. Why is this important? Because this can cause us huge problems if they were found not meeting the requirements, they will be punished — they must stop production for one week or one month and rectify and reform until it is correct. Consequently, they cannot delivery to us, which has a great impact on us. In the future, we will pay more attention to sustainability especially on environmental protection in our chemical industry.”</td>
</tr>
<tr>
<td>A promise not to increase pricing although market prices</td>
<td>Direct</td>
<td></td>
<td>(Less) price risk</td>
<td>Furniture’s Sales &amp; Marketing Manager: “Some suppliers made commitments to us that they would hold stocks of raw materials for us. Therefore, they were able to keep the same price when the market price increased.”</td>
</tr>
<tr>
<td>prices are rising</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharing information about a perceived risk event</td>
<td>Direct</td>
<td></td>
<td>(Less) supply shortage risk</td>
<td>Resin’s Quality Engineer: “The supplier in good guanxi would inform us in advance that they might deliver later, and they would offer us options like ‘wait until the full order is ready’ or ‘deliver part of the order on time’.”</td>
</tr>
<tr>
<td>Building inventory for the buyer when the raw material</td>
<td>Direct</td>
<td></td>
<td>(Less) price risk</td>
<td>Furniture’s Sales &amp; Marketing Manager: “Some suppliers hold wood inventory for us when the market price is very low. We would also pay them in advance and support them to hold inventory for us. As a result, we can buy the materials at a lower price and reduce our costs.”</td>
</tr>
<tr>
<td>price is low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finding alternative sources of supply for the buyer</td>
<td>Direct</td>
<td></td>
<td>(Less) supply shortage risk</td>
<td>Furniture’s Sales &amp; Marketing Manager: “There are some situations where suppliers will help us to protect against risks. For example, our suppliers will find alternative scarce raw materials for us through either their suppliers or their peer companies. Their peer companies will help each other in most cases.”</td>
</tr>
<tr>
<td>Maintaining the same price under seasonal demand</td>
<td>Direct</td>
<td></td>
<td>(Less) price risk</td>
<td>Alcohol’s General Manager: “After a long time, suppliers become our friends and will keep the same price under seasonal demand.”</td>
</tr>
<tr>
<td>Supplier offering continuous improvement suggestions</td>
<td>Direct</td>
<td></td>
<td>(Less) quality risk</td>
<td>Candy’s Lean Manager: “Suppliers will also offer improvement suggestions to us. For example, our packaging supplier A know we have issues with batch management at distributors. This supplier offered us a very good suggestion that we can use tapes with different colours to represent different months of BBD [best before date] so that the distributors can refer to the”</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Signal description</th>
<th>Adversarial BSR</th>
<th>Collaborative BSR</th>
<th>Potential risk(s)</th>
<th>Illustrative quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier prioritising delivery or service for the</td>
<td>Direct</td>
<td>(Less) supply shortage risk</td>
<td>colour to achieve FIFO [first-in-first-out] in their inventory management. This would help reduce the rate of aged products.”</td>
<td></td>
</tr>
<tr>
<td>buyer</td>
<td></td>
<td></td>
<td>Furniture’s Sales &amp; Marketing Manager: “Some of our suppliers with good guanxi would prioritise to supply and deliver to us when the material is scarce in the market.”</td>
<td></td>
</tr>
<tr>
<td>Supplier prioritising production plans for the buyer</td>
<td>Direct</td>
<td>(Less) supply shortage risk</td>
<td>Alcohol’s General Manager: “We have good guanxi with [Supplier X]. If they know that our order is very urgent, they will unload the moulding tools of other buyers and prioritise our production plans.”</td>
<td></td>
</tr>
<tr>
<td>Service becomes worse</td>
<td>Direct</td>
<td>Service risk</td>
<td>Auto’s Brand Manager: “Suppliers’ behaviours can help us to identify risks. Some indicators like service becoming worse would indicate service risk to us.”</td>
<td></td>
</tr>
<tr>
<td>Decreasing or discounting prices when the market</td>
<td>Indirect</td>
<td>Quality risk</td>
<td>Alcohol’s Senior Purchasing Manager: “One supplier unexpectedly told us that they could lower the price for us. We supposed that there were quality issues in that batch and this is why they wanted to sell it at a cheaper price”</td>
<td></td>
</tr>
<tr>
<td>price is flat</td>
<td></td>
<td></td>
<td>Medicine’s Purchasing Director: “Take our packaging supplier as an example, we normally pay them every three to four months. When they call us one or two months early asking if we could pay them, we then need to be very careful. Is this because they have financial problems, their cash flow broke down or any other issues? This is concerning whether they can sustain their business. We would consider that it is time we initiated our back up plan.”</td>
<td></td>
</tr>
<tr>
<td>Requesting early payment</td>
<td>Indirect</td>
<td>Financial risk</td>
<td>Alum’s Finance Manager: “Some suppliers said that they can offer us more discounts if we can pay them earlier. This might be that they have issues in capital turnover or they have less cash available, indicating a potential bankruptcy risk to us.”</td>
<td></td>
</tr>
<tr>
<td>Increasing the price when the market price is flat</td>
<td>Indirect</td>
<td>Price risk; Contract risk; Opportunism risk</td>
<td>Alcohol’s Senior Purchasing Manager: “If the supplier initially breaches the contract then they will be punished. But the sudden hike in price by this supplier might imply that he wanted you to induce or force you to initiate the action to discontinue the contract. Then he would not be punished… This is sensible, right? When another customer offered them a higher price, this is profitable for them to opportunistically breach the contract. In the situations where the penalty is very high, he would try all means to force you to initiate the action.”</td>
<td></td>
</tr>
<tr>
<td>Market price increases but no request is made to</td>
<td>Indirect</td>
<td>Quality risk</td>
<td>Auto’s RBD Manager: “Suppliers are also facing the rise in raw material prices, indicating less profit margins for them. They fear that they would lose some current customers if they request to increase the price of raw materials. Instead, they would rather figure out how they reduce the costs of product structure, equipment, technology etc. and sacrifice higher levels of quality standard. This would be increased quality risk for us.”</td>
<td></td>
</tr>
<tr>
<td>increase the price</td>
<td></td>
<td></td>
<td>Alum’s Supply Chain Manager: “One type of material we need is the cutting tool. There are various types of this product in the market. We choose one supplier of relatively low priced good quality tools… value for money. We want to purchase from this supplier. However, the supplier does not allow us to place orders with them. They request us to purchase from one of their dealers, which is a very small firm. There are no established business processes and systems. Although the quality of the cutting tools is very good, it performed badly at response speed and follow-up service.”</td>
<td></td>
</tr>
<tr>
<td>Requesting to change supply to another company</td>
<td>Indirect</td>
<td>Contract risk; Service risk</td>
<td>Alum’s Supply Chain Manager: “Some suppliers request to pay a third-party company after you purchased from their companies. This is a very complicated case, remaining a risk to us.”</td>
<td></td>
</tr>
<tr>
<td>Requesting to pay a subcompany</td>
<td>Indirect</td>
<td>Contract risk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
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<th>Potential risk(s)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Shareholder structure or ownership becomes more</td>
<td>Indirect</td>
<td></td>
<td>Financial risk; Supply</td>
<td>Auto’s Brand Manager: “Everything looks fine on the financial statements of . . . [at new supplier]. Later, we found this supplier was suffering financial distress as their venture capital partner [the majority shareholder] went bankrupt. Therefore, they cannot supply to us anymore.”</td>
</tr>
<tr>
<td>concentrated</td>
<td></td>
<td></td>
<td>interruption risk</td>
<td></td>
</tr>
<tr>
<td>A request to shorten accounts payable</td>
<td>Indirect</td>
<td></td>
<td>Financial risk</td>
<td>Alum’s Finance Manager: “Some suppliers request us to shorten the accounts payable payment terms. They probably have difficulties in their cash flow.”</td>
</tr>
<tr>
<td>payment terms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff change or turnover</td>
<td>Indirect</td>
<td></td>
<td>Quality risk</td>
<td>HealthCare’s Supplier Quality Engineer: “The job-hopping rate and staff turnover rate are quite high in some of our domestic suppliers. There are lots of issues on work handover particularly when staff suddenly leave without a clear handover to the new employee.”</td>
</tr>
<tr>
<td>Strategy change, e.g. investing in other markets</td>
<td>Indirect</td>
<td></td>
<td>Supply shortage risk</td>
<td>Auto’s R&amp;D Manager: “A high turnover of a supplier’s staff on the production line would result in quality risk . . . because the new employees may not have experienced skills and knowledge or they don’t really understand our requirements of the parts.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Auto’s Brand Manager: “One supplier was gradually changing their investment strategy and shrinking the current production for the part they supply to us.”</td>
</tr>
</tbody>
</table>
and this may be an indirect signal to the buyer of financial problems for the supplier, which is a risk to longer term supply. Medicine’s Purchasing Director explained:

Take our packaging supplier as an example, we normally pay them every three to four months. When they call us one or two months early asking if we could pay them, we then need to be very careful. Is this because they have financial problems, their cash flow broke down or any other issues?

The same risk can of course occur in a collaborative BSR, but the supplier may signal more directly and be supported by the buyer avoiding the risk coming to fruition. Alum’s Finance Manager stated:

Some suppliers in a good guanxi [relationship] with us may just call us directly and ask for a favour. They may have a recent problem with capital turnover and wonder if we can support them. We will shorten the accounts payable payment terms or pay cash on delivery.

While the above signal–BSR relationship is generally the case, there are exceptions, including where adversarial suppliers send direct signals to buyers. In particular, adversarial suppliers arguably invest in gaining ISO 14001 certification to send a direct signal to buyers about their commitment to the environment and the low level of sustainability risk. In a more collaborative relationship with greater transparency, this commitment would arguably be clear to the buyer regardless of the certification; but in more adversarial relationships, ISO 14001 becomes an important signalling device. Of course, it is also important because certification is increasingly becoming an order qualifier for many buyers. Thus, it is not an asset that is specific to a single BSR – it can help the supplier in its transactions with other (new and existing) buyers.

Finally, in our study, we limit our interest to signals carrying information about risk from the supplier (sender) to the buyer (receiver), although there are many other signals in the signalling environment that the buyer may also receive and interpret to identify risks. For example, negative news reports about a supplier, product recalls by competitors that source from the same supplier and a supplier being unable to fulfill the demand of another customer may suggest potential supply risks to the buyer. Such signalling is beyond the scope of this paper but warrants more investigation in the future.

Figure 3 Signalling timeline

5.2 Risk identification from a signalling perspective

Connelly et al. (2011) presented a generic timeline (from $t = 0$ to $t = 3$) for the signalling process between signaller and receiver where a signal is sent by the signaller and received/interpreted by the receiver (followed by feedback to the signaller). We now contextualise this timeline by making the supplier the sender/signaller and the buyer the receiver; and we expand it to indicate that:

- The supplier may (or may not) have an incentive to misrepresent their actions/intentions.
- The buyer may (or may not) have the capacity to interpret the signal correctly, as illustrated in Figure 3.

These dimensions are also used in Figure 4, which provides a $2 \times 2$ classification of suitable risk identification strategies observed in the data. Hence, it identifies four types of risk identification strategies: interactive, adaptive, passive and reactive strategies. The $x$-axis refers to the receiver’s (buyer’s) capacity to interpret the signal correctly (or not), and the $y$-axis refers to the signaller’s (supplier’s) incentive to misrepresent (or not) their intentions. The latter appears to be related to the type of BSR, i.e. suppliers in adversarial BSRs are more likely to have an incentive to misrepresent than suppliers in collaborative BSRs.

In Quadrant 1 of Figure 4, the supplier does not have an incentive to misrepresent and the buyer has the capacity to correctly interpret data or actions. This means the buyer can use “interactive” strategies to identify risks, such as by evaluating suppliers and inspecting goods at the buyer’s site. As the supplier does not have an incentive to misrepresent, the buyer can trust them and take them at face value. In Quadrant 2, suppliers do have an incentive to misrepresent their actions but the buyer still has the capacity to correctly interpret data or actions. Therefore, the buyer can use more “adaptive” strategies, including unannounced inspections, inspecting goods before they leave the supplier’s site, and by attempting to translate observed abnormal supplier behaviour into likely risks.

In Quadrant 3, the supplier does not have an incentive to misrepresent but the buyer is unable to interpret correctly. It may therefore need to use a “passive” strategy, where it relies on interpretations by other actors, such as via third-party

Source: Adapted from Connelly et al. (2011)
inspections. There is limited evidence in this quadrant as the buyer is normally able to interpret and translate direct signals sent by a supplier with no incentive to misrepresent into identified risks. Finally, in Quadrant 4, the supplier has an incentive to misrepresent but the buyer is unable to interpret correctly. Here, a buyer may be completely unaware of a potential risk until it materialises or is independently identified by another party, e.g. via customer complaints or feedback from other supply chain actors. We describe these as “reactive” approaches to risk identification.

5.3 Assessment based on social capital and signalling theories

Signalling theory has been used to complement social capital theory, demonstrating how risks can be identified in collaborative and adversarial BSRs. As discussed above, from a multi-level social capital perspective, buyers can improve risk identification through the development of overall social capital and by converging the aims and incentives of individuals with those of the organisational agenda. Meanwhile, the data suggest that the dominant form of signalling is dependent on the BSR type, i.e. direct signals about risks are mainly emitted by suppliers in collaborative BSRs while more indirect signals are found in adversarial BSRs. Thus, although it is difficult to identify risks through the relationship if it is adversarial, especially when there are divergent effects, buyers can improve risk identification by picking up on the predominantly indirect signals sent by suppliers and by choosing suitable strategies shown in Figure 4. Indirect signals provide the buyer with an opportunity to read between the lines and translate received signals into risks; and this means that buyers can find ways to identify risks even when suppliers do not openly disclose or share information or the buyer cannot benefit from their employees’ personal ties. In more collaborative BSRs, direct signals allow the buyer to effectively identify risks by reading on the lines. If divergent effects appear in collaborative relationships, risk identification suffers, although signals can once again be used to boost risk identification to some degree.

6. Discussion

The results from this study provide four key findings and lead to the formulation of five propositions. First, enablers and barriers of the three dimensions of social capital at both organisational and individual levels have been identified. These factors help explain why buyers in different types of BSRs may anticipate SCRs with differing degrees of likelihood and consequence. For example, there appears to be a higher probability but lower impact of quality risk in adversarial BSRs and a lower probability but higher impact in collaborative BSRs. This insight adds, for example, to the debate around whether trust impedes (Cheng et al., 2012; Li et al., 2015; Mishra et al., 2016) or induces opportunism (Chen et al., 2016). Our data suggest that this depends on the presence of divergence between organisational and individual social capital, e.g. caused by collective blindness. Although earlier SCR studies (Cheng et al., 2012; Johnson et al., 2013; Hartmann and Herb, 2014) have used social capital theory, they have tended to neglect interactions between the three dimensions, let alone examined interactions across organisational and individual levels. In line with the wider operations management literature (Liao and Welsch, 2005; Li et al., 2014), we have found that these interactions add explanatory power and provide a more nuanced understanding of risk identification in different BSRs. For example, different combinations of the dimensions of social capital at both levels can help to explain unexpected risks in collaborative BSRs. For instance, a barrier to individual relational capital (collective blindness) combined with an enabler of organisational relational capital (long relationship history) explains why financial risk exists in collaborative BSRs. Meanwhile, the data suggest that buyers may use different risk identification strategies or apply the same strategy in different ways according to the BSR type. For example, an unannounced

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**Figure 4** Classification of SCR identification strategies from a signalling perspective

<table>
<thead>
<tr>
<th>Signaller: Supplier’s Incentive</th>
<th>To Misinterpret</th>
<th>Not To Misinterpret</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactive</td>
<td>Interpretable</td>
<td>Passive</td>
</tr>
<tr>
<td>Adaptive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To Misinterpret</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Supplier performs cause-effect analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Historical events</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Supplier evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sampling check during supplier selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Scenario analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Inspection of goods at supplier’s factory (including co-location of employees)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- SWOT analysis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Receiver: Buyer’s Capacity</th>
<th>To Interpret Correctly</th>
<th>Not To Interpret Correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive</td>
<td>- Supplier performs cause-effect analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Supplier evaluation</td>
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<td></td>
<td>- Historical events</td>
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<td>- Sampling check during supplier selection</td>
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<td></td>
<td>- Scenario analysis</td>
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<tr>
<td></td>
<td>- Inspection of goods at buyer’s factory</td>
<td></td>
</tr>
<tr>
<td>Passive</td>
<td>- Third-party inspection</td>
<td></td>
</tr>
</tbody>
</table>

- Third-party inspection
- Customer complaints
- Customs inspection
- Feedback from downstream supply chain
- Feedback from other buyers

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inspection is more likely with adversarial than with collaborative suppliers. This leads to our first two propositions:

\textbf{P1.} A buyer’s evaluation of the likelihood and consequences of a given SCR is dependent on the type of BSR.

\textbf{P2.} Buyers may use different risk identification strategies or apply the same strategy in different ways according to the type of BSR.

Second, we find that social capital operates at both individual and organisational levels of analysis to affect risk identification. This multi-level approach builds on previous studies on social capital at a single level (Lawson et al., 2008; Whipple et al., 2015). Furthermore, enablers for building up organisational social capital were most evident in collaborative BSRs. Enablers of individual social capital, however, can appear in both types of BSRs, e.g. personal guanxi enables all three dimensions of individual social capital. Hence, our newly identified enablers and barriers to both organisational and individual social capital contribute to the extent BSR literature but particularly to that on SCRM. Our study lends support to previous studies on the dark side of social capital (Villena et al., 2011) and extends this stream by identifying the two distinct cross-level effects, i.e. convergent and divergent effects in different types of BSRs (Figure 2). In doing so, we refine the existing SCRM literature by suggesting a multi-level social capital perspective, i.e. convergent effects reinforce the positive impact of collaborative BSRs on risk identification, but more importantly, offer those buyers in adversarial BSRs an alternative route to, for example, overcoming institutional hurdles and contractual control (Xin and Pearce, 1996; Shou et al., 2016), thereby improving their risk identification. Moreover, divergent effects can impair the proactiveness and effectiveness of risk identification, not only in collaborative BSRs but also in adversarial BSRs. This leads to the following proposition:

\textbf{P3.} Social capital resides in BSRs at different levels of analysis (i.e. at an organisational level and an individual level). The impact of organisational social capital on risk identification is contingent upon convergence with individual social capital. Convergence with individual social capital reinforces the positive effects of organisational social capital and divergence induces negative effects.

Third, our signalling analysis suggests that the dominant form of risk signalling may depend on the type of BSR. Few prior studies have referred to risk signalling between actors in the form of early warning indicators (Craighead et al., 2007; Xie et al., 2009; Bode et al., 2014), and none of these contributions explicitly referred to signalling theory. However, our findings are in line with these studies in terms of the importance of early warning indicators for detecting and mitigating risks. We also claim to add to the wider literature on signalling processes (Connelly et al., 2011) by expanding two dimensions from signalling theory within the context of BSRs. It was found (from the perception of buyers) that adversarial suppliers are more likely to have an incentive to misrepresent than collaborative suppliers. Hence, more indirect signals were found in adversarial BSRs and more direct signals in collaborative BSRs. Therefore:

\textbf{P4.} There is a relationship between the signal type received by a buyer from a supplier and the type of BSR. In adversarial BSRs, buyers will mainly receive indirect risk signals from suppliers. In collaborative BSRs, buyers will increasingly receive direct risk signals from suppliers.

Fourth, we find that signalling theory offers a new insight into how buyers can identify risks. This is particularly advantageous in adversarial BSRs where there is information asymmetry. Risk signalling may be a strong and direct signal from one actor to another, alerting the other party to a potential risk event. But it could also be a weaker, indirect signal. For example, it has been suggested that a supplier requesting faster payment may indicate supplier cash flow problems and financial risk (Bode et al., 2014). Such signalling can inform the buyer about potential SCRs. Indeed, previous studies have also stressed how screening early indicators and building warning capabilities are essential to the success of SCRM (Craighead et al., 2007; Kern et al., 2012). Buyers can interpret signals to identify risks in a quick and effective way, including by “reading between the lines”, to translate indirect signals into risks. In more collaborative BSRs, direct signals allow the buyer to effectively identify risks by “reading on the lines”. This allows risks to be identified in both adversarial and collaborative BSRs, leading to our final proposition:

\textbf{P5.} Direct and indirect signals can be used to identify the type of risks to which the supply chain is exposed in collaborative and adversarial BSRs.

\textbf{7. Conclusions}

This paper started by asking how does the nature of the BSR affect SCR identification? We collected data from ten Chinese manufacturers and analysed them from a multi-level social capital perspective, complemented by signalling theory. We have been able to extend existing knowledge by identifying the enablers and barriers to social capital at both levels in a developing country context. Furthermore, a buyer may perceive there to be differing degrees of likelihood and consequence of certain SCRs and either use different risk identification strategies or apply the same strategy in different ways depending on the BSR type. The impact of organisational social capital on risk identification is suggested to be contingent upon convergence with individual social capital, i.e. convergence of the aims and incentives between the two levels reinforces the positive impact of organisational social capital and divergence induces negative effects. Social capital theory, however, failed to offer sufficient explanation concerning how buyers can identify risks in adversarial BSRs. We have shown that it is still possible to identify risks in adversarial relationships by picking up on the indirect risk signals. Further, signalling theory provided a new perspective for classifying suitable risk identification strategies into interactive, adaptive, passive and reactive approaches (Figure 4).
7.1 Theoretical implications
This study sheds light on how the BSR influences risk identification in a developing country context. It advances social capital as a multi-level theoretical lens and explains how social capital operates at both individual and organisational levels of analysis to affect an organisational-level outcome, i.e. risk identification performance. This represents an important contribution to social capital theory that responds to the research gap identified by Payne et al. (2011). The findings show that understanding individual-level social capital is important for understanding organisational-level social capital. We identified two different mechanisms relating to the cross-level effects of organisational and individual social capital on risk identification. Finally, we have demonstrated the value of using signalling theory to complement social capital theory, adding explanatory power to risk identification, particularly in adversarial BSRs.

7.2 Managerial implications
This study aids managerial understanding of how the types of relationships buyers develop with supply chain partners impact the SCRs they are exposed to, and this awareness may help managers better anticipate and predict potential risks, allowing them to select appropriate strategies to proactively identify risks. Meanwhile, firms should pay attention to individual social capital, evaluate whether the aims of individuals converge with those of the organisation and determine how best to manage and exploit the relationships between supply chain professionals and individuals in supplier firms. For example, the findings highlight the importance of retaining supply chain professionals who have strong individual ties with suppliers for the good of the overall BSR. Equally, the findings highlight the importance of having multiple contacts or rotating professionals for protecting the organisation from possible negative effects when the employed individuals are motivated to act in their own best interests and those interests run contrary to those of the organisation. Thus, firms in both adversarial and collaborative BSRs should encourage their employees to use individual social capital to produce benefits for the organisational purpose, and in doing so, firms can improve risk identification through the development of overall social capital and by fostering convergence between organisational and individual social capital.

In addition, the insights reveal that buyers need to consider how risks can best be identified in the context of a given BSR. It may be, for example, that firms that have adversarial relationships with suppliers need to become competent at reading between the lines to intercept and interpret risk signals. In other words, establishing learning capabilities for the risk signalling process could help firms to better anticipate potential risks. Equally, suppliers themselves need to be aware that buyers may be able to learn about risks not only from their direct actions but also from their indirect actions and consider how this should impact their behaviour.

7.3 Limitations and future research directions
This study is based on a qualitative research design. Thus, it is acknowledged that the results may lack external validity and the conclusions may be idiosyncratic (Eisenhardt, 1989). Future research could therefore involve a large-scale survey to add generality. Further, only the buyer perspective in the BSR has been captured; hence, future research could extend the work to include suppliers. Although we used the BSR as the smallest unit of analysis to study how supply chain relationships affect risk identification, we have found evidence that other supply chain actors such as customers, other buyers and competitors also play a role in identifying SCRs, indicating more research could be done in this direction. Similarly, the work could be extended to other stages of the SCRM process. Future research could also explore this topic in other countries where culture may play a different role than in China (guanxi). Our findings show that there are cross-level effects on risk identification between the different levels of social capital. Further research could investigate the impact of other organisational characteristics on the cross-level effects in this context, such as firm size, established routines and industry sector. Finally, future research could explore how research on SCRM and on supplier relationship management can be more formally integrated.

References


Reading on and between the lines

Yiyi Fan and Mark Stevenson

Supply chain management: model development and risk management


Yin, R.K. (2014), Case Study Research: Design and Methods, SAGE, Los Angeles, CA.
Appendix. 1. Interview questions

1.1 General background

- Background on organisation, position, job title and responsibilities.
- What is your understanding of buyer-supplier relationships, SCR and risk identification in particular?

1.2 Supply chain risks and risk identification strategies

1. Which of the following SCRs are most relevant to your company?
   - Inability to meet quality requirements;
   - Inability to adapt to required product design or technological changes;
   - Failures to make delivery requirements;
   - Cannot provide competitive pricing (including sudden hike in costs);
   - Supplier opportunism (including intellectual property risk);
   - Contractual agreements;
   - Single source of supply;
   - Selection of wrong partner;
   - Financial instability, including bankruptcy;
   - Lack of supplier involvement; and
   - Sustainability related problems.
   Are there any other SCRs (not listed) that are relevant to your company?
   - What strategies has your company used to identify risks, and how effective have these been?

1.3 Types of BSR, SCR and risk identification

- What are the different types (characteristics) of working relationships with your suppliers? How critical is a supplier in each type to your overall business?
- How do the types of relationships you have with suppliers affect SCR?
- How has working with your suppliers (with examples from different types of relationships) influenced risk identification?
- How would you evaluate your working relationships with your suppliers regarding SCRs and SCRM?

1.4 Final comments

Are there any further comments that you think are relevant to this research that either affect the company now or may do in the future?

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