The impact of risk management on the frequency of supply chain disruptions

A configurational approach

Elena Revilla
Department of Operations Management, IE Business School, Madrid, Spain, and
Maria Jesus Saenz
MIT-Zaragoza International Logistics Program, Zaragoza Logistics Center, Zaragoza, Spain

Received 10 March 2016
Revised 27 May 2016
29 July 2016
Accepted 31 October 2016

Abstract

Purpose – The purpose of this paper is to develop a taxonomy of how companies implement Supply Chain Risk Management (SCRM) in terms of two fundamental approaches: the first emerging from internal actions and operations within companies, and the other involving inter-organizational actions undertaken with external supply chain partners. This taxonomy aims to predict firms' performance with regard to the frequency of supply chain disruption.

Design/methodology/approach – A cluster analysis of survey data from 908 firms representing 69 countries together with an analysis of variance.

Findings – The authors' analysis demonstrates a clear structure of four different patterns of how companies manage supply chain risks: passive, internal, collaborative, and integral. The authors found that firms pursuing an inter-organizational orientation (collaborative and integral) face the lowest levels of supply chain disruption. On the contrary, strategies which simply concentrate on having greater control of internal operations are not vigorous enough to stop the cascade effect of a disruption at the supply chain level. Furthermore, the excellent performance of integral SCRM strategies also suggests that collaboration between buyers and suppliers ensures the efficacy of internal business continuity plans and security procedures.

Practical implications – Managers should play an active role in making sure that supply chain management and risk management disciplines evolve together. Obviously, when an exogenous event results in a supply chain disruption, a firm will try to put its operations under control through internal capabilities. But SCRM strategies designed proactively in advance with relevant partners are even more beneficial.

Originality/value – First, previous studies have limited the analysis of SCRM mainly to its reactive internal initiatives within a firm. This paper takes the SCRM literature beyond the internal focus by considering both internal and inter-organizational efforts and, more importantly, developing a single configurational model to analyze modes of interaction. Second, there is little empirical evidence showing the current situation of SCRM. Research in SCRM has been more qualitative than empirical, especially in global coverage. The research tackles this gap and, based on a broader scope of the samples the empirical findings show a higher level of generalizability.

Keywords Survey, Supply chain management, Collaboration, Disruption, Taxonomy

Paper type Research paper

1. Introduction

The dynamic and complex evolution of markets has encouraged many firms to implement various supply chain initiatives to try to boost efficiency (Sodhi *et al.*, 2012). Additionally, Supply Chain Risk Management (SCRM) has evolved to leverage outsourcing and globalization. As a result, aspects such as operational complexity and dispersion are making the supply chain more vulnerable to risks that negatively affect both short- and long-term operational and financial performance (Aon, 2013; Craighead *et al.*, 2007; World Economic Forum, 2008; Rao and Goldsby, 2009; Sheffi, 2001, 2015; Thun and Hoenig, 2011).

International Journal of Operations & Production Management
Vol. 37 No. 5, 2017
pp. 557-576

0144-3577
DOI 10.1108/IJOPM-03-2016-0129

Supply chain disruption risk is defined in the extant literature as an unplanned, unintended, and exceptional situation that disrupts the normal flow of goods and materials within a supply chain (Craighead *et al.*, 2007; Hendricks and Singhal, 2003; Kleindorfer and Saad, 2005; Svensson, 2002). It has the potential to cause physical damage, threaten production and distribution, damage sales, reduce company revenue, cut into market share, inflate costs, and cause budget overruns. Disruptions also can damage company credibility with investors, resulting in a devastating impact on shareholder value and driving up the cost of capital (Hendricks and Singhal, 2003, 2005). For example, Land Rover had to adjust production of its Discovery model because the exclusive chassis supplier filed for bankruptcy (Sheffi, 2005; Thun and Hoenig, 2011). Only by a high expenditure of goodwill was Land Rover able to avert a nine-month disruption of production as well as the loss of 1,500 jobs. Likewise, Japanese automaker Nissan was hit by fallout from the 2011 Japan tsunami; its plant in Iwaki was temporarily closed down but returned to full operation days later. Over recent years, manufacturing has been interrupted by floods in Thailand and Australia, droughts in the USA, earthquakes in New Zealand, shutdown of all air traffic in Europe due to terrorism in France or volcanic eruptions in Iceland, and a horrific fire in a clothing factory in Bangladesh, all of which affected deliveries to customers including Wal-Mart, Sears, or Disney. Consequently, academics and practitioners are reporting increased concerns about the rise of supply chain disruptions and their implications (Chopra and Sodhi, 2014; Christopher and Lee, 2004; Kleindorfer and Saad, 2005; Rao and Goldsby, 2009; Sheffi and Rice, 2005; Sodhi *et al.*, 2012).

Today's managers and researchers are aware that a better understanding of SCRM is needed (Chopra and Sodhi, 2014; Kaku and Kamrad, 2011; Manuj and Mentzer, 2008; Speier *et al.*, 2011). The development of a solid body of literature on SCRM is still in progress, with little effort to consolidate findings in a unifying picture (Jüttner and Maklan, 2011; Jüttner, 2005; Sodhi *et al.*, 2012). The existing literature has discovered a wide range of SCRM practices (Manuj and Mentzer, 2008; Simangunsong *et al.*, 2012), but findings remain disconnected, so there is no clear understanding of the strategic behavior that firms employ in response to supply chain disruption (Bode *et al.*, 2011). Additionally, the literature of SCRM tends to be conceptual and to lack empirical underpinning (Sheffi, 2005). Accordingly, the purpose of this study is to develop and test a taxonomy of SCRM strategies that explain how firms respond to supply chain disruption.

Another important element of risk that remains largely unexplored is the frequency (or likelihood) of supply chain disruption (Bode and Wagner, 2015). Most studies have investigated the firm's losses if a disruption actually occurs (Hendricks *et al.*, 2009). Although these studies offer valuable insights, they focus on the impact of disruption (Holton, 2004). Thus, a related research objective is to analyze how different strategies prevent a disruption from occurring.

Companies traditionally centered their risk management efforts on internal practices that entailed only functions within the boundaries of the company. Recently, however, a new phenomenon has gathered the attention of academics and industry around supply chain disruption at the inter-organizational level. This involves a minimum of two firms engaged in a relationship – typically, mature companies known for their excellence in supply chain operations, who have widened the focus of their SCRM efforts to encompass factors external to the firm in order to align internal efforts with key suppliers, strategically important buyers, and other relevant stakeholders (Chopra and Sodhi, 2014; Manuj and Mentzer, 2008). Therefore, two dimensions for managing supply chain risks can be recognized: one that emerges from internal actions and operations within companies, and another that involves interactions with external supply chain partners (Craighead *et al.*, 2007; Sáenz and Revilla, 2014; Sheffi and Rice, 2005). Considering both internal and inter-organizational

approaches, we propose a taxonomy with four types of strategies: passive, internal, collaborative, and integral. In addition, this research provides theoretical support to explain why certain strategies lead to success in avoiding disruptions.

This study offers two main contributions to the literature. First, previous studies have limited the analysis of SCRM mainly to its reactive internal initiatives within a firm (Kleindorfer and Saad, 2005; Melnyk *et al.*, 2014). However, in the present era of globalization, where organizations are increasingly expanding across international boundaries (Naor *et al.*, 2010; Speier *et al.*, 2011), firms must anticipate and manage proactive practices jointly with a dispersed network of suppliers and/or buyers in order to manage the vulnerabilities (Sheffi and Rice, 2005; Wieland and Wallenburg, 2013; Zsidisin and Wagner, 2010). This paper takes the SCRM literature beyond the internal focus by considering both internal and inter-organizational efforts and, more importantly, developing a single configurational model to analyze modes of interaction. This configuration perspective establishes patterns or profiles that capture the complexities of organizational reality (Ketchen and Shook, 1996; Miller, 1986), facilitating a strategic and holistic analysis of SCRM.

Second, despite this considerable attention, there is little empirical evidence showing the current situation of SCRM development within organizations. Research in SCRM has been more qualitative than empirical (see recent claims from Chen *et al.*, 2013; Sodhi *et al.*, 2012), especially in global coverage. Most of the reports are based on single or multiple case studies. Accordingly, typologies which often have been used in the extant literature to describe the phenomenon underlying SCRM (Oke and Gopalakrishnan, 2009; Simangunsong *et al.*, 2012) show a strong descriptive and prescriptive orientation. This literature lacks an explanatory and predictive orientation. Our research tackles this gap and, based on a rich sample of 908 firms representing 69 countries, provides solid empirical evidence about different configurations of SCRM strategies and how they relate to the frequency of supply chain disruptions. Hence, the empirical findings from this study provide a high level of generalizability.

2. SCRM

From the Industrial Revolution to the present day, supply chains have faced important changes, evolving from high-volume simple business models to extended supply chain networks. The consequences of these patterns of changes are clear, as nowadays supply chains include significant levels of dependence on globalization and efficiency (Chopra and Sodhi, 2014; Sáenz and Revilla, 2014). The opportunity for efficiency, however, is complicated. Efficiency helps smooth supply chain operations, but it also opens new sources of vulnerability if unexpected circumstances occur (Tang and Musa, 2011).

The tsunami catastrophe that struck Japan in March 2011 demonstrated the disturbing consequences of supply chain disruptions. Stoppages to supply and production in Japan had a ripple effect in many parts of the world. For example, Apple relied on suppliers in Japan for 25 percent of the components used in its new iPad2 product. Moreover, many of these contractors were sole-source suppliers. Without knowing about the tsunami occurrence, Apple decided to launch the iPad2 just hours after the wave hit. Subsequent shutdowns caused stock shortages and long delays in deliveries. As a result, the company's share price declined by 8 percent, which frustrated iPad2's buyers as well as Apple's shareholders (Revilla and Saenz, 2014). The firm's dependence on buyers and/or suppliers, along with subsequent inventory reduction, amplified the severity of the disruptive event, a phenomenon already discussed by Craighead *et al.* (2007), Swaminathan (2003), and Wagner and Bode (2006). The need to ensure continuity of the flow of goods along the supply chain, while using shorter time periods to return to the original or improved operations status, has motivated a fast-growing body of research in SCRM (Chopra and Sodhi, 2014; Kleindorfer and Saad, 2005; Revilla and Saenz, 2014; Simangunsong *et al.*, 2012; Zsidisin and Wagner, 2010).

Rooted in the literature of enterprise risk management, SCRM started employing internal practices with minimal insights on the collaboration between supply chain partners (Li *et al.*, 2015). However, when the degree of dependence on supply chain partners increases, it is more likely that a disruption will be transmitted from supply chain partners rather than the focal firm's facilities. Thus, the higher the degree of dependence on supply chain partners, the higher the need for collaboration to respond to a supply chain disruption (Bode *et al.*, 2011). Without incorporating the collaboration in terms of SCRM, managerial efforts to deal with the uncertainty are unlikely to be effective.

We highlight the importance of collaboration in SCRM and adopt the SCRM definition proposed by Juttner *et al.* (2003) 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" (p. 9). Accordingly, SCRM should go beyond a single company perspective and adopt not only internal initiatives but also relevant inter-firm practices (Oke and Gopalakrishnan, 2009; Scholten and Schilder, 2015; Li *et al.*, 2015). In this study, we distinguish two main SCRM strategies for avoiding supply chain disruption, the first emerging from internal actions and operations within a particular company, and the other involving inter-organizational actions undertaken with external supply chain partners.

2.1 SCRM approaches

Building on the internal dimension, we observe that as a direct consequence of making a global supply chain too "lean" and hence "fragile," many firms have created a risk management infrastructure to manage supply chain disruptions (Chopra and Sodhi, 2014). This infrastructure includes the presence of risk managers or groups, the deployment of business continuity plans, formal security procedures or emergency operations centers (Manuj and Mentzer, 2008; Revilla and Sáenz, 2011; Zsidisin *et al.*, 2005). A firm that is able to organize a resources structure with these characteristics shows continuous preoccupation with improving processes and preventing failure. This commitment to learning helps firms reduce process variability, fix root causes of problems, or use an advance warning system that identifies deviations from expectations and automatically pinpoints corrective actions to be taken immediately. In so doing, a risk management infrastructure allows firms to manage supply chain risks from a systematic approach, being regularly aware of the environment and able to proactively respond to disruption by learning from past experiences (Ambulkar *et al.*, 2015). Response time is critical when a firm is hit by a supply chain disruption (Bode *et al.*, 2011). As a result, firms must take quick action by implementing formalized procedures and resources that are integrated internally.

Interestingly, disruptions give firms a collection of rich experiences that can help tailor responses to new problems. For example, a post-incident analysis helps to identify relevant lessons learned, increasing the knowledge about supply chain risks to efficiently manage future disruptions. Firms may need to renew and reconfigure the resources and processes of the risk management structure to maintain and improve their capabilities in that regards.

An inter-organizational (external) SCRM dimension, on the other hand, requires the deployment of active cooperation upstream with the firm's supply chain partners (suppliers of products or services, as well as logistics service providers), and downstream with buyers. This cooperation ensures that changes caused by a disruption can be absorbed by the supply chain through a collective and effective response. Most authors identify two key elements of a collaborative SCRM approach: risk information sharing and risk sharing (Kleindorfer and Saad, 2005; Li *et al.*, 2015). The first term reflects the supply chain partners' willingness to share even sensitive operational or risk-event information (Faisal *et al.*, 2006). Sharing appropriate and timely information between supply chain actors may lead to improved supply chain visibility (Christopher and Lee, 2004) for identifying possible threats or sources of disruption, allowing firms to take mitigating action before a disruption occurs

(Brandon-Jones *et al.*, 2014). For example, the same disruptive event of a strike at the seaport of Los Angeles proved to be less severe for those retailers with better visibility systems, because it allowed goods to be routed through other ports of entry (Craighead *et al.*, 2007).

The second term, risk sharing, acknowledges joint obligations and responsibilities in activities and resources relating to SCRM (Li *et al.*, 2015). Because risk sharing requires coordination among buyers, suppliers and services providers, all supply chain members must be able to make joint sense of supply chain vulnerabilities and potential consequences. That issue is especially relevant since the perception of risk, rather than the objective assessment of risk, guides decision-making behavior (March and Shapira, 1987). Similarly, subjective judgments of risk are a significant determinant of managerial choice (Ellis *et al.*, 2010; Zsidisin *et al.*, 2005; Zsidisin and Wagner, 2010). Even when objective data are available to support decision-making, issues related to interpretation may interject bias into the risk assessment process (Stone *et al.*, 1994). Thus, a joint understanding of supply chain vulnerability is needed to advance the logic of mutual adjustments and to enact mechanisms for reducing exposure to potential supply chain disruptions.

2.2 A SCRM taxonomy

This research builds upon the configurational approach based on the internal and inter-organizational dimensions of SCRM to classify firms into mutually exclusive and exhaustive groups. Because companies may emphasize differing SCRM practices (internal, inter-organizational or a combination of both approaches), various configurations of SCRM can exist. Hence, we develop a parsimonious taxonomy, shown in Figure 1, that organizes and consolidates all information about group configurations, illustrating the differences in the two fundamental approaches that characterize SCRM.

Figure 1 highlights how the two SCRM dimensions result in four extreme configurations. Low levels of both internal and inter-organizational risk management practices indicate a passive SCRM strategy. Managers who perceive SCRM as something that obstructs their major objectives of cutting costs and inventories will strive to achieve their objectives without any efforts in prediction, prevention, or mitigation. As passive firms, they accept the environment as given, interpret it within narrow limits and simply improvise once an important contingency occurs. A passive firm is less motivated to spend time and resources to understand and prevent sources of uncertainty (Daft and Weick, 1984). As result, these firms do not learn much from past experiences, provide feedback on how to handle vulnerabilities, or know how to implement complementary corrective actions. Without effort and relevant prior experience managing disruptions, we do not expect that this strategy helps prevent disruptions from occurring.

Low levels of inter-organizational practices along with high levels of internal SCRM indicate an internal SCRM strategy. This configuration mainly articulates internal

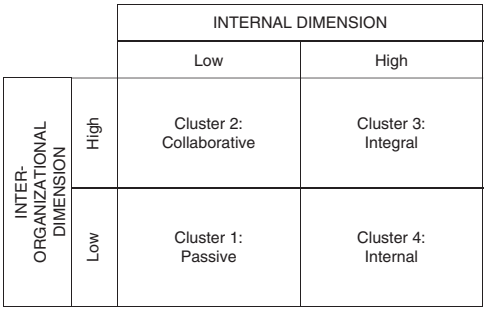

Figure 1.
SCRM taxonomy

resources and capabilities for a risk management infrastructure that guarantees the continuity of the operations and information flow within the company. Having a risk management infrastructure enables firms to systematically manage supply chain risks (Ambulkar *et al.*, 2015). It also helps firms to be continuously vigilant about their environments, behave proactively, and try to learn from their experiences (Daft and Weick, 1984). Additionally, this strategy uses previous experience for dealing with supply chain disruption. Successful decisions at the internal level, however, might require joint decision-making, effective synchronization of operations beyond boundary spanners, and clear convergence of interests among independent supply chain partners.

When SCRM is biased toward an inter-organizational perspective with low levels of internal practice, a collaborative SCRM strategy exists. In this configuration, firms attempt to deal with disruption issues mainly through the external network, liaising with other partners in the supply chain. Through risk information sharing between partners, this strategy enhances supply chain visibility, facilitating the identification of broad warning systems and improving responsiveness. Likewise, this strategy may include contracts that stipulate supply chain partners' obligations and responsibilities relating to SCRM, as well as collaborative mechanisms that align incentives among firms and facilitate their understanding (i.e. collaborative planning or vendor-managed inventories) to reduce the vulnerability of the supply chain. However, firms adopting this strategy without a minimal internal risk management infrastructure may spend more time on negotiation about shared duties and obligations and work less effectively when resolving SCRM problems.

Finally, an integral SCRM strategy appears when firms combine efforts of internal and inter-organizational risk management. In this configuration, managers are not willing to mitigate and reduce risks alone. They are willing to connect processes and align forces to provide a more coordinated response to the high levels of environmental and operational risks inherent in global and complex supply chains. In this case, SCRM practices such as business continuity analysis or security procedures are developed in collaboration with supply chain partners. This configuration builds holistic and inter-organizational capabilities to cope with threats to supply continuity and hastens to restore the supply chain after a disruption. Thus, we propose the following hypothesis:

H1. An emergent taxonomy of SCRM can be developed based on a firm's internal and inter-organizational efforts.

2.3 Disruption occurrences

One major goal of this research is to determine whether the use of different SCRM strategies reduces the frequency with which firms experience the effects of disruptions. We further believe that diverse methods significant and differently affect the frequency of supply chain disruptions.

According to our SCRM taxonomy, it is obvious to think that firms with a passive SCRM strategy evoke the highest levels of disruption. Passive firms do not work actively on SCRM or do not consider it effective. Their managers lack a risk orientation to alert them to possible supply chain disruption (Bode *et al.*, 2011). As a result, they are reluctant to engage in active information searches, behave proactively, and learn from their experience as active firms (Daft and Weick, 1984). Without previous experience that gives firms a framework for how to deploy SCRM, including benefits and performance, we do not expect a passive strategy to reduce the frequency of supply chain disruptions. Historically, insurance has been used as a primary component of SCRM (Aon Risk Solutions, 2013). But when a firm faces a significant disruption, the previously contracted insurance does not replace buyers who have impatiently turned to other suppliers (FM Global, 2011) – thus exposing a weakness of the insurance strategy. As understanding of supply chain vulnerabilities broadens, firms do not need to rely solely on insurance or to accept new supply chain risks

as insurmountable; they can move from a scant level of concern about disruption toward more proactive policies of SCRM (Sáenz and Revilla, 2014).

Internal SCRM strategies put in place a risk management infrastructure to manage supply chain disruption. With greater control of the internal operations and a commitment to learn from disruption, firms develop rules and routines for dealing with supply chain disruption. For example, the implementation of an emergency operations center standardizes procedures for coordinating all of the functions affected by a disruption. It facilitates the re-establishment of control over supply chain operations, so the firm may continue with normal activities and responsibilities (Manuj and Mentzer, 2008). In addition, this strategy exploits prior experience to illuminate supply chain vulnerabilities and guide choices from available options. An internal risk management strategy should therefore be positively related with a reduction of disruption occurrences; however, the effectiveness of this relationship might improve if continuity plans are jointly developed with key supply chain partners (Zsidisin *et al.*, 2005). Even for internal SCRM methods, firms need to be alert about how the other supply chain players control internally their own operations.

In the case of collaborative SCRM strategy, firms work jointly with their supply chain partners to deal with supply chain risks. Buyers and suppliers collaboratively make decisions related to risk management priorities and paradigms (Manuj and Mentzer, 2008). This opportunity for communication, cooperation, and coordination creates a sharing culture of reliability. Decision guidelines aid firms involved in SCRM when an important contingency happens and everyone needs to react in a quick, easy, and properly aligned manner (Wagner and Neshat, 2012). Furthermore, proper visibility and joint understanding in SCRM issues ensure that disruptions are handled with agile and effective responses (Christopher and Lee, 2004). Pursuing a collaborative strategy reduces the frequency of supply chain disruption, but the lack of an internal risk management infrastructure may diminish its effectiveness. For example, a firm facing problems with finished-goods manufacturing or product quality may collaborate with suppliers but still have a limited range of response without internal operational processes (Chapman *et al.*, 2002; Kleindorfer and Saad, 2005). Likewise, best-performance firms should pursue the adoption of an integral SCRM strategy that goes beyond operational processes and spans the firm's relationships with buyers and suppliers. Some companies have been working for a decade on maturing a robust integral SCRM strategy. Cisco Systems, for example, uses supply chain risk planning activities throughout the design process, including supplier monitoring, information exchange with suppliers and buyers, and contingency plans aimed to control internal operations as well as of those partners (Sáenz and Revilla, 2014).

Accordingly, we offer the following hypotheses:

H2. SCRM strategies determine the frequency with which firms experience the effects of disruption.

H2a. Firms pursuing SCRM strategies that show higher levels of internal efforts will obtain lower levels of disruption than those that make lower efforts.

H2b. Firms pursuing SCRM strategies that show higher levels of inter-organizational efforts will obtain lower levels of disruption than those that make lower efforts.

H2c. Firms pursuing an integral SCRM strategy will obtain the lowest levels of disruption.

3. Methodology

3.1 Data collection

Survey-based research (Hair *et al.*, 2006; Saris and Gallhofer, 2007) was used as the main empirical research methodology of this study. A group of academics and researchers led by the Center of Transportation and Logistics at MIT, under the MIT Global SCALE

Risk Initiative, designed and developed the questionnaire tool based on a thorough literature review. The questionnaire was then validated through a pre-test carried out with four academics, five supply chain executives, and two senior consultants in the field of SCM. These interviews allowed us to purify our survey items and rectify potential deficiencies. Minor adjustments were made on the basis of specific suggestions. Finally, the survey was reviewed and approved by MIT's Committee on the Use of Humans as Experimental Subjects (COUHES). All facets of this project adhered to COUHES regulations and protocols.

A large-scale, worldwide, online survey was used as the base. Target respondents consisted of supply chain professionals at decision-making levels and in strategically oriented positions from different cultures, countries, and industries. Respondents were asked to provide information about their SCRM experience, attitudes and opinions, major disruptions on their site, and supply chain practices. To ensure the validity of the data, we also evaluated the respondents' competency and knowledge of the subject at hand. Table I shows the profiles of the respondents.

We measured respondents' backgrounds: age (63.2 percent were older than 40), gender (82.2 percent were males and 14.4 percent females, having no response for the rest), and education (62.1 percent held a university or master's degree). Respondents averaged 12.9 years of experience in their industry (median = 13 years); 32.5 percent of them were middle managers, 32.8 percent senior managers, and 8 percent vice presidents. Collectively, the selected respondents were proven to be competent to complete the survey.

Due to the global scope of this study, the survey was formally translated from English into eight languages or dialects (Portuguese, Brazilian Portuguese, Mexican Spanish, Castilian Spanish, German, Greek, Italian, and Mandarin Chinese) following a homogeneous and rigorous procedure for subsequent testing and further distribution to the target audience. In each of the different regions, a professional association for supply chain managers was key in reaching a larger number of potential respondents. For example, the American Production and Inventory Control Society and the Council of Supply Chain Management Professionals collaborated in the USA and the Centro Español de Logistica in Spain. They sent e-mails to their members asking them to participate in the survey. The data-gathering process took two months (December 2009 through January 2010) with information collected simultaneously in all of the countries. The average time required to complete the survey was 12 minutes.

The webpage where the survey was posted attained 2,240 visits, with 1,460 persons answering the survey. After screening out spurious and incomplete responses (less than half of the questions answered on the survey), conducting a missing value analysis (with a result of 1.5 percent overall) and deleting responses from countries not sufficiently represented, there were 908 valid, complete survey responses for the study. Table II shows the diversity among the participating firms based on the number of employees and the different roles of

	%		%
Job level		*Age*	
Worker	11.3	20-39	36.78
Team leader	6.5	40-59	58.33
Supervisor	7.1	60+years	4.89
Middle manager	34.5	*Gender*	
Senior manager	32.8	Males	82.2
Vice president	8.0	Females	14.4

Table I.
Profile of respondents

Note: $n = 908$

the companies in their supply chains. Likewise, Table III displays the variety of countries to which the participating firms belong.

Before examining the data, every member of the research team who would have contact with the survey results took a basic online course on social and behavioral research and passed a final exam. This course was provided by the Collaborative Institutional Training Initiative Program for the Protection of Human Research Subjects.

Because we collected information on the variables of interest from a single respondent within a single firm, common method bias could present a problem. The potential for common method bias was assessed based on Harman's test as described in Podsakoff *et al.* (2003). It consisted of loading all of the variables into an exploratory factor analysis (EFA) and examining the unrotated factor solution. Results revealed seven distinct factors with eigenvalues above 1.0, which together explained more than 63.7 percent of the variance. The first factor accounted for only 20.9 percent of the variance. Since a single factor did not emerge and the first factor did not account for most of the variance, common method bias should not be an issue in the data.

3.2 Measures

Measurement for the study was based on the multiple-items method, which enhances confidence in the accuracy and consistency of the assessment (Saris and Gallhofer, 2007). All perceptual variables used a Likert-type scale response format. The survey items are reported in Table IV.

Two managerial dimensions were assessed, pursuant to the literature. Internal dimension expresses the degree to which a firm effectively organizes a risk management resources structure. It includes the development of a risk manager or group, business continuity plan, formal security strategy, or emergency operations center (Kleindorfer and

	Total	Manufacturer (%)	Retailer (%)	3PL (%)	Other (%)
Total number of employees	908	66	5	9	21
1-100	26%	23	19	37	38
101-1,000	35%	36	28	36	30
1,001-over 2,000	39%	42	53	27	33

Table II.
Profiles of responding companies by size

Country	%
Brazil	4.1
Canada	1.6
Colombia	1.2
China	3.8
Germany	1.0
India	4.6
Italy	5.1
Mexico	2.6
South Africa	10.8
Spain	8.0
Switzerland	9.2
UK	1.5
USA	33.1
Other	13.4
Total	100.0

Table III.
Variety of countries participating in the research

Variables	Factor
Control variables	
SIZE	
Number of people worldwide	
Size of annual revenues (globally) in USD	
SC ROLE	
Manufacturer	
Retailer	
3PL	
Natural Hazards $\alpha = 0.75$	
How often has your supply chain been disrupted by these events?	
1 Hurricanes, tornados, or typhoons[a]	0.82
2 Earthquakes or tsunamis[a]	0.85
3 Floods or mudslides[a]	0.74
Market $\alpha = 0.79$	
How often has your supply chain been disrupted by these events?	
1 Price collapse due to a new competitor[a]	0.86
2 Sales collapse due to a new competing product[a]	0.87
Socioeconomic $\alpha = 0.67$	
How often has your supply chain been disrupted by these events?	
1 Economic recession[a]	0.67
2 Protracted labor disputes[a]	0.75
3 Sudden currency devaluation[a]	0.78
Operational Contingency $\alpha = 0.76$	
How often has your supply chain been disrupted by these events?	
1 Raw material supplier failure[a]	0.71
2 Finished goods manufacturing failure[a]	0.81
3 Transportation carrier failure[a]	0.72
4 Product quality failure[a]	0.74
Supply Chain Risk Management (SCRM)	
Internal $\alpha = 0.80$ degree of effective development of α	
1 Risk manager or group[b]	0.75
2 Business continuity plan[b]	0.77
3 Formal security strategy[b]	0.69
4 Emergency operations center[b]	0.75
Inter-organizational $\alpha = 0.79$	
1 We actively work on supply chain risk management[b]	0.69
2 We work with buyers on supply chain risk management[b]	0.79
3 We work with suppliers on supply chain risk management[b]	0.89
Disruption occurrence $\alpha = 0.70$	
How often has your firm experienced the following types of supply chain disruption?	
1 Your own internal operations are interrupted (e.g. power failure, machine breakdown, fire, etc.)[a]	0.78
2 You cannot communicate with vendors, buyers or other sites (e.g. systems fail, internet down, etc.)[a]	0.79
3 You lose supply of quality materials (e.g. supplier fails or cannot deliver, bad product quality, etc.)[a]	0.75
4 You cannot ship or deliver your products (e.g. no transportation, ports closed, roads blocked, etc.)[a]	0.78

Table IV.
Measurement items

Notes: [a]Scale: never; rarely; about yearly; weekly or monthly; almost daily. [b]Scale: Yes and it is effective; Yes but it is not effective; No, I do not know; Not applicable

Saad, 2005; Zsidisin *et al.*, 2005). Inter-organizational dimension expresses the degree to which the firm actively works with its supply chain partners in risk management issues (Sheffi and Rice, 2005; Thun and Hoenig, 2011; Zsidisin *et al.*, 2005).

Supply chain disruptions occur when the normal flow of goods and materials within a supply chain is disturbed. When internal operations are interrupted and a company cannot communicate with supply chain participants, the goods supply is lost, or products cannot be

delivered or shipped. In accordance with Norrman and Jansson (2004) and Oke and Gopalakrishnan (2009), we measured the frequency of a company's supply chain disruptions.

In control variables, we included firm size, role in the supply chain, and risk sources. We examined firm size, measured as the number of employees and the annual revenues of the firm for the year 2009 (Wagner and Neshat, 2012), because it seems plausible that larger firms will be more often involved in complex supply chains more susceptible to disruption. With supply chain roles, we controlled for differences between the following roles: manufacturer, retailer, and logistics service provider. Compared with manufacturing firms, other intermediate supply chain participants, such as retailers, wholesalers or logistics service providers, have loosely coupled processes. When the interdependency of processes in a firm is less complex, disruption occurrence will be rather low (Perrow, 1984; Speier *et al.*, 2011; Wagner and Neshat, 2012).

Risk sources were included because the higher the uncertainty, the higher the frequency of supply chain disruption. Four areas were measured: market – as noted by Rao and Goldsby (2009), risks associated with the market include price or sales collapse when a firm faces new competition; natural hazards – these are very well identified in the extant literature, covering hurricanes, tornados, typhoons, earthquakes, tsunamis, floods, or mudslides (Chopra and Sodhi, 2004; Kleindorfer and Saad, 2005; Rao and Goldsby, 2009; and Sheffi and Rice, 2005); socioeconomic context – this issue affects the overall business atmosphere across industries, including problems of economic recession, protracted labor disputes, or sudden currency devaluation (Rao and Goldsby, 2009; Sheffi and Rice, 2005); and operational contingences (Revilla and Saenz, 2014). This area includes issues related to supplier, manufacturing, transportation, or product quality failures (Kleindorfer and Saad, 2005).

The validation process for the survey instrument involved two steps: construct validity and reliability. Construct validity was measured with EFA where 0.4 is considered to be the lowest significant factor loading to define constructs (Hair *et al.*, 1998). Our EFA for all the items of multi-item scales resulted in theoretically expected factor solutions. We then computed the reliability coefficients using Cronbach's α (Cronbach, 1951), which ranged between 0.67 and 0.80, well exceeding the minimum limit of 0.6 (Nunnally, 1978). We also computed the average variance explained (Anderson and Gerbing, 1988), which was in the range of 52.5-66.1 percent.

3.3 Analysis approach

Following the approach described by Revilla and Villena (2012), analysis was conducted in two stages: first, the identification of the patterns/profiles of SCRM and later, the comparison of contextual antecedents and performance outcomes in the groups. In the first case, we employed cluster analysis to classify the firms based on their internal and inter-organizational SCRM practices, thereby identifying SCRM configurations. In the second case, we used ANOVA and Tukey comparison tests in order to identify significant differences across the SCRM clusters in terms of occurrences of disruption.

4. Results

H1 states that an emergent taxonomy of SCRM can be developed based on a firm's internal and inter-organizational efforts, and the data supported this hypothesis. Table V shows the differences in SCRM in terms of internal and inter-organizational SCRM practices among each of the four clusters.

Cluster 1 includes 311 firms with low levels in both internal and inter-organizational SCRM practices, representing a passive SCRM strategy. Cluster 3 includes 231 firms with high levels in internal and inter-organizational SCRM practices, representing an integral SCRM strategy. These two clusters represent strategies that combine either high or low levels across the two integrative mechanisms. In contrast, Clusters 2 and 4

highlight the importance of only one of the SCRM approaches and present a focused SCRM strategy compared with Clusters 1 and 3. Cluster 2, with 218 cases, is characterized by low levels of internal risk management practices and high levels of inter-organizational practices, while Cluster 4, with 148 cases, has high levels of internal practices and low levels of inter-organizational practices. Hence, Cluster 2 companies follow a collaborative SCRM strategy, while Cluster 4 firms pursue an internal SCRM approach.

To examine the other hypotheses, next we used ANOVA and Tukey comparison tests to identify significant differences across the clusters in terms of frequency of supply chain disruption. We also tested the assumption of homogeneity of variance (Levene's test and Brown-Forsythe test). Table VI provides general support for *H2*.

As indicated by the ANOVA test, distinctions in terms of disruption occurrences are particularly salient between firms that emphasize the inter-organizational approach (collaborative or integral SCRM) and the remaining firms, supporting *H2b*. Although firms following an integral SCRM strategy are the best performing (lowest mean value) in terms of disruption occurrences, these firms and those characterized by collaborative strategies can be considered homogeneous in terms of disruption. This result only partially supports *H2c* since it is not validated by the case of collaborative SCRM strategies. Additionally, our results do not find complete support for *H2a* since internal SCRM strategies do not obtain significantly lower levels of disruption than passive SCRM strategies. Figure 2 summarizes these results and shows how the four clusters were differentiated from each other by the two SCRM basic approaches as well as the final effect on disruption occurrences, whose degree is represented by the ball's diameter.

Finally, we followed the same procedure for controlling SCRM strategies. Table VII shows descriptive statistics (mean and deviation values) and the results of the ANOVA test, Levene test, and Brown-Forsythe test for each cluster in terms of control variables.

Our results show that integral SCRM strategies (Cluster 3) are associated with the largest companies. Significant differences in size, both in annual revenues and number of employees, are also found between those firms that follow an internal approach (integral or internal strategies) and those that exhibit a lower level (passive and collaborative). So, firms choosing an internal SCRM orientation (Cluster 3 and 4) are bigger than the other

Table V.
Cluster results for SCRM strategies

	Cluster 1: passive	Cluster 2: collaborative	Cluster 3: integral	Cluster 4: internal	*F* (ANOVA)
Internal	1.14	0.86	2.96	2.53	1167.31***
Inter-organizational	1.44	3.14	2.87	1.18	675.72***
n	311	218	231	148	7.80***
Percentage	34.2	24	25.4	16.2	

Notes: *$p < 0.1$ **$p < 0.01$ ***$p < 0.001$

Table VI.
ANOVA results for disruption occurrence: mean (standard deviation)

	Cluster 1: passive	Cluster 2: collaborative	Cluster 3: integral	Cluster 4: internal	*F* (ANOVA)	Levene's test	Brown-Forsythe
Disruption Occurrence	2.29 (1.08)	1.99 (0.88)	1.89 (1.04)	2.20 (1.03)	7.80***	3.25*	7.92***
Main group differences (Tukey test)							
Disruption occurrence			(1-2)** (1-3)*** (3-4)*				

Notes: *$p < 0.1$; **$p < 0.01$; ***$p < 0.001$

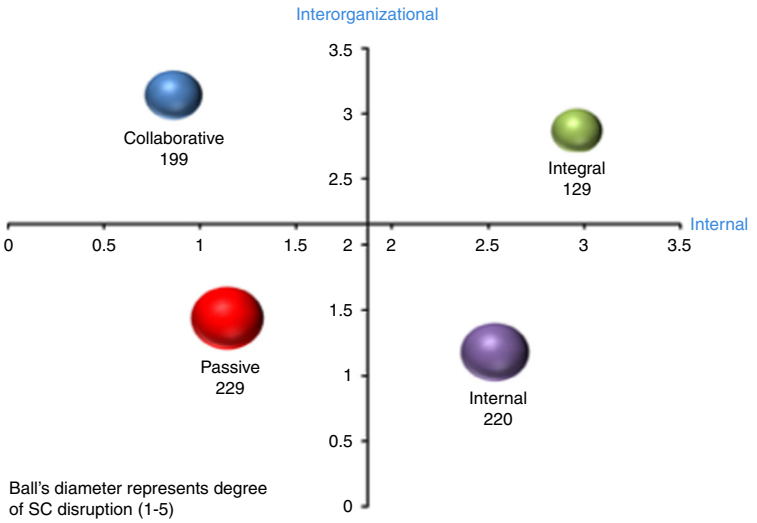

Figure 2.
SCRM taxonomies and their effect on SC disruption

	Cluster 1: passive	Cluster 2: collaborative	Cluster 3: integral	Cluster 4: internal	*F* (ANOVA)	Levene's test	Brown-Forsythe
Size-annual revenues	2.35 (0.98)	2.46 (0.94)	3.11 (0.94)	2.79 (0.95)	28.74***	0.33	29.02***
Size- number of employees	1.74 (0.80)	1.86 (0.77)	2.22 (0.68)	2.08 (0.76)	36.12***	2.24*	36.62***
SC Role-manufacturer	0.65 (0.45)	0.68 (0.47)	0.62 (0.49)	0.54 (0.50)	2.78*	7.10***	2.75*
SC Role-Retailer	0.05 (0.21)	0.05 (0.21)	0.04 (0.20)	0.06 (0.24)	0.32	1.25	0.31
SC Role-3PL	0.09 (0.28)	0.10 (0.30)	0.12 (0.32)	0.13 (0.33)	0.71	2.85*	0.69
Natural Hazards	1.39 (0.94)	1.48 (0.97)	1.54 (1.04)	1.54 (1.17)	1.12	3.48*	1.05
Market	2.13 (0.99)	2.09 (1.10)	2.03 (0.93)	2.12 (1.00)	0.41	1.58	0.41
Socioeconomic	2.23 (1.02)	2.07 (0.94)	2.28 (1.11)	2.34 (0.97)	2.11	1.21	2.14
Operational contingency	2.72 (0.94)	2.66 (0.91)	2.37 (1.00)	2.72 (0.90)	5.04**	1.54	4.95**
Main group differences (Tukey test)							
Size-annual revenues			(1-3,4)*** (2-3,4)*** (3-4)***				
Size- number of employees			(1-3,4)*** (2-3,4)*** (3-4)***				
SC Role-manufacturer			(2-4)*				
Operational contingency			(1-3)** (2-3)* (3-4)*				

Notes: *$p < 0.1$; **$p < 0.01$; ***$p < 0.001$

Table VII.
ANOVA results for control variables: mean (standard deviation)

two groups. In the case of the supply chain role of the firm, our results show that manufacturing firms tend to follow a collaborative SCRM strategy (Cluster 2) more frequently than an internal SCRM strategy (Cluster 4). Although our results did not find any difference in SCRM strategies due to risk sources coming from factors outside the firm or the supply chain, we observed that operational contingencies are related with SCRM strategies. Table VII shows that firms with the lowest levels of operational vulnerability use an integral SCRM strategy (Cluster 3).

5. Discussion and conclusions

Extensive treatment of supply chain disruptions and related issues in the literature indicates the ongoing challenge that academics and industry executives worldwide face. In fact, the

value of the supply chain begins to decay and the rate of benefits slows down as unanticipated incidents hinder the normal flow of goods and materials within a supply chain. This section provides research avenues as well as managerial implications with regard to the role of different SCRM strategies and how they affect supply chain disruptions.

5.1 A taxonomy of SCRM strategies

This research uses a configuration approach to propose a taxonomy of SCRM strategies highlighting the multidimensional character of SCRM. Our analysis demonstrates a clear structure of four different patterns of how companies manage supply chain risks. The use of two fundamental approaches to SCRM (internal and inter-organizational) offers a simple way to understand how firms face supply chain disruptions. Passive SCRM strategy simply improvises once a firm is hit by a supply chain disruption.

Internal SCRM strategy mainly engages internal resources and capabilities in an isolated pattern and may be resistant to collaborating and sharing risk information with third parties. Collaborative SCRM strategy considers that, when firms are more dependent on their supply chain partners, they can more effectively manage supply chain disruptions through inter-organizational relationships. Integral SCRM strategy believes in the complementarity of internal and inter-organizational risk management resources, and accordingly presents an equilibrate combination of SCRM efforts, with reliance on supply chain partners and internal risk management infrastructures.

Based on the number of the companies that integrate each SCRM strategy (the largest group, passive strategies, represent 34 percent of the sample), we might conclude that a large amount of firms seem to be totally unconscious, or ignorant, to risk, or alternatively, do not work actively on SCRM. If we compare the magnitude of risk sources and the efforts on SCRM between groups, it is clear that, given the frequency of supply chain disruptions, the level of implementation or effectiveness of disruption management practices by passive firms does not seem to correlate with its risk sources. These observations are supported by the current results of risk management studies. A recent study by Aon Risk Solutions (2013) reported that readiness for dealing with risks has dropped 7 percent, from 66 percent in 2011 to 59 percent in 2013. Furthermore, supply chain managers recognize that the top two business pressures are rising complexity within the supply chain and the increased need for supply chain resiliency (Aberdeen Group, 2013). These two aspects are definitively interrelated.

Why is it that despite our accumulating knowledge of dealing with disasters, in addition to the extensive experience gained by companies in building and running supply chains in global markets, many enterprises still struggle to cope with large-scale disruptions? In our view, one reason is that risk management is still a relatively new discipline in the supply chain management field. Another reason is that there is a lack of quick wins to give these efforts momentum. As a result, managers do not have an effective framework to guide them when deploying risk management practices and when selecting the best ones for their supply chain structure and associated strategy.

Examining how different SCRM strategies affect disruption occurrences provides several interesting findings. First, we note that firms pursuing an inter-organizational orientation (either integral or collaborative SCRM strategy) face the lowest levels of supply chain disruption. Contrary to our expectations, firms that seek an internal SCRM strategy (developing business continuity plans, assigning clear responsibilities and roles in terms of risk management teams, and deploying formal emergency and security procedures) do not show significant differences in terms of disruption occurrences from those firms that follow a passive SCRM strategy. It may be that strategies which simply concentrate on having greater control of internal operations are not vigorous enough to stop the cascade effect of a disruption at the supply chain level. Although an internal approach provides many benefits for the firm, it may also act as an impediment to the development of alternatives to manage

disruptions (Ambulkar, *et al.*, 2015). An internal SCRM strategy limits the boundaries of a particular firm, but that "firewall" may allow disruptions downstream in the supply chain and therefore trigger a negative effect in supply chain performance.

Second, our results indicate that internal risk management is shifting to a broader scope, including inter-organizational efforts. This is consistent with extant literature about the benefits of collaboration and the idea that supply chain collaboration can significantly help diminish disruption occurrences (Christopher and Peck, 2004; Sáenz and Revilla, 2014). Collaboration has been suggested as the "glue that holds supply chain organizations in a crisis together" (Richey, 2009, p. 623). Supply chain collaboration avoids opportunistic behavior on behalf of individual interests which would negatively diminish the response capability of the whole system. Suppliers and buyers who share risk awareness and collaborate on SCRM understand the perception, capabilities and potential actions of the partner and benefit from increased visibility and transparency. Furthermore, the excellent performance of integral SCRM strategies also suggests that collaboration between buyers and suppliers ensures the efficacy of business continuity plans and security procedures. Finally, we note that our results about the effectiveness of inter-organizational SCRM in reducing the effects of disruption occurrences may be in conflict with the apparent reluctance of companies to collaborate under risk situations, as mentioned in previous research (Jüttner and Maklan, 2011).

To complete the exploration of our results, we examined the relationship between SCRM strategies and control variables. Our findings show that focal firm size influences SCRM. Integral SCRM strategies are preferred by larger companies, while small companies tend to follow a passive strategy. This finding supports the idea that SCRM is in general expensive and complex to implement; it is not surprising that small- and medium-sized enterprises (SMEs) implement active SCRM strategies to a lesser degree than large-scale firms. For example, Thun and Hoenig (2011) found that SMEs clearly focus on reactive instruments of SCRM, whereas large-scale firms concentrate on preventive actions.

Surprisingly, we note that risk sources arising from the external environment (market, natural hazards, and socioeconomic context) do not determine the SCRM strategy. That finding is contrary to contingency theory, which pointed out the external environment as a contingent variable for SCRM strategies (Talluri *et al.*, 2013). There are several reasons why managers do not pay attention to the external environment as a source of vulnerability, including the relative infrequency of the exogenous events and the perception that they generally cannot be reduced, since they are not under the control of the firm. However, given the significant influence that environmental vulnerabilities have on disruption occurrences (e.g. tsunami in Japan, floods in Thailand and Philippines, terrorist attacks, volcanic eruption on Iceland, fire in a clothing factory in Bangladesh or BP oil spill, just to name a few), we postulate that in order to reduce the impact of disruption incidents, firms and supply chain partners might work together. By assessing the level of exposure to external vulnerabilities, supply chain partners may jointly develop contingency plans for different types of vulnerabilities – before a disruption occurs. Li & Fung Ltd. provides an example of this stance, with contingency plans that enable it to move production from a supplier in one country to another supplier in a different country (Chopra and Sodhi, 2014).

However, we observe that supply chains with fewer operational contingencies are linked to the most active SCRM strategy, the integral perspective that combines internal and inter-organizational SCRM orientations. Firms following an internal strategy build reliability into their supply chains by focusing on efficient processes and the elimination of failures within organizational boundaries and along the supply chain. Considering Total Quality Management principles that see failure as a waste that must be eliminated (Juran and Gryna, 1993), it is plausible that firms which face a lower level of operational contingencies are those that develop integral SCRM.

5.2 Managerial implications

This study brings important lessons to global risk managers as well as supply chain managers. In particular, managers should take note of the importance of SCRM. This is the starting point for the large group of firms that do not work actively on SCRM and therefore ignore or fail to recognize supply chain risk, sometimes with dire consequences. Our research shows that firms can diminish the frequency of supply chain disruptions by actively cooperating with supply chain partners. In doing this, buyers and suppliers are likely to maintain an awareness of disruption and take steps to collectively respond to real and perceived risks. This inter-organizational orientation for managing supply chain risk can be reinforced through the establishment of a formal risk management infrastructure. Managers should also seek to connect processes and to develop in collaboration with supply chain partners practices such as business continuity analysis or security procedures. Our findings demonstrate that although the mere presence of an internal resources structure does not significantly reduce the frequency with which firms experience the effects of disruption, they can ensure the efficacy of collaboration in SCRM. Based on the low percentage of firms using the most effective SCRM strategy (integral), it appears that there is a long way to go in widespread implementation. Only mature and big companies with strong base of resources and knowledge are able to implement these strategies.

Managers should play an active role in making sure that supply chain management and risk management disciplines evolve together. Obviously, when an exogenous event results in a supply chain disruption, a firm will try to put its operations under control through internal capabilities. But SCRM strategies designed proactively in advance with relevant partners are even more beneficial. A continuous learning loop of combinations of SCRM dimensions, after having accumulated experiences dealing with past disruptions, responds to the dynamism required by mature supply value networks in a global world. How to mesh supply chain management and risk management, not only within a company but also with key stakeholders and decision makers, becomes a crucial determinant in surviving high-magnitude disruptions. Each company needs to carefully identify the right combination of SCRM dimensions to be implemented, whether that means strengthening internal capabilities and infrastructure, aligning with key suppliers upstream and key customers downstream, or bringing these activities into balance.

5.3 Limitations and future research avenues

This study must be viewed in the light of some limitations. The main focus is on internal and inter-organizational approaches, and more research is needed to shed light on their complementary effects. This would require expanding the study to specific practices recognized by the literature for building resilience, such as redundancy in the supply base, extra capacity, supply chain flexibility deployment, postponement strategies, customization, extra inventory, and lean supply chains, among others (Sheffi and Rice, 2005; Wagner and Bode, 2008; Zsidisin and Wagner, 2010). Most of these practices are closely related to how a supply chain is designed and consequently how it is operated.

While we analyze disruption occurrences in terms of SCRM strategy, we also acknowledge that this measure does not capture the full impact of supply chain disruption. There are two common measures of disruption: the likelihood of occurrence of an undesirable event and the magnitude of the supply chain disruption. Future research should include both measurements of risk (Ellis *et al.*, 2010).

In addition, considering the worldwide scope of the data gathered for this empirical study, the examination of cultural issues in the context of supply chain disruption may be pertinent. As suggested by several scholars in this field, the investigation of how organizational culture affects the perception of risks and how diverse national cultures

would react to an assortment of threats is awaiting future research (Sheffi, 2005; Zsidisin and Wagner, 2010).

Finally, this was a cross-sectional rather than longitudinal study. How firms switch from passive to integral SCRM strategy is an important topic to research. Why some firms pursue an integral SCRM strategy, combining an internal and inter-organizational approach, while others alternate between the two focused strategies, was not studied. These issues are of great interest and will be explored in our future research.

References

Aberdeen Group (2013), "Operational risk management: how best-in-class manufacturers improve operating performance with proactive risk reduction", March, available at: www.plantservices.com/assets/wp_downloads/pdf/operational-risk-management-improve-operating-performance.pdf

Ambulkar, S., Blackhurst, J. and Grawe, S. (2015), "Firm's resilience to supply chain disruptions: scale development and empirical examination", *Journal of Operations Management*, Vol. 33, pp. 111-122.

Anderson, J.C. and Gerbing, D.W. (1988), "Structural equation modeling in practice: a review and recommended two-step approach", *Psychological Bulletin*, Vol. 103 No. 3, pp. 411-423.

Aon (2013), "Report on global risk management survey", Aon Risk Solutions, available at: www.aon.com/attachments/risk-services/2013-GRMS-Executive-Summary.pdf

Bode, C. and Wagner, S.M. (2015), "Structural drivers of upstream supply chain complexity and the frequency of supply chain disruptions", *Journal of Operations Management*, Vol. 36, pp. 215-228.

Bode, C., Wagner, S.M., Petersen, K.J. and Ellram, L.M. (2011), "Understanding responses to supply chain disruptions: insights from information processing and resource dependence perspectives", *Academy of Management Journal*, Vol. 54 No. 4, pp. 833-856.

Brandon-Jones, E., Squire, B., Autry, C.W. and Petersen, K.J. (2014), "A continent resource-based perspective of supply chain resilience and robustness", *Journal of Supply Chain Management*, Vol. 50 No. 3, pp. 55-73.

Chapman, P., Christofer, M., Jüttner, U., Peck, H. and Wilding, R. (2002), "Identifying and managing supply-chain vulnerability", *Logistic and Transport Focus*, Vol. 4 No. 4, pp. 59-64.

Chen, J., Sohal, A.S. and Prajogo, D.I. (2013), "Supply chain operational risk mitigation: a collaborative approach", *International Journal of Production Research*, Vol. 57 No. 1, pp. 2186-2199.

Chopra, S. and Sodhi, M. (2004), "Managing risk to avoid supply chain breakdown", *MIT-Sloan Management Review*, Vol. 46 No. 1, pp. 53-61.

Chopra, S. and Sodhi, M. (2014), "Reducing the risks of supply chain disruptions", *MIT Sloan Management Review*, Vol. 55 No. 3, pp. 73-80.

Christopher, M. and Lee, H. (2004), "Mitigating supply chain risk through improved confidence", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 5, pp. 388-396.

Christopher, M. and Peck, H. (2004), "Building the resilient supply chain", *International Journal of Logistics Management*, Vol. 15 No. 2, pp. 1-13.

Craighead, C., Blackhurst, J., Rungtsunatham, M.J. and Handfield, R. (2007), "The severity of supply chain disruptions: design characteristics and mitigation capabilities", *Decision Sciences*, Vol. 38 No. 1, pp. 131-156.

Cronbach, L.J. (1951), "Coefficient alpha and the internal structure of tests", *Psychometrika*, Vol. 16 No. 3, pp. 297-334.

Daft, R.L. and Weick, K.E. (1984), "Toward a model of organizations as interpretation systems", *Academy of Management Review*, Vol. 9 No. 2, pp. 284-295.

Ellis, S.C., Henry, R.M. and Shockley, J. (2010), "Buyer perceptions of supply disruption risk: a behavioral view and empirical assessment", *Journal of Operations Management*, Vol. 28 No. 1, pp. 34-46.

Faisal, M.N., Banwet, D.K. and Shankar, R. (2006), "Mapping supply chains on risk and customer sensitivity dimensions", *Industrial Management & Data Systems*, Vol. 106 No. 6, pp. 878-895.

FM Global (2011), "Supply chain risk study".

Hair, F., Anderson, R., Tatham, R. and Black, W. (1998), *Multivariate Data Analysis with Readings*, Prentice Hall Internacional, NJ.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E. and Tatham, R.L. (2006), *Multivariate Data Analysis*, 6th ed, Pearson Education International, Upper Saddle River.

Hendricks, K. and Singhal, V. (2003), "The effect of supply chain glitches on shareholder value", *Journal of Operations Management*, Vol. 21 No. 5, pp. 501-522.

Hendricks, K. and Singhal, V. (2005), "An empirical analysis of the effect of supply chain disruptions on long-run stock price performance and equity risk of the firm", *Production and Operations Management*, Vol. 14 No. 1, pp. 25-53.

Hendricks, K.B., Singhal, V.R. and Zhang, R. (2009), "The effect of operational slack, diversification, and vertical relatedness on the stock market reaction to supply chain disruptions", *Journal of Operations Management*, Vol. 27 No. 3, pp. 233-246.

Holton, G.A. (2004), "Defining risks", *Financial Analysts Journal*, Vol. 60 No. 6, pp. 19-25, available at: www.fmglobal.com/assets/pdf/SupplyChain_RiskStudy.pdf

Juran, J.M. and Gryna, F.M. (1993), *Quality Planning and Analysis*, McGraw Hill, New York, NY.

Jüttner, U. (2005), "Supply chain risk management: understanding the business requirements from a practitioner perspective", *International Journal of Logistics Management*, Vol. 16 No. 1, pp. 120-141.

Jüttner, U. and Maklan, S. (2011), "Supply chain resilience in the global financial crisis: an empirical study", *Supply Chain Management*, Vol. 16 No. 4, pp. 246-259.

Juttner, U., Peck, H. and Christopher, M. (2003), "Supply chain risk management: outlining an agenda for future research", *International Journal of Logistics: Research and Applications*, Vol. 6 No. 4, pp. 197-210.

Kaku, B. and Kamrad, B. (2011), "A framework for managing supply chain risks", *Supply Chain Management Review*, Vol. 15 No. 4, pp. 24-31.

Ketchen, D.J. and Shook, C.L. (1996), "The application of cluster analysis in strategic management research: an analysis and critique", *Strategic Management Journal*, Vol. 17, pp. 441-460.

Kleindorfer, P.R. and Saad, G.H. (2005), "Managing disruption risks in supply chains", *Production and Operations Management*, Vol. 14 No. 1, pp. 53-68.

Li, G., Fan, H., Lee, P.K.C. and Cheng, T.C.E. (2015), "Joint supply chain risk management: an agency and collaboration perspective", *International Journal of Production Economics*, Vol. 164, pp. 83-94.

Manuj, I. and Mentzer, J.T. (2008), "Global supply chain risk management", *Journal of Business Logistics*, Vol. 29 No. 1, pp. 133-151.

March, J.G. and Shapira, Z. (1987), "Managerial perspectives on risk and risk taking", *Management Science*, Vol. 33 No. 11, pp. 1404-1418.

Melnyk, S.A., Closs, D.J., Griffis, S.E., Zobel, C.W. and Macdonald, J.R. (2014), "Understanding supply chain resilience", *Supply Chain Management Review*, January-February, pp. 34-41.

Miller, D. (1986), "Configuration of strategy and structure: towards a synthesis", *Strategic Management Journal*, Vol. 7 No. 3, pp. 233-249.

Naor, M., Linderman, K. and Schroeder, R. (2010), "The globalization of operations in Eastern and Western countries: unpacking the relationship between national and organizational culture and its impact on manufacturing performance", *Journal of Operations Management*, Vol. 28 No. 3, pp. 194-205.

Norrman, A. and Jansson, U.L.F. (2004), "Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 5, pp. 434-456.

Nunnally, J. (1978), *Psychometric Theory*, McGraw Hill, New York, NY.

Oke, A. and Gopalakrishnan, M. (2009), "Managing disruptions in supply chains: a case study of a retail supply chain", *International Journal of Production Economics*, Vol. 118 No. 1, pp. 168-174.

Perrow, C. (1984), *Normal Accidents*, Basic Books, New York, NY.

Podsakoff, P.M., MacKenzie, B., Lee, J.Y. and Podsakoff, N.P. (2003), "Common method biases in behavioural research: a critical review of the literature and recommended remedies", *Journal of Applied Psychology*, Vol. 88 No. 5, pp. 879-903.

Rao, S. and Goldsby, T.J. (2009), "Supply chain risks: a review and typology", *International Journal of Logistics Management*, Vol. 20 No. 1, pp. 97-123.

Revilla, E. and Sáenz, M.J. (2011), "What is the right disruption management for your supply chain?" *Forbes (India)*, October, available at: www.forbesindia.com/article/ie/what-is-the-right-disruption-management-for-your-supply-chain/29412/1?utm=slidebox60129545314

Revilla, E. and Sáenz, M.J. (2014), "Supply chain disruption management: global convergence versus national specificity", *Journal of Business Research*, Vol. 67 No. 6, pp. 1123-1135.

Revilla, E. and Villena, V. (2012), "Knowledge integration taxonomy in buyer-supplier relationships: trade-offs between efficiency and innovation", *International Journal of Production Economics*, Vol. 140 No. 2, pp. 854-864.

Richey, R.G. (2009), "The supply chain crisis and disaster pyramid", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 7, pp. 619-628.

Sáenz, M.J. and Revilla, E. (2014), "Creating more resilient supply chains", *MIT Sloan Management Review*, Vol. 55 No. 4, pp. 22-24.

Saris, W.E. and Gallhofer, I. (2007), *Design, Evaluation and Analysis of Questionnaires for Survey Research*, Wiley Interscience, Hoboken, NJ.

Scholten, K. and Schilder, S. (2015), "The role of collaboration in supply chain resilience", *Supply Chain Management*, Vol. 20 No. 4, pp. 471-484.

Sheffi, Y. (2001), "Supply chain management under the threat of international terrorism", *International Journal of Logistics Management*, Vol. 12 No. 2, pp. 1-11.

Sheffi, Y. (2005), *The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage*, MIT Press, Cambridge, MA.

Sheffi, Y. (2015), *The Power of Resilience: How the Best Companies Manage the Unexpected*, MIT Press, Cambridge, MA.

Sheffi, Y. and Rice, J. (2005), "A supply chain view of the resilient enterprise", *MIT Sloan Management Review*, Vol. 47 No. 1, pp. 41-48.

Simangunsong, E., Hendry, L.C. and Stevenson, M. (2012), "Supply-chain uncertainty: a review and theoretical foundation for future research", *International Journal of Production Research*, Vol. 50 No. 16, pp. 4493-4523.

Sodhi, M.S., Son, B.-G. and Tang, C.S. (2012), "Researchers' perspectives on supply chain risk management", *Production and Operations Management*, Vol. 21 No. 1, pp. 1-13.

Speier, C., Whipple, J.M., Closs, D.J. and Voss, M.D. (2011), "Global supply chain design considerations: mitigating product safety and security risks", *Journal of Operations Management*, Vol. 29 No. 7, pp. 721-736.

Stone, E.R., Yates, J.F. and Parker, A.M. (1994), "Risk communication: absolute versus relative expressions of low-probability risks", *Organizational Behavior and Human Decision Processes*, Vol. 60 No. 3, pp. 387-408.

Svensson, G. (2002), "A conceptual framework of vulnerability in firms' inbound and outbound logistics flows", *International Journal of Physical Distribution & Logistics Management*, Vol. 32 No. 2, pp. 110-134.

Swaminathan, J.M. (2003), "SARS exposes risks of global supply chains", *Journal of Commerce*, Vol. 4 No. 23, p. 38.

Talluri, S., Kull, T.J., Yildiz, H. and Yoon, J. (2013), "Assessing the efficiency of risk mitigation strategies in supply chains", *Journal of Business Logistics*, Vol. 34 No. 4, pp. 253-269.

Tang, O. and Musa, S.N. (2011), "Identifying risk and research advancements in supply chain risk management", *International Journal of Production Economics*, Vol. 133 No. 1, pp. 25-34.

Thun, J.-H. and Hoenig, D. (2011), "An empirical analysis of supply chain risk management in the German automotive industry", *International Journal of Production Economics*, Vol. 131 No. 19, pp. 242-249.

Wagner, S. and Bode, C. (2006), "An empirical investigation into supply chain vulnerability", *Journal of Purchasing & Supply Management*, Vol. 12 No. 6, pp. 301-312.

Wagner, S. and Bode, C. (2008), "An empirical examination of supply chain performance along several dimensions of risk", *Journal of Business Logistics*, Vol. 29 No. 1, pp. 307-325.

Wagner, S.M. and Neshat, N. (2012), "A comparison of supply chain vulnerability indices for different categories of firms", *International Journal of Production Research*, Vol. 50 No. 11, pp. 2877-2891.

Wieland, A. and Wallenburg, C.M. (2013), "The influence of relational competencies on supply chain resilience", *International Journal of Physical Distribution & Logistics Management*, Vol. 43 No. 4, pp. 300-320.

World Economic Forum (2008), "Global risk 2008: a global risks network report", Geneva.

Zsidisin, G.A. and Wagner, S.M. (2010), "Do perceptions become reality? The moderating role of supply chain resiliency on disruption occurrence", *Journal of Business Logistics*, Vol. 31 No. 2, pp. 1-20.

Zsidisin, G.A., Melnyk, S.A. and Ragatz, G.L. (2005), "An institutional theory perspective of business continuity planning for purchasing and supply management", *International Journal of Production Research*, Vol. 43 No. 16, pp. 3401-3420.

Corresponding author
Elena Revilla can be contacted at: elena.revilla@ie.edu