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Quan Zhu, Harold Krikke, Marjolein C. J. Caniëls,

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Integrated supply chain risk management: a systematic review

Abstract

Purpose - Supply chain risks specifically refer to risks that transmit among supply chain members, thus they should be understood and managed as a whole for an end-to-end supply chain. The purpose of this paper is to review literature of integrated supply chain risk management (ISCRM) that connects supply chain integration (SCI) with supply chain risk management.

Design/methodology/approach – The systematic literature review methodology was used to select and categorize articles between 1998 and 2015 in peer-reviewed journals. A contingency analysis was further applied to detect association patterns and links between category items.

Findings - Through a systematic literature review, our research has clearly analyzed risk sources, scopes and dimensions of SCI, scopes and dimensions of performance in the field of ISCRM. Furthermore, by applying the contingency analysis, our paper has proposed future research directions that are based on the extant literature findings.

Originality/value – The identified insights, gaps, and future research directions will encourage researchers as well as managers to drive the development of ISCRM.

Keywords Supply chain integration, Supply chain risk management, Performance measures, Systematic literature review, Contingency analysis

Paper type Literature review

1. Introduction

Modern supply chains are interconnected. Firms increasingly depend on a complex network of global partners to deliver products at the right time and place, in the right quantity, and under persistent cost pressures (Datta and Christopher, 2011). The integration of business processes

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across multiple firms can provide economic benefits, thus helping maintain the competitive advantages of the firms involved. However, such advantages are accompanied by many potential risks resulting from intermeshed processes (Breuer *et al.*, 2013). For instance, the Japanese earthquake and tsunami in 2011 caused not only a local disruption on supply and demand, but also a manufacturing slowdown in European and North American countries where they need Japanese suppliers' inputs (MacKenzie *et al.*, 2012). According to a recent study by Aon Risk Solutions, the percentage of global companies reporting a loss of income due to a supply chain disruption increased from 28% in 2011 to 42% in 2013 (Sáenz and Revilla, 2014). Supply chain risk management (SCRM) has become a very important area of study (Ghadge *et al.*, 2012).

To mitigate the negative impacts of supply chain risks, various strategies, such as redundancy (Sheffi, 2005), dual sourcing (Trkman and McCormack, 2009), and postponement (Yang and Yang, 2010), have been discussed to provide help. However, these strategies employ the focal firm perspective that they are internal practices with scant insights on the integration between the focal firm and its supply chain partners. As supply chain risks specifically refer to risks that transmit among supply chain members (Li *et al.*, 2015) and their magnitude and probability can be significantly influenced by supply chain rippling and network effects (Jüttner, 2005), they should be understood and managed as a whole for an end-to-end supply chain (Rao and Goldsby, 2009). The way to achieve this goal is thus to facilitate supply chain integration (SCI).

This paper reviews literature of integrated supply chain risk management (ISCRM) that connects SCI with SCRM. Although the idea of ISCRM has been discussed in several recent articles (e.g., Breuer *et al.*, 2013; Chen *et al.*, 2012; Li *et al.*, 2015), many concepts and relationships in this field are still inconsistent and fragmented. For instance, some ISCRM articles considered

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"environmental uncertainty" as the risk source of their research (e.g., Chong and Zhou, 2014; Iyer *et al.*, 2004; Wang *et al.*, 2006; Wang *et al.*, 2013; Wong *et al.*, 2011). However, what "environmental uncertainty" they referred to are different: most of their research considered demand/market risks as one aspect (an exception is Wang *et al.* (2013), which regarded supply risks as "environmental uncertainty"); besides demand/market risks, Iyer *et al.* (2004) also checked organizational risks, while Wang *et al.* (2006) also looked at competitive/technological risks; Wong *et al.* (2011) even studied four aspects: demand/market, supply, competitive/technological, and organizational risks. Another example is that it is often believed that SCI has a positive impact on performance, but Fabbe-Costes and Jahre's (2008) literature review indicated that 12 out of 31 studies showed that more SCI does not always improve performance.

In addressing these critical gaps, our research provides a systematic literature review (Denyer and Tranfield, 2009; Rousseau *et al.*, 2008; Tranfield *et al.*, 2003) in the field of ISCRM. We first draw and justify the boundaries of ISCRM and related issues in section two. In the third section, we present the methodology of systematic literature review and how we implement it in this paper. The descriptive and thematic results are summarized in section four. This is followed by a contingency analysis to identify association patterns (i.e. relationships) in the extant literature findings and provide theoretical mechanisms in section five. The paper concludes with our key findings, implications for managers, and future research directions in section six.

2. Integrated Supply Chain Risk Management (ISCRM)

The underlining assumption of ISCRM is that there are certain risks the supply chain has to face. Identifying risk sources is thus the first important issue of ISCRM (Lavastre *et al.*, 2012). In

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general, there are two types of supply chain risks: operational risks and disruption risks (Chen *et al.*, 2012; Tang, 2006). Operational risks relate to supply-demand coordination and result from inadequate or failed processes, people, and systems (Zhao *et al.*, 2013). In a supply chain, supply-demand variations are raised mainly from three sides: upstream from suppliers' performance, downstream from customers' demand, and internally from the production and distribution processes of the focal firm (Germain *et al.*, 2008). In addition, competitive/technological risks are operational risks that are faced by all supply chain members. Manifested as the extent of unpredictable changes in the technological environment, competitive/technological risks may quickly render existing technology obsolete. Firms need to develop better innovation capabilities in its exchange relationships in order to stay ahead of the competition (Jean *et al.*, 2012). Disruption risks are environmental risks that affect the overall business context across industries (Ritchie and Marshall, 1993). They include legal risks caused by law and policy changes, infrastructure risks caused by man-made issues (e.g., strikes and industrial accidents), and catastrophic risks (e.g., terrorist attacks, epidemics, and floods) (Wagner and Bode, 2008). To balance the coverage and condensation of all risk sources, we adapt Rao and Goldsby's (2009) typology of supply chain risks that ranges from the organization itself to the environment affecting the whole supply chain: organizational risks (i.e. the focal organization's production and/or distribution risks), industrial risks (including demand/market risks, supply risks, and competitive/technological risks), and environmental risks (that affect the overall business context across the supply chain). The detailed definition of each category item will be shown in Table 1, which also applies to the following category items.

ISCRM can be broadly defined as a practice that key firms of a supply chain work jointly to ensure their continuity and profitability (Tang, 2006). "Key firms of a supply chain working

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jointly" means key members should facilitate SCI, a practice that key supply chain partners collaboratively manages intra- and inter-organization processes (Flynn *et al.*, 2010). So at first, it is important to know who are "key supply chain partners", i.e. the scope of SCI, which shows the nature and number of organizations included in the "integrated supply chain" (Mentzer *et al.*, 2001). To our best knowledge, Frohlich and Westbrook (2001) first categorized different scopes of SCI (please note they used "arcs of integration" instead of "scopes of SCI"). The five scopes they identified are: inward-facing, periphery-facing, supplier-facing, customer-facing, and outward-facing. However, their categorization of scopes of SCI is restricted to five types of dyadic integrations with delicate differences and not fully compatible with the typology of supply chain risks. In this research, we follow Fabbe-Costes and Jahre (2008) to investigate scopes of SCI that range from dyadic integrations to extended integration that integrates more than three parties. For dyadic integrations, we only look at three types: limited dyadic downstream integration, limited dyadic upstream integration, and limited dyadic integration (i.e. buyer-supplier integration without a focal firm). Please note our definition of limited dyadic integration is different from Fabbe-Costes and Jahre's (2008) definition, in which the focal company integrates with both up and downstream partners, but separately. On the one hand, our main purpose is to identify association patterns (i.e. relationships) in the extant literature findings, which is different from their purpose to form mutually exclusive definitions to classify each paper into one single scope of SCI. Therefore, we can calculate one paper twice, if it covered both limited dyadic downstream integration and limited dyadic upstream integration. On the other hand, we notice there are articles discussing buyer-supplier integration without a focal firm (e.g., Chan and Chan, 2006; Demirkan and Cheng, 2008; Ma *et al.*, 2013). To simply including these articles in our framework, we decide to continue using "limited dyadic integration", but with a different definition. Second, it is necessary to understand what "intra- and inter-organization

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processes" need to be collaboratively managed, i.e. the dimension of SCI, which demonstrates the major interrelated activity that SCI performs (Alfalla-Luque *et al.*, 2013). To help reduce competitive/technological risks, Tatikonda and Stock (2003) proposed three dimensions of SCI: communication, coordination, and cooperation. These dimensions parallel the three essential "components of the relationship" identified by Walton (1966): exchange of information in the decision process, structure of inter-unit interactions and joint decision making, and attitudes toward the other unit. Holding a similar idea, Leuschner *et al.* (2012) summarized three different dimensions of SCI as information integration, operational integration, and relational integration. In this paper, we keep in line with Leuschner *et al.*'s (2012) expressions, as they directly point out the interrelated activities for ISCRM.

Similar to the aim of SCRM on performance maintenance, the goal of ISCRM is to "ensure their continuity and profitability". Following the same logic of analyzing SCI, we need to first realize what "their" covers, i.e. the scope of performance. According to Kache and Seuring (2014), most ISCRM articles evaluate focal firm performance or whole supply chain performance or both. We also notice there are papers (e.g., Bhaskaran and Krishnan, 2009; Wei *et al.*, 2012) evaluating all firms' performance (i.e. individual performance of all the firms in the supply chain). Therefore in this paper, we will investigate all these three scopes. Furthermore, it is equally important to understand what "continuity and profitability" stands for, i.e. the dimension of performance. There are two sources: "continuity" and "profitability". "Continuity" means the maintenance of competitive advantages, including customer intimacy, operational excellence, and product leadership (Treacy and Wiersema, 1995), which corresponds with four risk sources: demand/market risks (for customer intimacy), supply risks and organizational risks (for operational excellence), and competitive/technological risks (for product leadership). Thus, we

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will look at customer service performance, operational performance, and innovation performance, respectively. "Profitability" represents overall business performance, which includes market performance and financial performance (Flynn *et al.*, 2010). The short-term objective of ISCRM is to maintain cash flow, return on investment (ROI), and profit margin on sales (which are financial performance), while the long-term objective is to increase market share and sales (which are market performance) (Li *et al.*, 2006).

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3. Research Methodology

Systematic literature review has become a major research approach in evidence-based practice (Hohenstein *et al.*, 2015). It differs from the traditional narrative literature review by the inclusion of all relevant studies, the use of transparent analyses, and the critical interpretation with specific criteria, to provide the evidentiary value of a body of previous literature (Rousseau *et al.*, 2008). The review starts by emphasizing the fit to the research questions, then focuses on a systematic and replicable approach to answer them (Tranfield *et al.*, 2003). According to Denyer and Tranfield (2009), our research steps are: (1) question formulation: after an iterative process of definition, clarification, and refinement of concepts (the results were presented in the previous section), research questions are formed; (2) locating studies: keywords directly related to our research questions, as well as alternatives of each keyword, are included to cover the broadest array of relevant studies; (3) article selection and evaluation: inclusion and exclusion criteria are defined and applied; (4) analysis and synthesis: the aim of analysis is to break down individual studies into constituent parts and describe how each relates to the other, while the aim of synthesis is to make associations between the parts identified in individual studies; and (5) reporting and using the results: what is known and unknown about the research questions are

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addressed to provide suggestions for practice and future research. The implementation processes of step (1) to (4) are presented below. Step (5) is discussed in the following sections.

3.1 Question formulation

In the first step, the research questions guiding the review were defined by the authors through several rounds of thoughtful discussions. The review question is: "How does SCI secure specific performance maintenance and/or improvement under given supply chain risks?"

Following Pilbeam *et al.* (2012), we adopted a strategy to deconstruct the review question into two sub-questions, each with their own sub-sections:

RQ1. What supply chain risks lead to the selection of SCI for performance maintenance and/or improvement?

- Sources of supply chain risks.
- Scopes of SCI for ISCRM.
- Dimensions of SCI for ISCRM.
- Scopes of performance for ISCRM.
- Dimensions of performance for ISCRM.

RQ2. How does SCI secure performance maintenance and/or improvement?

- Association patterns (i.e. relationships) in the extant literature.
- Theoretical mechanisms underpinning the relationships.

3.2 Locating studies

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To locate proper studies, we first identified the keywords used in different research streams. Alternative words were found for different terms to address the divergence in terminology used by different research streams. The selected keywords were connected in a Boolean logic (OR and AND) to build search strings. The strings, i.e. "supply chain" (OR "logistics" OR "supplier" OR "customer" OR "upstream" OR "downstream") AND "integration" (OR "collaboration" OR "coordination" OR "cooperation") AND "risk" (OR "disruption" OR "uncertainty") AND "performance", were then used to search for titles and abstracts containing these terms in various online databases, including EBSCO, Emerald, Science Direct, Taylor and Francis, and Google Scholar. This procedure yielded 442 unique articles from 1998 to 2015.

3.3 Selection and evaluation

This step started with limiting our review to published peer-reviewed journal articles (Denyer and Tranfield, 2009), as the peer review process is a quality indicator that assesses a study's conceptual and methodological rigor (Hohenstein *et al.*, 2015). Based on this criterion, we reduced the number of articles to 335. Next, we read the abstracts to determine the relevancy to all of the four keywords or their alternatives. Problems were mostly generated from the use of "integration". For example, some of the articles were excluded, because "integration" in these researches only referred to "mathematics integration" as a methodology. Articles not written in English, editorials, or book reviews were also removed in this round. After this round, 88 articles were left in our selection. Finally, all the articles were read in their entirety to check whether they discussed the relationships of all of the four keywords or their alternatives. In this round, some of the articles were excluded, because they only discussed: (1) risks that (potentially) raised from SCI, for example, quality problems raised by suppliers (Lee *et al.*, 2013); (2) internal integration, which examines integration across various parts of a single organization (Pagell, 2004); (3)

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horizontal integration, which is defined as concerted practices between companies operating at the same tier in the market (Cruijssen *et al.*, 2007); (4) outsourcing, contracting, or providing incentives that is only from the focal firm perspective, not "collaboratively manages intra- and inter-organization processes" (Wu *et al.*, 2015). After this final round, 67 articles were left in the selection set. They are indicated by an asterisk in the reference list.

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3.4 Analysis and synthesis

After selecting the appropriate studies, the data analysis and synthesis commenced. The data analysis started with the extraction, categorization, and storage of information on a data extraction form for every study included in the review (Denyer and Tranfield, 2009). Due to the length of this paper, the extraction form is available upon request from the corresponding author. The detailed descriptive and thematic results are discussed in section 4 to give answers to the first research question. The data synthesis goes beyond mere description by recasting the information into a new or different arrangement and developing knowledge that is not apparent from reading individual studies in isolation (Denyer and Tranfield, 2009). Therefore, a contingency analysis was applied to highlight the interrelationships in the data (Kache and Seuring, 2014). The results of the contingency analysis are discussed in section 5 to answer the second research question.

4. Descriptive and Thematic Results

4.1 Descriptive results

Our literature search yielded a first appearance of an ISCRM article in 1998 (Figure 1). The number of articles reached the first peak in 2005, when information technologies and systems emerged as a facilitator of integration (White *et al.*, 2005). However, the strong increase in the number of publications actually occurred in recent years: 70% of the selected articles (47 out of

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67) were published from 2009 to 2015. This is in accord with both Leuschner *et al.*'s (2012) observation of increasing publication in SCI since 2008 and Hohenstein *et al.*'s (2015) observation of increasing publication in SCRM since 2009. It highlights the need for a thorough analysis of the expanding body of literature in ISCRM. Moreover, in contrast to Ghadge *et al.*'s (2012) results, U.S.-Canadian (25), European (19), and Asia-Pacific (23) academics equally contribute to our selected papers. It is worth noticing that more and more global projects (e.g., the High Performance Manufacturing project (Zhao *et al.*, 2013)) help academics think in a global view.

Insert Figure 1 Here

The 67 selected articles were published in 37 peer-reviewed journals. Most journals (only two exceptions) were ranked in Academic Journal Guide 2015, a quality rating published by Chartered Association of Business Schools (2015). Of them, 20 journals received 3, 4, or 4* (4* is the highest rating). Four journals are leading in this field: *Decision Sciences* (5 articles), *International Journal of Production Economics* (5 articles), *Supply Chain Management: An International Journal* (5 articles), and *International Journal of Production Research* (4 articles). Most papers (68%) were published in the area of Operations and Technology Management (52%) or Operations Research and Management Science (16%).

According to Pilbeam *et al.*'s (2012) suggestion, we classified the selected articles into three categories: analytical, empirical, or a literature review. Analytical papers (15) contain conceptual, mathematical, or simulation methods, while empirical papers (49) use surveys, case studies, experiments, or mixed methods. The remaining 3 are literature reviews. Empirical research has

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become the most popular methodology (used by 73% of the selected articles) to explore ISCRM in the last 18 years. Analytical research only accounts for 22% of the selected papers, because most of analytical works took a single-item view (Datta and Christopher, 2011), which cannot cover all of the four keywords in this review. The remaining literature reviews account for 5%.

4.2 Thematic results

The definition of each category item and the corresponding thematic results are shown in Table 1. Details will be discussed below to provide answers to RQ1.

Insert Table 1 Here

4.2.1 Risk sources

During times of high market turbulence, competitive intensity, technological change, and supply pressure, there is greater likelihood that the synchronization between the supply chain's offerings and customers' needs may be lost (Matanda and Freeman, 2009). Our results show that these three industrial risks, which are demand/market risks (67%), competitive/technological risks (48%), and supply risks (40%), are also the top three risk sources. In contrast, organizational risks are not often mentioned in the reviewed literature (30%). In the context of ISCRM, organizational risks are mainly triggered by supply and demand/market risks (Chen *et al.*, 2012). It is verified by our results that only one paper (Naspetti *et al.*, 2011) discussed organizational risks without supply or demand/market risks. This paper looked at production risks in the food industry, which is always affected by many environmental risks, such as extreme weather and pest and disease outbreaks (Leat and Revoredo-Giha, 2013). Moreover, production activities are directly controlled by the focal firm, ending up with less uncertainty (Zhao *et al.*, 2013).

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Environmental risks have the lowest percentage of appearance in ISCRM literature (18%), but they have received much attention in recent years (Li *et al.*, 2015). Our results also show that all the reviewed articles that are related to environmental risks were published from 2009 to 2015. As managers perceive their business environment as inherently unstable and find supply chains to experience the "age of turbulence" (Christopher and Holweg, 2011), we expect this risk source will receive more attention in the future.

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4.2.2 Scopes of SCI

Limited dyadic upstream integration accounts for the most scope of SCI (58%), while limited dyadic downstream integration ranks the second (40%). In the field of ISCRM, most articles of limited dyadic upstream integration discussed about collaborative new product development, an inter-firm interaction to accomplish product technology transfer (Tatikonda and Stock, 2003). In contrast, most articles of limited dyadic downstream integration discussed about vendor-managed inventory (VMI), a collaborative arrangement typically between a vendor and its customer to achieve operational excellence (Hung *et al.*, 2013). A VMI relationship requires a higher level of trust and commitment, as transactions initiated by the customer (e.g., purchase orders) are now initiated by the vendor (Waller *et al.*, 1999). This may be the reason why research in limited dyadic downstream integration is not as popular as that in limited dyadic upstream integration. Due to our strict definition (Table 1), limited dyadic integration (18%) is the least popular scope in three types of dyadic integrations. Such papers include analytical modeling of a two-tier supply chain with no focal firm (e.g., Chan and Chan, 2006), and empirical studies (e.g., Simatupang *et al.*, 2004) and literature reviews (e.g., Pereira, 2009) that theoretically discuss a buyer-supplier integration.

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Limited triadic integration (6%) and extended integration (10%) are not popular in the literature of ISCRM either. On the one hand, they are not as controllable as three forms of dyadic integration, as upstream firms can directly share information with downstream firms without informing the focal firm (Cadden *et al.*, 2013). On the other hand, empirical data of limited triadic integration or extended integration is very difficult to collect (Closs *et al.*, 1998). For example, only one study (White *et al.*, 2005) used a single case to describe the extended scope of SCI. The remaining six articles of extended integration are either analytical studies or literature reviews.

4.2.3 Dimensions of SCI

Surprisingly, only 49% of the reviewed papers discussed relational integration, as the other two dimensions of SCI are built on, and intertwined with this attitudinal aspect (Van der Vaart and Van Donk, 2008). The quality of information integration heavily depends on the appropriateness of information for exchange, which is based on trust among supply chain partners (Zhou and Benton, 2007). Also, it is not easy to break down departmental and business barriers to adopt the strategy of operational integration, which depends on the mutual interest of integrated firms (Lambert *et al.*, 1999). The omission of relational integration may explain some of the failures of SCI practices in ISCRM (Kim *et al.*, 2008; Simatupang *et al.*, 2004; Terjesen *et al.*, 2012).

Most articles (87%) have included information integration in their research. This is in line with Kulp *et al.*'s (2004) observation that information integration has given companies a competitive advantage since early-1990s, which constituted a first step in supply chain integration. Compared to information integration, operational integration only appeared in 35 papers (52%). Operational integration requires all the integrated firms to jointly redefine the terms of their relationships so

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that they share risks, costs, and rewards equitably (Lee, 2004). It is more difficult to successfully achieve, so the lower percentage of appearance is logical.

4.2.4 Scopes of performance

Focal firm performance was measured in more than half of the reviewed literature (61%), as the purpose of most research is to improve focal firm performance. Another reason is that surveys introduce a bias when asking a manager from the focal firm to assess its partners' performance (Van der Vaart and Van Donk, 2008). Therefore, although some survey papers (e.g., Paulraj and Chen, 2007; Wang *et al.*, 2013; Wei *et al.*, 2012) do investigate all firms' performance or whole supply chain performance, they are not the majority. In addition to these survey papers, analytical articles can evaluate all firms' performance and/or whole supply chain performance through mathematical programming (e.g., Nagurneya and Qiang, 2012) and simulation (e.g., Datta and Christopher, 2011; Sari, 2010). However, these analytical papers are not the majority, either. Altogether, 14 articles evaluated all firms' performance (21%) and 19 articles evaluated whole supply chain performance (28%).

4.2.5 Dimensions of performance

Operational performance (69%) is the most measured performance in ISCRM literature, as it reflects the core idea of supply chain management to outperform on product supply (Morris and Carter, 2005; Zack *et al.*, 2009). Compared to operational performance, customer service performance and innovation performance are lack of attention, maybe because they cannot immediately contribute to profitability (Koufteros *et al.*, 2005). Of them, customer service performance (45%) has a relatively higher chance of appearance than innovation performance (16%). Customer service performance reflects current achievement on customer value creation,

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while innovation performance concerns the ability to retain current customers and create more value in the future. Although long-term orientation has received more attention recently (e.g., Huang *et al.*, 2014; Luzzini *et al.*, 2015), short-term performance measures still dominate in ISCRM literature. The same logic applies to the results of market performance (15%) and financial performance (34%). Financial metrics have served as a tool for comparing organizations' current performance over time (Holmberg, 2000), while long-term performance are always measured by market metrics, such as market share and the growth of sales (Li *et al.*, 2015).

5. Contingency Analysis

To extract more in-depth results from the thematic categories to answer RQ2, we applied the contingency analysis methodology to detect association patterns and links between category items (Kache and Seuring, 2014). This technique identifies pairs of category items that occur relatively more frequently together in one paper than the product of their single probabilities would suggest (Gold *et al.*, 2010). The test of statistical significance is conducted using Fisher's exact test (Upton, 1992).

The data of thematic categories has 21 (5+5+3+3+5) category items, which account for 174 (21×20/2-5×4/2-5×4/2-3×2/2-3×2/2-5×4/2) pairs that are from two different categories. Each pair was analyzed using the "Crosstabs" function of IBM SPSS Statistics 22, which supports the application of Fisher's exact test (Kache and Seuring, 2014). The "Crosstabs" function helped count the number of cases that were in common (and different) between two classifications (i.e. whether or not two category items appeared as a pair) (Frohlich and Westbrook, 2001). The quality of each pair is measured by the Phi coefficient (φ), while φ exceeding 0.300 and significance level higher than 0.05 denote a significant relation (Fleiss, 1981).

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The assessment yielded 20 statistically significant pairs, as presented in Table 2. The whole picture of correlations is shown in Figure 2. To further summarize the extant literature findings and provide future research directions, we categorize these correlations into three research streams (Figure 2), according to our typology of supply chain risks. Please note no pair between organizational risks and any other category item is found to be statistically significant, so there is no research stream related to organizational risks. Instead, one research stream has no certain risk source. We name it after its dimension of SCI: information integration in ISCRM. We will explain the theoretical mechanism for each research stream in details below.

Insert Table 2 Here

Insert Figure 2 Here

5.1 The first research stream: integrated industrial risk management

As the environment (at industrial level) becomes more dynamic and disruptive through exogenous and endogenous changes, we have entered the age of temporary advantage that incurs high transaction costs (D'Aveni *et al.*, 2010). Transaction costs are the expenses generated by identifying fair market prices, negotiating and carrying out economic exchange. With respect to SCI, transaction cost economics predicts that firms should fare better, if they appropriately adjust their governance mechanisms to the underlying transactions (Williamson, 1975). In this research stream, the underlying transactions are in new product development (with competitive/technological risks), demand (with demand/market risks), and supply (with supply risks) (Yigitbasioglu, 2010). The integration can start with exploiting supplier innovativeness (i.e.

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limited dyadic upstream integration) for new product development through knowledge integration (Bengtsson *et al.*, 2013; Cao *et al.*, 2010). For the purpose of conforming to customer requirements, limited dyadic downstream integration can greatly reduce uncertainty associated with product launch (Bowersox *et al.*, 1999). Both practices, together with limited dyadic integration, are correlated with relational integration, which is supported by social exchange theory that relational governance mechanisms, such as trust and commitment, can be used to achieve a higher degree of integration between supply chain partners (Leuschner *et al.*, 2012). Such integration efforts benefit innovation performance (Chong and Zhou, 2014) and customer service performance (Kim *et al.*, 2008), and can be measured by either focal firm performance (Wong *et al.*, 2012) or whole supply chain performance (Villena *et al.*, 2009).

5.2 The second research stream: integrated environmental risk management

Classic contingency theory assumes that high performance is derived from the "fit" of the focal firm's structure and strategy to the focal firm's context (Chattopadhyay *et al.*, 2001). Nowadays, firms are working collaboratively in supply chains rather than through arm's-length market transactions (Bengtsson *et al.*, 2013). Especially in the last few years, firms have become more vulnerable to environmental risks (Manuj *et al.*, 2014; Zsidisin and Wagner, 2010). Accidents become inevitable or even normal in complex and tightly coupled systems, as they extend the focal firm's context to its supply chain's context (Zhu *et al.*, 2017). When its supply chain's context is changed by environmental risks, the focal firm has to collaborate with all its supply chain partners (i.e. extended integration) for recovery (Breuer *et al.*, 2013). Therefore, the evaluation of SCI efforts can be rest on the focal firm (Kache and Seuring, 2014), but more towards the whole supply chain perspective (Sheu, 2005).

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5.3 The third research stream: information integration in ISCRM

According to information processing theory, increased flow and quantity of information can lead decision-makers to be able to improve performance (Swink *et al.*, 2007). Furthermore, knowledge-based view states that SCI can help firms coordinate and deploy knowledge resources by exchanging strategic information across the organizational boundary with key suppliers and customers (Grant, 1996; Kogut and Zander, 1992). Such practices influence the process of innovation generation, which are evaluated by innovation performance improvements (Jean *et al.*, 2012).

6. Discussion and conclusion

6.1 Discussion

Although risk sources, scopes and dimensions of SCI, and scopes and dimensions of performance are mostly inter-connected in the first research stream, there is one obvious missing link: supply risks are directly connected to customer service and operational performance, without a link to any scope or dimension of SCI. Two of our reviewed articles (Kim *et al.*, 2008; Terjesen *et al.*, 2012) may provide us with some clues to explain this discrepancy. Kim *et al.* (2008) considered two sourcing strategies--searching for alternative suppliers and collaboration with an incumbent supplier--at the same time. They found that (1) high competitive/technological risks enhance the focal firm's search and collaboration, while high demand/market risks lower the focal firm's search and collaboration; (2) the focal firm reduces search and enhances collaboration, as its dependence on incumbent supplier increases; (3) execution of both sourcing strategies has a positive effect on responsiveness of the incumbent supplier. Terjesen *et al.* (2012) drew on differentiation-integration duality to suggest that manufacturing firms should seek to achieve both integration through supply chain coordination activities and differentiation through modularity-

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based manufacturing practices (MBMP). They identified an inverse U-shaped relationship between SCI and operational performance and further found that high levels of SCI and MBMP result in enhanced operational performance, especially when industrial risks are high. Their research and findings point out two important issues that are not considered in this research stream: first, supply risks may coexist with the other two industrial risks, therefore future research should investigate the interactions among three industrial risks. Second, SCI alone may not be the best strategy to mitigate supply risks. Any strategy that may have a positive joint effect with SCI on supply risk mitigation is worth researching in the future.

Dimensions of both SCI and performance are missing in the second research stream. Following contingency theory, we propose that future research should carefully choose dimensions of SCI and performance for this research stream, so that they "fit" with certain environmental risks. As we mentioned earlier, Wagner and Bode (2008) identified three risk sources for environmental risks: legal risks, infrastructure risks, and catastrophic risks. As disruptions originated from infrastructure and catastrophic risks always happen suddenly, joint decision-making (i.e. operational integration) helps the supply chain quickly react to such disruptions (Villena *et al.*, 2009). In this sense, short-term performance metrics (i.e. customer service, operational, and financial performance) are more suitable for assessments (Heimbürger and Dietrich, 2012). In contrast, legal changes have a long impact on the focal firm and its supply chain. Hence, long-term relational integration and strategic information integration are more helpful for legal risk mitigation (Kumar *et al.*, 2014). To evaluate their outcomes, long-term oriented performance metrics (i.e. innovation and market performance) are recommended (Li *et al.*, 2015).

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The third research stream is the one without certain risk source, maybe because this research stream covers all the risk sources. Our deduction is supported by our reviewed literature from two different tracks (i.e. information processing theory and knowledge-based view). Information is easily codified knowledge that can be transferred "without loss of integrity once the syntactical rules required for deciphering it are known" (Kogut and Zander, 1992, p. 386). Wong *et al.* (2011) aligned information processing theory with contingency theory (that considers both focal firm's context and its supply chain's context) to test the contingency effects of industrial and environmental risks on the relationship between SCI and performance. They found that under high levels of industrial and environmental risks, the association between SCI and performance would be strengthened. According to the interaction between information processing theory and contingency theory, information integration can contribute to ISCRM through facilitating risk-related information sharing, which can be connected with the second research stream. In contrast, know-how, the main focus of knowledge-based view, involves knowledge that is tacit, complex, and difficult to codify (Kogut and Zander, 1992). Built on knowledge-based view, Naspetti *et al.* (2011) studied the linkage between SCI and supply chain performance improvement with respect to food quality and safety (i.e. organizational risks). They found that perceived organizational risks increase SCI, but mainly on the information integration area. When significant organizational risks are perceived, people engage in knowledge creation and sharing of information benefits. Moreover, in facing a technological change, firms that are integrated vertically into the new technology will perform better than those that are not (Aeuah, 2001). According to knowledge-based view, information integration can contribute to ISCRM through facilitating know-how creation and transfer, therefore saving transaction costs (the theoretical foundation of the first research stream). In sum, future research is encouraged to connect this research stream to the first two research streams to find more interactions for theory development.

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6.2 Conclusion

Through a systematic literature review, our research has clearly analyzed risk sources, scopes and dimensions of SCI, scopes and dimensions of performance to give answers to the first research question (Table 1). The thematic results also remind managers that ISCRM practices are still in an early stage: environmental risks need to receive more attentions; the scope of SCI is mostly restricted in a dyadic relationship; the dimension of SCI stays at the level of information integration; performance improvement is always based on the focal firm perspective; and short-term performance measures (i.e. customer service, operational, and financial performance) still dominate. Furthermore, by applying the contingency analysis, our paper has proposed three research streams to answer the second research question (Figure 2). Three research streams can also help managers realize the ways to improve their ISCRM practices: for integrated industrial risk management, managers are recommended to appropriately adjust their governance mechanisms to demand/market, supply, and competitive/technological risks and facilitate relational governance mechanisms; for integrated environmental risk management, managers are suggested to collaborate with all supply chain partners (i.e. extended integration) and evaluate the outcomes from whole supply chain perspective; for information integration in ISCRM, strategic information sharing will help maintain advantages on innovation performance. We encourage researchers as well as managers to utilize our findings and suggestions to drive the development of ISCRM.

This study has several limitations. First, when forming search strings, we did not include any alternative for the key word “performance”. However, a paper may refer to, for instance, “quality improvement” rather than explicitly “performance”. We may miss some articles due to this

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limitation, but the rigor adopted in our research leads us to believe the robustness of our results. Second, we did not consider the differences between key words and their alternatives. The main reason is to focus on our research questions. Nevertheless, such differences are worth researching, and thus may become a research direction.

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Table 1. Thematic results

Theme	Definition	No.	%
Risk Sources			
Organizational risks	Uncertainty regarding specialized labor, machine/delivery failure, and other random factors	20	30%
Demand/Market risks	Uncertainty in the demand for the focal firm's or its supply chain's output	45	67%
Supply risks	Uncertainty surrounding the acquisition of adequate quantities and qualities of inputs into the production/distribution process	27	40%
Competitive/ Technological risks	Uncertainty associated with rivalry among existing firms and potential entrants into the industry	32	48%
Environmental risks	Uncertainty affecting the overall business context across the supply chain	12	18%
Scopes of SCI			
Limited dyadic downstream integration	Integration between the focal firm and its customer(s)	27	40%
Limited dyadic upstream integration	Integration between the focal firm and its supplier(s)	39	58%
Limited dyadic integration	Integration between two firms, but no focal firm is specified	12	18%
Limited triadic integration	Integration of supplier(s) - the focal firm - customer(s) as a whole	4	6%
Extended integration	Integration of more than three firms along the supply chain	7	10%
Dimensions of SCI			
Information integration	The coordination of information transfer, collaborative communication and supporting technology among firms in the supply chain	58	87%
Operational integration	The collaborative joint activity development, work processes and coordinated decision making among firms in the supply chain	35	52%
Relational integration	The adoption of a strategic connection between firms in the supply chain characterized by trust, commitment, and long-term orientation	33	49%
Scopes of Performance			
Focal firm performance	Performance of the focal firm	41	61%
All firms' performance	Individual performance of all the firms in the supply chain	14	21%
Whole supply chain performance	Performance of the supply chain as a whole	19	28%
Dimensions of Performance			
Customer service performance	Performance of customer value and satisfaction	30	45%
Operational performance	Performance of delivery, production cost, product quality, and production flexibility	46	69%
Innovation performance	Performance of time-to-market and innovation level	11	16%
Market performance	Performance of market share, the growth of market share, and the growth of sales	10	15%
Financial performance	Performance of cash flow, return on investment (ROI), profit margin on sales, and the growth of ROI	23	34%

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Table 2. Identified statistically significant pairs

Pairs	Expected relative frequency count (%)	Observed relative frequency count (%)	Exact significance (one-sided)	Phi coefficient (φ)
D/MR -- LDDI	17.7 (26.4%)	23 (34.3%)	0.005	0.338
D/MR -- IP	7.2 (10.7%)	3 (4.5%)	0.006	0.358
SR -- CSP	11.6 (17.3%)	17 (25.4%)	0.007	0.330
SR -- OP	17.9 (26.7%)	23 (34.3%)	0.005	0.340
C/TR -- LDUI	18.6 (27.8%)	24 (35.8%)	0.007	0.326
C/TR -- FFP	19.6 (29.3%)	28 (41.8%)	0.000	0.516
C/TR -- WSCP	9.1 (13.6%)	1 (1.5%)	0.000	0.535
C/TR -- IP	5.3 (7.9%)	9 (13.4%)	0.015	0.302
ER -- EI	1.3 (1.9%)	4 (6.0%)	0.016	0.349
LDDI -- RI	13.3 (19.9%)	19 (28.4%)	0.005	0.347
LDDI -- FFP	16.5 (24.6%)	22 (32.8%)	0.005	0.342
LDUI -- RI	19.2 (28.7%)	25 (37.3%)	0.004	0.351
LDUI -- FFP	23.9 (35.7%)	29 (43.3%)	0.009	0.319
LDUI -- WSCP	11.1 (16.6%)	6 (9.0%)	0.006	0.340
LDUI -- CSP	17.5 (26.1%)	24 (35.8%)	0.001	0.398
LDI -- RI	5.9 (8.8%)	2 (3.0%)	0.013	0.304
LDI -- WSCP	3.4 (5.1%)	9 (13.4%)	0.000	0.483
EI -- FFP	4.3 (6.4%)	1 (1.5%)	0.012	0.329
EI -- WSCP	2.0 (3.0%)	5 (7.5%)	0.017	0.326
II -- MP	8.7 (13.0%)	6 (9.0%)	0.023	0.326

Notes: Acronym codes: D/MR -- Demand/Market risks; SR -- Supply risks; C/TR -- Competitive/Technological risks; ER -- Environmental risks; LDDI -- Limited dyadic downstream integration; LDUI -- Limited dyadic upstream integration; LDI -- Limited dyadic integration; EI – Extended integration; II -- Information integration; RI -- Relational integration; FFP -- Focal firm performance; WSCP -- Whole supply chain performance; CSP -- Customer service performance; OP -- Operational performance; IP -- Innovation performance; MP -- Market performance.

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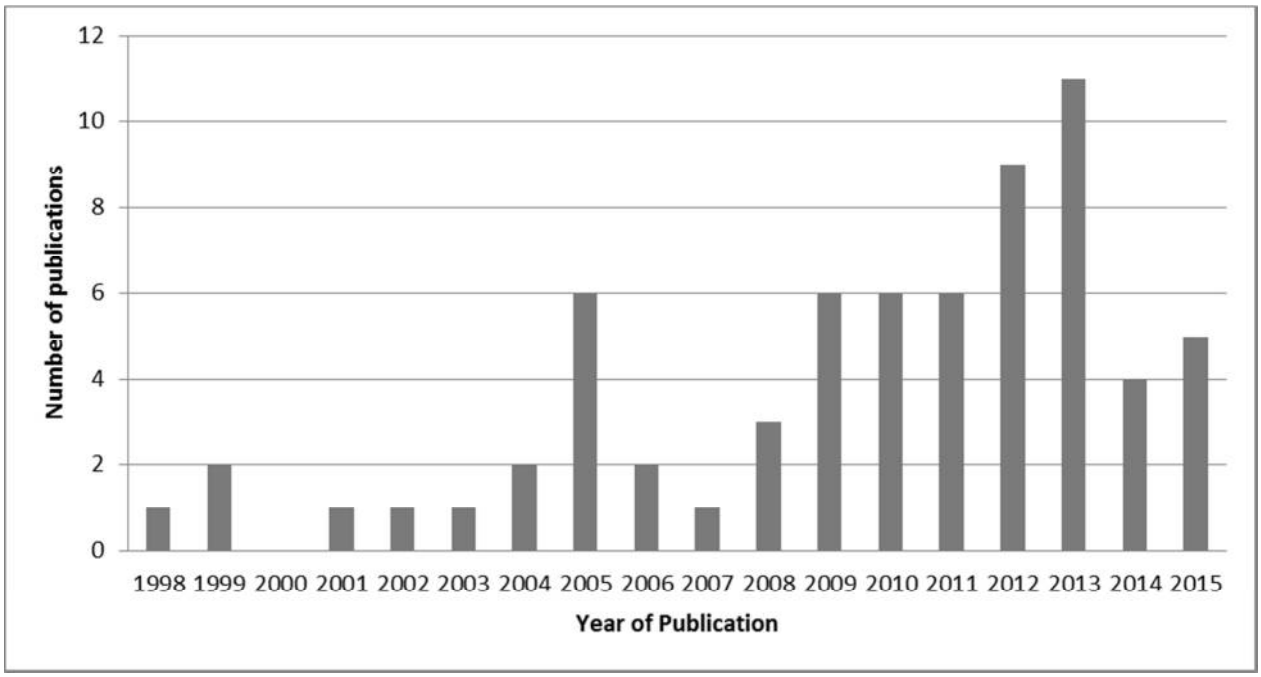

Figure 1. Descriptive results based on year of publication

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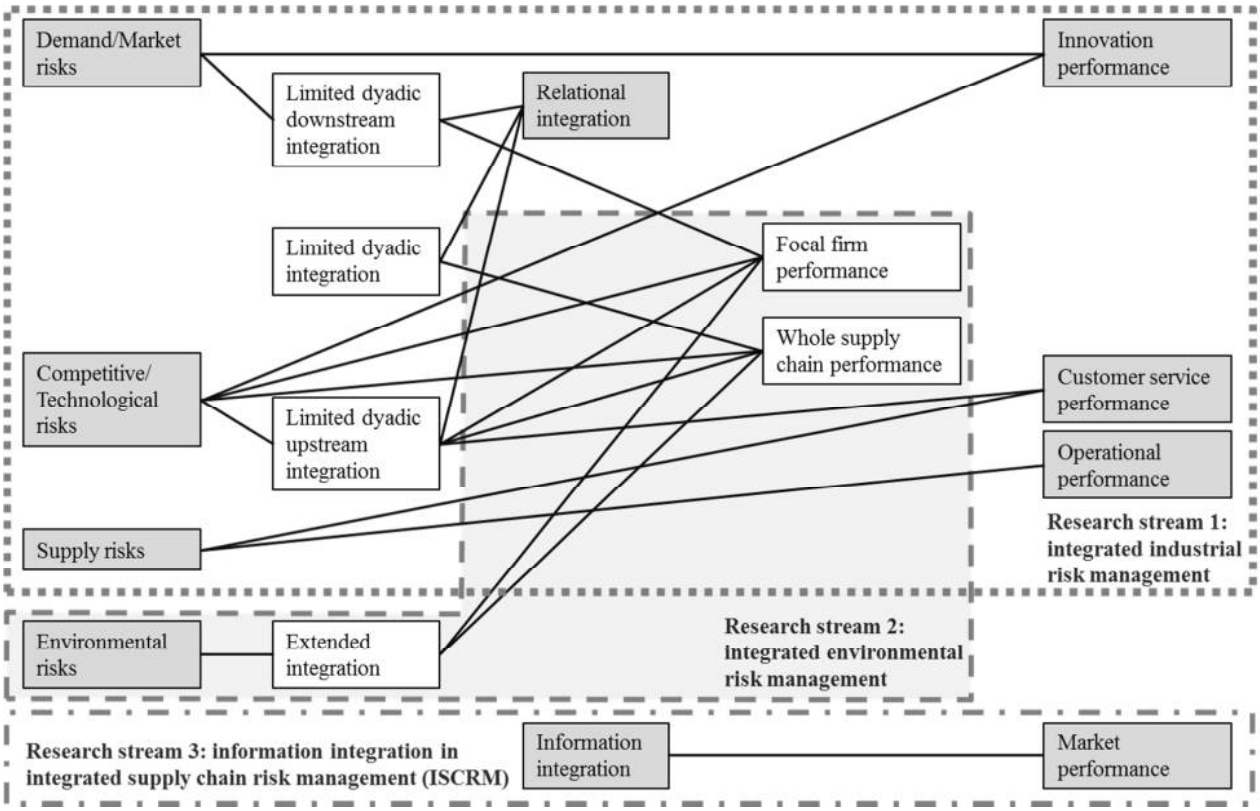

Figure 2. The whole picture of correlations and the separation of three research streams

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