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Supply chain risk management and operational performance: The enabling role of supply chain integration

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ABSTRACT

The academic community and practitioners widely recognize the significance of risk management and integrative practices in supply chains to deal with complexity and uncertainties faced. Firms strive to manage risk, handle unexpected disruptions and improve performance in ever changing uncertain business environments. This paper builds upon the information processing view of risk management and explores the association between supply chain integration (SCI) and supply chain risk management (SCRM) to improve operational performance. Subsequently, the mediating role played by SCRM between SCI and firms' operational performance is examined. In this paper, covariance-based structural equation modeling is applied to test the developed hypotheses using data of 931 manufacturing companies obtained from the sixth version of International Manufacturing Strategy Survey (IMSS VI). The findings of the study suggest that internal, supplier and customer integration positively effects SCRM whereas the impact of internal integration is also partially mediated by supplier and customer integration. Additionally, the results present that SCRM partially mediates the relationship between internal integration and operational performance and fully mediates the association between supplier and customer integration and operational performance. This paper contributes to research by proposing and empirically testing a holistic framework demonstrating the effects of SCI on SCRM, and consequently on performance outcomes to develop theoretical and managerial implications.

1. Introduction

Modern firms operate in a rapidly changing complex environment (Chen et al., 2013; Haleem et al., 2018; Wiengarten et al., 2016) and increasingly depend on complex networks of supply chain partners to deliver goods and services in the accurate quantity at the right time and place under persistent cost and quality pressures. Likewise, firms are increasingly applying sophisticated operations strategies such as lean manufacturing and global sourcing to gain competitive advantage (Blome and Schoenherr, 2011; Kauppi et al., 2016). Together the fast changing complex environment and complicated operational strategies of firms contribute to a higher level of vulnerability and supply chain risks. Resultantly, organizations are increasingly subjected to unexpected disruptions, which affect whole supply chains. Widely known examples include the fire at the Philips plant in 2000 that affected both Nokia and Ericsson and disrupted their supply chains and the quadruple disasters that affected Japan in 2011 inflicting disruptions in global supply chains. Thus, heightened risks in increasingly complex supply chain networks have brought risk management to the forefront of research and managerial efforts. Supply Chain Risk Management (SCRM), referred as the identification and management of supply chain risks through coordinated approaches among supply chain partners (Jüttner et al., 2003; Kauppi et al., 2016) plays a crucial role in coping with the challenges of today's dynamic and uncertain business environment and is widely adopted by firms to address increasing risks (Lavastre et al., 2014; Manuj et al., 2014).

Various strategies have been discussed to mitigate and manage the negative impact of supply chain risks such as postponement (Yang and Yang, 2010) dual sourcing (Trkman and McCormack, 2009) and redundancy (Sheffi, 2005). These strategies do provide help in managing risks, however, they employ a focal firm perspective i.e. they are firms' internal practices with scant insights on the integration between the firm and its supply chain partners. Whereas risks that transmit among supply chain partners (Li et al., 2015), the probability and magnitude of which

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can be influenced significantly by supply chain network and its rippling effects (Jüttner, 2005), should be managed for end-to end supply chain (Rao and Goldsby, 2009). Moreover, since SCRM is an information intensive process (Fan et al., 2017), its successful implementation relies on collaboration and coordination between the focal firm and its supply chain partners (Kauppi et al., 2016; Li et al., 2015). Therefore the need to approach risk management collaboratively has been increasingly stressed in the recent literature (Li et al., 2015) and a key to achieve this goal is to facilitate supply chain integration (SCI). The integrated supply chain is achieved by extending the scope of management both inside as well as outside of the firm by involving suppliers and customers (Geary et al., 2002). Integration within a firm enables the circulation of risk information among intrafirm departments whereas integration between firms improves the exchange of information among supply chain partners and assists them to stay alert and rapidly respond to disruptions through information sharing and coordinated operations (Liu and Lee, 2018). Thus, firms need to facilitate intra and inter firm integration to facilitate effective SCRM.

The importance of SCI for managing supply chain risks and improving performance has been increasingly recognized in the recent literature (Chaudhuri et al., 2018; Zhu et al., 2017), however, the concepts and relationships are still fragmented and further research is needed to thoroughly analyze the influence of SCI on SCRM and consequent performance (Chaudhuri et al., 2018). Therefore, to address this gap, this study draws on information processing theory to crystallize the association between SCI and SCRM and how they enhance the performance outcomes of a firm. According to information processing theory (IPT), a firm can contend with uncertainty and realize superior performance outcomes by increasing their capabilities in gathering, processing and implementing information from the environment (Galbraith, 1974). As contemporary business environment characterizes dynamic change, unpredictability, and turbulence, the information required to manage risks in supply chains tends to be highly complex, uncertain and ambiguous. Therefore, to be effective in SCRM, firms need to develop, along the whole supply chain, an effective information gathering, and processing system having the adequate capability to timely process and apply the information gathered from the external environment. In this study, we conceptualize the requisite information processing capability as being accomplished by three SCI dimensions, namely (i) internal integration, (ii) supplier integration, and (iii) customer integration. Building on IPT, we maintain that SCRM is an information intensive process, which contributes to improving operational performance of the firm, and SCI enables the process of SCRM by enhancing information processing capabilities of the firm through timely accessing and absorbing accurate information. Specifically, we address the following research question: How supply chain integration contributes to managing risks in supply chains?

Generally, it has been argued that firms pursuing an inter-organizational orientation to risk management face the lowest levels of disruptions across supply chains (Revilla and Saenz, 2017), and that the integration of processes across multiple firms provide economic and competitive advantages, however, such advantages also accompany many potential risks resulting from intermeshed processes. For example, the 2011 Japanese earthquake and tsunami not only caused a local disruption in supply and demand, but also a manufacturing slowdown in North American and European countries where Japanese suppliers' inputs were needed (MacKenzie et al., 2012). While it is commonly believed that SCI has a positive impact on performance, nonetheless, Fabbe-Costes and Jahre (2008), in their literature review study, indicated that a considerable number of studies showed that increased SCI does not always improve performance. Different factors have been considered in the literature to explain these mixed findings such as logistical capabilities (Wiengarten et al., 2014), environmental uncertainty (Wong et al., 2011) and risks (Wiengarten et al., 2016), however, the role of SCRM in explaining the link between SCI and performance has been ignored. We maintain that SCRM is a relevant concept in this regard as higher levels of integration may lead to increased interdependencies among firms and in effect, higher exposure to risks (Hallikas et al., 2004; Wieland and Wallenburg, 2013) and inflexibility (Terjesen et al., 2012) to changes in the environment. Higher coordination and information sharing also increases complexity and can have negative impacts as accidents become inevitable or even normal in tightly coupled complex systems (Perrow, 1984). Thus, firms need to develop SCRM processes to identify, mitigate and respond to risks more adequately and improve their performance. We propose that SCRM mediates the relationship between SCI and operational performance of a firm and address the following research question: How does SCRM enhance operational performance along integrated supply chains?

Overall, this study endeavors to contribute to the literature by identifying the supply chain antecedents and performance consequences of SCRM. Although the existing literature recognizes various strategies and frameworks for identifying, analyzing and mitigating risks in supply chains, there is a relative dearth of research on factors that influence their adoption and implementation. There is a gap in SCRM literature regarding the relationship between SCRM processes and their antecedents (Fan et al., 2017; Manuj and Mentzer, 2008). This study extends the existing literature by proposing three SCI dimensions namely, internal integration, supplier integration, and customer integration, as essential antecedents of SCRM. In doing so, we address the call in the literature (Chaudhuri et al., 2018) to test the effect of SCI on the effectiveness of SCRM and consequently on performance outcomes. Following Fan et al. (2017) we also attempt to contribute to the information processing perspective of SCRM by highlighting the importance of SCI in influencing SCRM using IPT. Fan et al. (2017), proposed that SCRM practices act as information processing systems and examined organizational antecedents and performance consequences of this system. Taking a step further, we maintain that the three dimensions of SCI i.e. internal, supplier and customer integration help mitigate ambiguity and uncertainty by providing relevant and reliable information and enhancing information processing capability of the system. Also, by highlighting SCRM as a mediator between SCI and operational performance, this study provides a plausible explanation for the mixed findings reported in the extant literature between SCI and performance measures (Flynn et al., 2010; Wong et al., 2011) thus contributing to SCI-performance literature. In addition, this paper contributes to practice by providing guidelines on how firms can gather, process and absorb information using different dimensions of SCI (internal, supplier and customer integration) and how SCI facilitates SCRM leading to enhanced operational performance.

The rest of the paper is structured as follows. We develop a research framework for this study in the next section 2 followed by theoretical background and hypothesized model linking SCI, SCRM and operational performance of firms in section 3. Section 4 describes the research methodology, data collection and statistical analysis being used for testing the hypotheses. Finally, we report and discuss the findings and theoretical and managerial implications of our study in section 5 and conclude with limitations and future research directions in section 6.

2. Research framework

2.1. Linking supply chain integration and supply chain risk management

A supply chain, at the least level of complexity, comprises of a firm, a supplier and a customer, directly involved in both upstream and downstream flows of information, services, products and finances (Jüttner, 2005; Mentzer et al., 2001). The main characteristic of managing a supply chain is the coordination of activities between these interdependent entities. Risks in supply chain centers around the disruption of flows (i.e. information, products, materials, and finance) between supply chain entities. Therefore, from a supply chain perspective, the approach of risk management must have a wider scope than that of a single firm and provide insights regarding the key processes to be performed across the entire supply chain (Jüttner, 2005). SCI refers to the extent of strategic alignment and interconnection of a firm and its supply chain partners, consisting of internal (cross-functional) and external (customer and supplier) integration (Flynn et al., 2010). It facilitates coordination and ensures an efficient and effective flow of information, decision, material and other resources for maximizing customer value (Flynn et al., 2010; Schoenherr and Swink, 2012).

The literature conceptualizes SCI as consisting of three main dimensions i.e., supplier, customer, and internal integration. External integration, which is commonly divided as customer and supplier integration, refers to the degree to which a firm partners with its key suppliers and customers to structure inter-organizational strategies, practices and processes in a synchronized and collaborative manner for creating mutual value (Flynn et al., 2010; Frohlich and Westbrook, 2001). Supplier integration refers to information sharing and coordination with key suppliers, providing the firm insights into suppliers' capabilities, processes, and constraints, allowing effective forecasting and planning, designing processes and products and overall effective operations management (Schoenherr and Swink, 2012). Customer integration involves activities of information sharing and close collaboration with key customers which facilitates the firm in developing strategic insights into opportunities and expectations of the market (Wong et al., 2011), eventually enabling the firm to respond to customer needs more effectively and efficiently (Swink et al., 2007). Internal integration refers to the extent of intra-firm cross-functional collaboration and activities of information sharing which takes place via synchronized and interconnected systems and processes for fulfilling customer requirements (Williams et al., 2013).

Firms need reliable and quality information to deal with environmental uncertainty (Galbraith, 1974) originating from frequent changes in environmental variables and complexity. This would require external integrative mechanism i.e. supplier and customer integration, to collect information, coordinate and monitor activities of supply chain partners and facilitate flexible response and quick decision making. From a risk perspective, supplier and customer integration lower supply chain risks through transparency and visibility which is achieved when all supply chain members share information throughout the chain (Waters, 2011). Information sharing among supply chain partners through supplier and customer integration enhances visibility into external conditions thus enabling better and faster decision making in supply chains (Williams et al., 2013). Internal integration, on the other hand, creates the information processing capability within a firm allowing the effective absorption and application of information gained from suppliers and customers (external integration) supporting better decision making (Schoenherr and Swink, 2012) and mitigation of risks. Internal integration is arguably the basis of SCI (Schoenherr and Swink, 2012; Zhao et al., 2011) as it removes functional barriers (Flynn et al., 2010) and facilitates information sharing across internal functions resultantly reducing uncertainty and enabling the implementation of SCRM. Building on these arguments, we propose that supplier and customer integration act as the input or source of information sharing while internal integration creates the information processing capability to process, absorb, analyze and implement the information gathered from supplier and customer integration. Together, all three dimensions of SCI improves the information processing capability of the firm and facilitate SCRM. In other words, the realization of an integrated supply chain provides firms with an opportunity to implement SCRM practices to improve their operational performance.

Several recent articles have discussed the idea of collaborative or integrated risk management along supply chains to enhance performance (Chaudhuri et al., 2018; Kauppi et al., 2016; Zhu et al., 2017). However, different studies have conceptualized the association between SCI and SCRM quite diversely thus suggesting different performance outcomes (See Table 1). While some studies suggest benefits of SCI for firms facing supply chain risks (Wiengarten et al., 2016; Wong et al., 2011; Zhao et al., 2013), as integration among supply chain partners improve visibility and the speed of response (Wieland and Wallenburg, 2013). Others highlight the role of SCRM in managing risks arising as a result of higher levels of integration (Chaudhuri et al., 2018) and supporting SCI to enhance performance in high risk situations (Wiengarten et al., 2016). Hence, it can be argued that the existing literature does not provide conclusive evidence of the association between SCI and SCRM in improving firm performance. Two points are important in this regard. First, although it is theoretically established that SCI helps in mitigating risks and improves SCRM, there is no empirical quantitative study to date supporting this claim and analyzing SCI as an antecedent of SCRM. Secondly, while it has been argued that the integration of processes across multiple firms provide economic and competitive advantages, yet, such advantages also accompany many potential risks due to intermeshed processes, therefore, leading to inconsistent results for the relationship between SCI and operational performance. In this study, we address these gaps and examine how SCI dimensions effect SCRM to enhance performance and how SCRM facilitates the association between SCI and operational performance.

2.2. *Supply chain integration, supply chain risk management and operational performance*

Existing theoretical studies suggest performance benefits for firms implementing SCRM by preventing disruptions and lowering operational accidents (Manuj et al., 2014; Thun and Hoenig, 2011). SCRM allows reacting to the external environment and improves operational performance. In this paper, we suggest that SCRM is an information intensive process that contributes to operational performance by mitigating uncertainty and should be preceded by SCI practices to access reliable and timely information and enhance information processing capabilities. SCI assists in extending SCRM efforts throughout the supply chain and improve performance. External supplier and customer integration allow the collection of accurate, timely and reliable information, providing the firm with the knowledge that can improve risk detection, prevention, and reaction capabilities. Internal integration facilitates information sharing within internal functions and creates the capability to process, absorb, analyze and implement the information gathered from supplier and customer integration. Hence, SCI is important in achieving effective SCRM and increasing operational performance.

The majority of existing studies have generally concluded that SCI leads to superior operational performance (Braunscheidel and Suresh, 2009; Frohlich and Westbrook, 2001; Lee et al., 1997; Schoenherr and Swink, 2012; Wieland and Wallenburg, 2013; Wong et al., 2011) however, a considerable body of research has also reported negative or mixed results (Devaraj et al., 2007; Fabbe-Costes and Jahre, 2008; Flynn et al., 2010; Narasimhan et al., 2010; Stank et al., 2001). Flynn et al. (2010) claimed that neglecting the importance of internal integration and considering only external integration can be a reason of contradiction in the literature. The inconsistency in the findings can be attributed to the fact that despite many benefits, integrated supply chains bring with them the risk of amplified and propagated disruptions along the supply chain if not managed properly. Increased integration among supply chain partners may lead to increased interdependencies and inflexibility (Terjesen et al., 2012) to environmental changes. Thus, SCI may come at the cost of increased exposure to risk and disruptions as accidents become inevitable in tightly coupled complex systems (Perrow, 1984). We argue that SCRM can be an important mediating variable in explaining this inconsistency in the literature.

Finally, as SCRM is an enterprise wide phenomenon, so, for this study, we opted for conventional performance variables of quality, flexibility, delivery and customer service to measure the operational performance of firms that were consistent with supply chain operations (Schoenherr and Swink, 2012). We excluded cost as in the literature SCRM practices are often criticized for cost escalations (Christopher and Peck, 2004; Jüttner and Maklan, 2011). It has been argued in the risk management literature that even though implementation of risk

Table 1
Representative supply chain integration and supply chain risk management literature.

Themes	Author	Year	Journal	Method	Main Findings
Importance of SCI for mitigation of SCR and/or effective SCRM	Juttner	2005	IJLM	Survey and focus groups	• Traditional approaches to risk management derived from a single firm perspective are not ideally suited to the requirements in a supply chain context.
	Kleindorfer and Saad	2005	POM	Empirical Quantitative	• Formulated 10 principles for risk management deriving from supply chain and industrial risk management literature.
	Braunscheidel and Suresh	2009	JOM	Survey	• Market orientation impact internal and external integration, along with external flexibility. • Learning orientation influences internal integration but does not influence external integration and external flexibility. • II leads to EI. • II and EI do not lead to external flexibility. • EI, external flexibility and II positively impacts supply chain agility which is a risk management initiative.
	Chen et al.	2013	IJPR	Survey	• Process and demand risks negatively impact performance, whereas supply risk does not have an impact on performance. • Supply chain collaboration reduces all the risks associated with supply chains.
	Lavastre et al.	2014	IJPR	Mixed Method	• Firms need to consider SCRM at a strategic level, requiring long term information exchanges with partners. • In SCRM, the length of partner relationship is very important as methods employed differ as per the duration of relationship. • For the successful implementation of SCRM, methods based on partner collaboration are most effective.
	Ellinger et al.	2015	IJLRA	Survey	• Supplier, customer and internal integration mediates the relationship between SCRM and learning orientation. • SCRM improves overall logistics performance.
	Gualandris and Kalchschmidt	2015	IJLM	Field Interviews and survey	• Balanced use of integration practices with SCRM approaches i.e. revenue sharing and dual sourcing can enhance competitive advantage.
	Li et al.	2015	IJPE	Survey	• Risk information sharing and risk sharing mechanisms are positively associated with financial performance. • Relationship length and supplier trust positively moderate risk information sharing – financial performance relationship, while shared SCRM understanding does not. • Shared SCRM understanding moderates the relationship between risk sharing mechanism and financial performance while relationship length and supplier trust do not.
	Kauppi et al.	2016	IJPE	Survey	• Traditional risk management practices and external SCI practices complement each other in facing disruption risk and improving operational performance.
	Brusset and Teller	2017	IJPE	Survey	• Integration capabilities and flexibility capabilities are positively associated with resilience. • External capabilities do not lead to resilience. • Supplier risk does not moderate the relationship between external/flexibility capabilities and resilience, however, it negatively moderates the relationship between integration capabilities and resilience. • Customer risk does not have moderating effects between external capabilities, integrative capabilities, flexibility capabilities, and resilience.
	Revilla and Saenz	2017	IJOPM	Survey	• Firms having inter organizational collaborative and integral relationships face the lowest level of supply chain disruptions. • At supply chain level, having control over internal operations alone is not enough to handle disruptions. • Collaboration between partners enhances the efficacy of security procedures and internal business continuity plans.
	Zhu et al.	2017	IJLM	Systematic Literature Review	• Supply chain risks transmit through supply chain members and they should be managed for end-to-end supply chain as a whole. • To mitigate supply chain risks firms should facilitate SCI.
SCI and SCRM mediation and/or moderation impact	Wiengarten et al.	2016	IJPE	Survey	• SI positively impacts cost and innovation performance. • CI does not lead to cost and innovation performance. • Rule of law (Risk) does not moderate between integration-performance relationships.
	Chaudhuri et al.	2018	IJOPM	Survey	• II and SCRM have a direct effect on manufacturing flexibility. • SCRM moderates the relationship between EI and flexibility.
	Shou et al.	2018	IMDS	Survey	• SCRM positively impacts both operational flexibility and efficiency and has an indirect effect on financial performance. • SI enhances the impact of SCRM on operational flexibility but does not moderate the association between SCRM and operational efficiency.

SCRM: Supply chain risk management, SCR: Supply chain risk, II: Internal integration, EI: External integration, SI: Supplier integration, CI: Customer integration.
IJPE: International Journal of Production Economics, IJLM: International Journal of Logistics Management, IJPDM: International Journal of Physical Distribution, and Logistics Management, IJOPM: International Journal of Production Management, JOM: Journal of Operations Management, IJPE: International Journal of Production Research, BPMJ: Business Process Management Journal, POM: Production and Operations Management, IMDS: Industrial Management and Data Systems.

management along supply chain may help in mitigating risk and reducing potential losses it also require upfront investments in excess inventories, capabilities, and resources (Bode et al., 2011; Shou et al., 2018; Sodhi et al., 2012). Therefore, it has been suggested that SCRM may not impact financial performance directly but indirectly through other performance measures e.g. flexibility (Shou et al., 2018). Thus, the focus of this research is also on non-financial operational performance measures.

3. Theoretical background and hypotheses development

3.1. SCRM and information processing view

Predominantly the challenge of turbulent environments is related to the inability of firms to plan and operate deterministically due to scarcity and reliability of information (Bode et al., 2011). To contend with high levels of uncertainty firms must organize and use information effectively. According to information processing theory (IPT), organizations are information processing systems whose main function, when facing various uncertainties, is to create appropriate configuration of work units for enhancing organization's information processing capabilities, i.e. facilitating effective collection, processing, and distribution of information (Galbraith, 1974; Tushman and Nadler, 1978), or by reducing the need of information processing (Galbraith, 1974). Information processing needs can be reduced by creating slack resources and/or redundancies whereas, information processing capability can be increased through investing in information sharing (Kauppi et al., 2016). IPT suggests that firms could achieve superior performance when their information processing capability fits their information processing requirements (Rogers et al., 1999; Srinivasan and Swink, 2015).

Supply chain risk management (SCRM) refers to the coordinated approach among the members of a supply chain for identifying and managing supply chain risk in order to reduce supply chain vulnerability (Jüttner et al., 2003). Such an approach is developed by adopting various risk management practices that involve basic facets of identification of risk, assessment of sources of risk, tracking of risk in the chain and mitigation of risk throughout the supply chain (Jüttner et al., 2003). Consistent with information processing theory, the approaches developed by firms for mitigating risk range from more reactive ones i.e. aimed at reducing information processing needs to more proactive ones i.e. aiming to increase the information processing capability. Previous, studies in supply chain risk management research undertook a reactive approach towards supply chain risk (Bode et al., 2011; Colicchia and Strozzi, 2012; Kauppi et al., 2016). In this premise, firms often have used buffering strategies to handle the uncertainties of a complex environment, which include excess capacity, inventory and backup suppliers (Rocky Newman et al., 1993). Such strategies have reduced the needs of information processing related to a specific association through slack resources and redundancy (Bode et al., 2011). However, such strategies are cost intensive and do not directly contribute to responsiveness (Chaudhuri et al., 2018; Hallikas et al., 2004). Kleindorfer and Saad (2005) suggested a more proactive mitigation approach, which extends throughout the entire supply chain. The research on proactive approaches emphasizes the role of information sharing and integration in mitigating risk (Kauppi et al., 2016; Kleindorfer and Saad, 2005). Information sharing within and between firms improves visibility and transparency of supply chain (Christopher and Lee, 2004), thus reducing uncertainty. Sharing of risk information offers a base to advance monitoring and warning systems, to predict the disruption before it occurs or quickly discover a disruption when it occurs. Information sharing helps in disseminating the pertinent information to relevant supply chain partners so that they can prepare for disruption or execute effective response when a risk event occurs (Craighead et al., 2011; Kleindorfer and Saad, 2005).

Recently researchers have highlighted the significance of information aspect of SCRM using the lens of information processing theory (Fan et al., 2017; Kauppi et al., 2016; Shou et al., 2018), and in doing so they also explored the role of supplier and customer integration. Kauppi et al. (2016) adopted contingency theory and information processing view to investigate the relationships between risk management practices, external integration, exogenous disruption risk, and operational performance. Fan et al. (2017) proposed a conceptual model linking supply chain risk information processing system, organizational antecedents, and operational performance. A most recent development in the field is presented by Shou et al. (2018), who scrutinized the effects of SCRM on financial performance, operational efficiency and operational flexibility. They also investigated the moderating effect of supplier integration in the association between SCRM and operational performance.

From the foregoing, it is understood that the extant literature focuses more on those aspects of risk management practices that pertain to reducing information processing needs, i.e., identifying possible risks against which different buffering strategies are developed. However, in today's complex and dynamic environment an alternative approach to face disruption risk is to increase the information processing capability of the firm by increasingly investing in information sharing and integrative activities inside as well as outside the boundaries of the firm (Kleindorfer and Saad, 2005). In this direction, some studies recognize the proactive approach of information processing theory to discern SCRM's information aspects and in doing so emphasize the significance of various types of SCI. However, there remain some research gaps that need to be addressed. Firstly, the existing studies explore the role of supplier integration (Shou et al., 2018) or external integration (Kauppi et al., 2016) in facilitating risk management practices. The importance of internal integration in this regard is not explored. Secondly, the existing studies do not provide conclusive evidence of the association between supply chain integration and SCRM in improving operational performance. We develop hypotheses to address these gaps in the following section.

3.2. Supply chain integration and supply chain risk management

The positive influence of SCI on SCRM can be analyzed through the lens of Information Processing Theory (IPT) (Galbraith, 1974). IPT is centered on the pivotal concepts of information processing needs and information processing capability. It suggests the need for quality information and enhancing information processing capability to deal with environmental uncertainty originating from complexity and frequent changes. The greater the uncertainty, the greater the risk and accordingly the greater the amount and quality information that must be processed by decision makers to manage risk and execute tasks in order to achieve positive performance outcomes. Supplier and customer integration allow gathering timely and reliable external information (Kauppi et al., 2016; Schoenherr and Swink, 2012) for the focal firm in order to improve traditional risk detection, prevention and reaction capabilities. Meanwhile, internal integration creates information processing capabilities within a firm allowing the absorption of information gained from suppliers and customers for mitigating the risk (Schoenherr and Swink, 2012). Thus, SCI enables firms to cope with uncertainty and manage risks in the supply chain environment by enhancing the gathering and processing of information related to planning, operational and logistics activities.

Different mechanisms for supplier and customer integration i.e. information sharing, joint decision making and systems coupling help in mitigating supply chain related risks. For instance, information sharing is integral to advance monitoring and warning systems through which risks can be predicted before occurring or can be discovered quickly, as disseminating pertinent risk information to relevant supply chain partners can prepare them for risk event before it occurs and help in executing effective response (Fan et al., 2017). When engaged in integrative and collaborated relationship, a firm make decisions jointly with their suppliers and customers (Flynn et al., 2010). Supplier and customer integration help in reducing information distortion leading to accurate forecasts of demand, efficient allocation of resources and lowering the bullwhip effect (Lee et al., 1997; Schoenherr and Swink, 2012). By coupling systems with suppliers and customers through "Just in Time" (JIT), "Vendor Managed Inventory" (VMI) and Collaborative Planning, Forecasting and Replenishment (CPFR) practices, which are based on coordination and information sharing of supply chain partners, bullwhip effect can be reduced, and through joint decision making the ability to respond to changes in supply and demand can be improved (Danese et al., 2013). It is worth noting the firms can exchange real time and accurate data for not only supply and demand but also on unexpected problems on the basis of which SCRM activities can be adjusted. This openness of communication and problem sharing facilitates SCRM by reducing uncertainty and improving the decision making process. Hence supplier and customer integration can benefit risk management in supply chains. Therefore, we hypothesize:

H1. Supplier integration is positively associated with SCRM.

H2. Customer integration is positively associated with SCRM.

Recently it has been shown that visibility itself is a necessary but insufficient resource for better and faster decision making (Williams et al., 2013). Firms need information processing capability for interpreting and acting upon the visibility provided by their systems. This information processing capability is grounded in the internal integration of firms (i.e. firms' internal processes and systems whereby cross-functional teams within firms interpret, analyze, and take decisions and actions on the information obtained) embedded within supply chains (Schoenherr and Swink, 2012; Williams et al., 2013). Internal cross-functional integration enables the absorption and application of knowledge attained from the external environment (Schoenherr and Swink, 2012; Williams et al., 2013) allowing managers to make more reliable decisions. Integration and information sharing between different departments and functional areas within a firm enable managers to search through and understand real time data and subsequently adjust corresponding operational settings when necessary (Flynn et al., 2010; Riley et al., 2016). Hence, managers can withstand uncertainty and gain more and better returns from their investments in technologies and processes of information sharing if and when they build complementary capabilities of information processing through internal integration. Internally integrated systems ensure the prevention and mitigation of internal disruptions and facilitate in responding to unforeseen changes. Moreover, an effective internal integration can strengthen the ability of early identification of risks and reduce the impact duration of consequences (Riley et al., 2016). Thus, we can hypothesize that:

H3. Internal integration is positively associated with SCRM.

3.3. Supply chain risk management and operational performance

The increasing complex supply chains and uncertain environment make firms vulnerable to risks and disruptions (Bode and Wagner, 2015). The extant literature recognizes the contribution of SCRM to a firm's performance through lowering operational loss, fast response, and prevention of disruptions in supply chains (Manuj et al., 2014; Ritchie and Brindley, 2007; Thun and Hoenig, 2011). From the IPT view, uncertainty indicates the difference between the information required and the information already processed to perform a task (Galbraith, 1974). Therefore, firms need to gather and process information to deal with uncertainty in the environment and achieve superior performance. In the supply chain context, information is concerned with logistics, inventory, quantity, quality, market, technology, and politics to name a few (Fan et al., 2017). The information regarding production, supply and demand is highly uncertain, complex and ambiguous. In this study, we argue that SCRM including risk detection, prevention, response and recovery act as firms' capabilities for gathering and processing supply chain information. Thus, as an information processing system, the SCRM helps to mitigate uncertainty (Fan et al., 2017) and is beneficial for enhancing operational performance (Fan et al., 2017; Kauppi et al., 2016).

In this study, we have focused on four key performance indicators i.e. quality, flexibility, delivery and customer service performance (Rho et al., 2001). SCRM provides the ability to identify and mitigate potential risk factors in supply chain and operations and aids to reduce errors and reworks leading to higher efficiency and improved operational performance (Fan et al., 2017). SCRM enables prompt detection of potential threats (Wieland and Wallenburg, 2012) which can be acted upon resulting in increased accuracy in forecasting and reduce the delivery lead time. SCRM can also improve flexibility performance by addressing upstream as well as downstream risks (Jüttner and Maklan, 2011; Wieland and Wallenburg, 2012). Finally, better customer service and satisfaction can be achieved by preventing possible failures of product or material (Zsidisin, 2003). Hence, we suggest that SCRM facilitates in reducing uncertainty and avoiding disruptions in the supply chain, eventually improving operational performance. This leads to our hypothesis:

H4. SCRM is positively associated with operational performance.

3.4. Mediation effects

The supply chain literature asserts the positive impact of internal integration on supplier and customer integration (Braunscheidel and Suresh, 2009; Flynn et al., 2010; Zhao et al., 2011) as coordination and information sharing among functional units of a firm enhance the ability to engage with supply chain partners effectively. Internal integration is frequently posited as an absorptive capacity to process the information gathered from suppliers and customers (Huo, 2012; Schoenherr and Swink, 2012; Zhao et al., 2011). In risk management literature, the importance of internal integration as a precursor of external integration is highlighted by Kleindorfer and Saad (2005) who suggested that internal supply chain integration must precede any interfirm interfaces. However, empirical research at the intersection of SCRM and SCI tends to ignore the role of internal integration in managing risks and reducing its impact in supply chains (Kauppi et al., 2016; Shou et al., 2018). This could be because in dynamically changing and complex supply chains the positive effects of internal integration on SCRM can be seen only when it processes and implements the information gathered from the external environment i.e. through supplier and customer integration. Hence, we argue that the positive impacts of internal integration on SCRM will be strengthened through supplier and customer integration. Combining the positive associations between internal, supplier and customer integration with our first three hypotheses, we proposed the following hypotheses:

H5. Supplier integration partially mediates the relationship between internal integration and SCRM.

H6. Customer integration partially mediates the relationship between internal integration and SCRM.

The relationships between supplier, customer, and internal integration and firm performance have been an active research area and extensive literature has attached significant importance to SCI in achieving financial as well as operational performance (Danese and Romano, 2011; Flynn et al., 2010; Frohlich and Westbrook, 2001; Huo, 2012; Schoenherr and Swink, 2012). A number of studies support a positive relationship between the three dimensions of SCI and firm performance (Flynn et al., 2010; Schoenherr and Swink, 2012; Wong et al., 2011). Yet, some studies also report mixed findings regarding the association between firm performance and different dimensions of SCI (Devaraj et al., 2007; Gimenez and Ventura, 2005; Koufteros et al., 2005). Several factors have been considered to explain these mixed findings including logistical capabilities (Wiengarten et al., 2014), relationship dynamics (Fynes et al., 2005), risks (Wiengarten et al.,

2016) and environmental uncertainty (Wong et al., 2011). SCRM might prove to be a beneficial concept in this regard (Bagchi et al., 2005). The higher levels of integration increase the dependency between supply chain links (Perrow, 1984) and may result in increased vulnerability to risks (Hallikas et al., 2004; Wieland and Wallenburg, 2013) and inflexibility (Terjesen et al., 2012). Therefore, in such situations, SCRM can help reduce uncertainty and ambiguity (Fan et al., 2017), and also improve flexibility. However, the role of SCRM in explaining the link between integration and performance has been ignored in the existing literature.

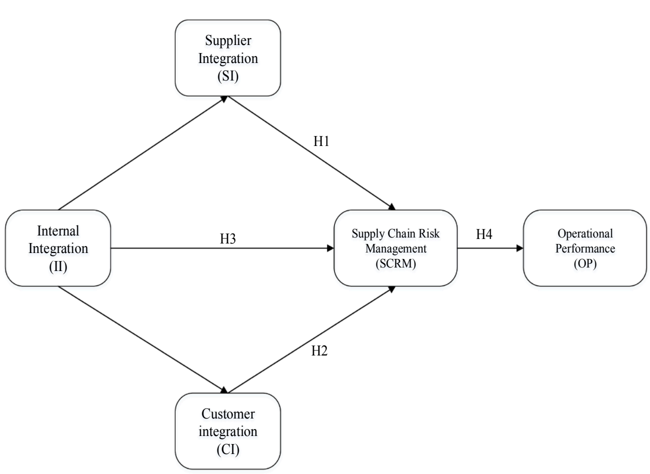
There are some exceptions (Chaudhuri et al., 2018; Ellinger et al., 2015; Wiengarten et al., 2016) who, however, adopted different approaches and likewise reported different results. For example, Wiengarten et al. (2016) found that supplier integration efforts are complemented by SCRM practices under weak rule of law or high risk environments, thus strengthening the performance impact of supplier integration, whereas no such support was found for customer integration efforts. Chaudhuri et al. (2018) explored the moderating effects of SCRM on the relationship between internal and external integration and flexibility performance. They found support for SCRM moderating the relationship between external integration and flexibility performance, however, the same hypothesis was not supported for the relationship between internal integration and flexibility. While existing studies have conceptualized SCRM as a contextual factor and found mixed results, we argue for a mediating effect of SCRM between the association of SCI and operational performance. We maintain that a higher degree of SCI increases complexity and uncertainty in supply chain thus increasing exposure to risks (Hallikas et al., 2004) and reducing flexibility (Terjesen et al., 2012). A higher level of SCI does not necessarily improve performance (Fabbe-Costes and Jahre, 2008) and can lead to negative outcomes as accidents become inevitable in tightly coupled complex systems (Perrow, 1984). Thus, firms need to develop SCRM to detect, prevent, mitigate and response to supply chain risks more adequately and improve their responsiveness to environmental changes. SCRM equip firms with the ability to identify and control potential risks in manufacturing and supply chain processes, thus contributing to performance improvement. Based on these arguments we present the following hypotheses:

H7. SCRM mediates the relationship between internal integration and operational performance.

H8. SCRM mediates the relationship between supplier integration and operational performance.

H9. SCRM mediates the relationship between customer integration and operational performance.

The theoretical model of this study is illustrated in Fig. 1.



H_5: II → SI → SCRM	H_7: II → SCRM → OP
H_6: II → CI → SCRM	H_8: SI → SCRM → OP
H_9: CI → SCRM→OP	

Fig. 1. Research model.

4. Research methodology

4.1. Data collection

The proposed hypotheses were tested using the data from the sixth version of International Manufacturing Strategy Survey (IMSS VI), which is a global research network of institutions and manufacturing firms collaborating with each other for developing a standard survey instrument and protocol for data collection for studying global manufacturing and supply chain management. Initiated by Chalmers University of Technology and London Business School, the IMSS research network was established in 1992. IMSS VI focuses on wide-ranging aspects of manufacturing practices, including those related to the supplier, customer and internal integration, and it also contains items related to SCRM and several different operational performance measures thus making it suitable for this study. The IMSS VI has been used by several scholars to investigate various research topics in the broad field of operations and supply chain management (Boer and Boer, 2019; Chaudhuri et al., 2018; Cheng et al., 2016; Haleem et al., 2017; Hong et al., 2019; Jajja et al., 2018; Kauppi et al., 2016; Shou et al., 2018; Vanpoucke et al., 2014; Wiengarten et al., 2016).

Initially, the questionnaire was developed in English, and then it was translated in different languages (e.g., Spanish, Chinese and French) by researchers, in a coordinated manner, using double and reverse translation procedures for countries having language constraints (Vanpoucke et al., 2014). The selection criterion for target respondents was the awareness and knowledge required for responding to the operational and strategic information sought in the IMSS IV questionnaire. The questionnaires were sent by local research teams by ordinary mail, email or fax. If and when necessary, reminders were also sent periodically for increasing the response rates. The respondents for this survey were supply chain, operations, production or plant managers who provided information regarding the performance, practice, and strategy of the plant.

The sixth iteration of IMSS data collection was carried out from June 2013 to June 2014. The survey was designed to collect data from the population of assembly manufacturing plants (ISIC 25–30 classifications) having more than 50 employees. Across different countries, 2586 IMSS questionnaires were distributed. The final useable sample of the sixth edition of IMSS, as shown in Table 2, consisted of 931 firms from 22 countries situated in the Americas, Europe, and Asia, giving an overall effective response rate of 36%. Non-respondent and late respondent biases were tested by local teams by comparing the publicly available secondary information in terms of sales, size, industry or proprietorship of target companies with received response. In case of unavailability of such secondary information, survey responses were used to test the differences between early and late responses. However, any evidence of non-response and late response bias was not found in the data (Armstrong and Overton, 1977).

Following the techniques of Podsakoff et al. (2003), common method bias (CMB) was minimized from the survey proactively. Firstly, items prone to CMB, such as criterion and predictor variables, were separated from each other in the questionnaire. Secondly, different scale anchors/formats were employed in the survey to measure independent and dependent variables. Thirdly, the anonymity of the respondent and the firm was maintained throughout the data collection process to reduce the social desirability bias. Finally, the survey employed objective concepts and provided an explanation of items where needed to reduce ambiguity. Additionally, we conducted two tests to examine potential CMB. Firstly, Harman's one factor test was performed by using

Table 2
Sample demographics.

Firm size (number of employees)	Number	Percentage
Small (<250)	409	43.93
Medium (250–500)	179	19.23
Large (>500)	341	36.63
Missing	2	0.22
Industry		
Fabricated metal products, except machinery and equipment	282	30.29
Computer, electronic and optical products	123	13.21
Electrical equipment	153	16.43
Machinery and equipment not elsewhere classified	231	24.81
Motor vehicles, trailers, and semi-trailers	93	9.99
Other transport equipment	49	5.26
Region		
Europe	479	51.45
Asia	343	36.84
North America	78	8.38
South America	31	3.33

Total sample size = 931.

principal component analysis with unrotated factor solution on the 5 scales with 24 items. The results indicated 5 factors with eigenvalues greater than 1. The first factor explained only 34.944% of the variance suggesting that it did not explain majority of the variance, hence providing additional support that in this study CMB is not an issue.

Secondly, we used CFA marker technique for observing shared variance between hypothesized variables and a marker variable (Podsakoff et al., 2003; Zacharia et al., 2011). The marker variable or method factor must be theoretically unrelated to other variables under investigation (Lindell and Whitney, 2001; Williams et al., 2010). Insignificant correlation between hypothesized variables and marker variable indicates a lack of significant common method bias. Following Das et al. (2000) and Kim (2014), we selected a single item scale (measuring the level of competitive rivalry within the industry on five point Likert scale: (1 = very low, 5 = very high) for competitive rivalry as a marker variable.

CMB is evaluated within CFA setting based on statistical significance in chi squares (Craighead et al., 2011; Liu et al., 2016; Richardson et al., 2009). A chi-square difference test was performed and checked for statistical difference between the original measurement model and a measurement model including hypothesized variables and the theoretically irrelevant marker variable. The analysis indicated no significant improvement in the fit indices of the original measurement model (i.e., $\chi^2 = 658.29$, CFI = 0.965, GFI = 0.943, AGFI = 0.927, TLI = 0.959, RMSEA = 0.044) and the extended measurement model with a marker variable (i.e., $\chi^2 = 665.80$, CFI = 0.965, GFI = 0.944, AGFI = 0.928, TLI = 0.959, RMSEA = 0.042) hence indicating that CMB is not a serious issue in this study (Liu et al., 2016; Williams et al., 2010).

4.2. Measures

All constructs in this study are operationalized as first-order reflective constructs, except operational performance, which is operationalized as a second order construct using items from IMSS VI survey. All items selected from IMSS VI survey were measured using five-point Likert scales.

Supplier and customer integration were operationalized by using four items indicating levels of implementation related to i) sharing information, ii) developing collaboration approaches iii) joint decision making, and iv) system coupling with key suppliers and customers respectively (Braunscheidel and Suresh, 2009; Closs et al., 2005; Devaraj et al., 2007; Frohlich and Westbrook, 2001; Vijayasarathy, 2010). Internal integration was operationalized in terms of the current level of information sharing and joint decision making between the purchasing/sales and manufacturing departments (Germain and Iyer, 2006; Gimenez and Ventura, 2005; Zhao et al., 2011). These items of IMSS VI have been used in earlier studies to operationalize supplier, customer and internal integration constructs (Kauppi et al., 2016; Shou et al., 2018).

Supply chain risk management practices were measured by the current level of implementation of activities for detecting, preventing, responding and recovering from the effects of disruptions along the supply chain through different contingency plans and buffering strategies. Earlier studies have also used these items from IMSS VI to measure SCRM (Chaudhuri et al., 2018; Kauppi et al., 2016; Shou et al., 2018).

Operational performance has been recognized as a multidimensional construct in the extant literature (Shou et al., 2018) and is typically assessed along the dimensions of flexibility, quality, delivery and customer service (Flynn et al., 2010; Kauppi et al., 2016; Rosenzweig and Roth, 2004; Shin et al., 2000). In their study, Inman et al. (2011) addressed this multidimensionality and described operational performance as comprising five distinct factors and treated it as a second order construct. Therefore, following Inman et al. (2011), in this study, operational performance was operationalized as a second-order reflective construct consisting of four first-order reflective constructs: quality, flexibility, delivery and customer service performance (Kauppi et al., 2016; Rosenzweig and Roth, 2004; Shin et al., 2000). Quality performance was operationalized in terms of i) conformance quality and ii) product quality and reliability (Jayaram et al., 2011; Kauppi et al., 2016). Likewise, flexibility performance was operationalized as i) volume flexibility and ii) mix flexibility (Hallgren and Olhager, 2009; Jayaram et al., 2011; Scherrer-Rathje et al., 2014; Van der Vaart et al., 2012). Delivery performance was operationalized as i) delivery reliability and ii) delivery speed (Flynn et al., 2010; Huo, 2012; Kauppi et al., 2016). For customer service performance i) product assistance and ii) customer service quality were considered (Fan et al., 2017; Kauppi et al., 2016).

We used firm size as a control variable which may influence the adoption of risk management practices (Kim, 2009). We measured firm size in terms of number of employees and operationalized it as a logarithm of total number of employees in a business unit (Sreedevi and Saranga, 2017). We also control for uncertainty, which was operationalized, using five point Likert scale, as fluctuations in the volume and mix of supply, demand and manufacturing, and product specifications (Chaudhuri et al., 2018).

4.3. Measurement model analysis

We adopted a structural equation modeling (SEM) approach for empirical examination. SEM analysis involves the simultaneous evaluation of multiple variables and their relationships. According to Hair et al. (2012) there are basically two types of SEM techniques i.e. covariance based SEM (CB-SEM) and partial least squares based SEM (PLS-SEM). In this study, CB-SEM analysis is opted as this approach is recommended for the research involving complex models and seeking theory testing using existing theoretical foundation (Shah and Goldstein, 2006) whereas PLS-SEM is deemed to be more suitable for exploratory research (Peng and Lai, 2012). Prior to testing the structural model, the measurement model was tested for construct validities and reliabilities. Confirmatory factor analysis (CFA) was carried out to examine the proposed factor structure. The CFA model showed reasonably good model fit (χ^2/d. f. = 2.81, CFI = 0.965, GFI = 0.943, AGFI = 0.927, TLI = 0.959, RMSEA = 0.044). Table 3 shows the values of Cronbach's α, Joreskog ρ, average variance extracted (AVE), comparative fit index (CFI), and standardized factor loadings (SFL) for each construct and its indicators.

We computed Cronbach's α and Joreskog ρ to assess reliability and internal consistency of the constructs (Braunscheidel and Suresh, 2009; Chin, 1998). For the proposed model, all values of Cronbach's α and Joreskog ρ exceeded the recommended threshold of 0.70 (Chin, 1998; Nunnally and Bernstein, 1994) thus indicating construct reliability and internal consistency.

Table 3
Construct reliability and validity analysis (n = 931).

Construct/indicator	SFL
Supplier Integration (Cronbach's α = 0.838, Joreskog ρ = 0.846, AVE = 0.581, CFI = 0.987)	
Sharing information with key suppliers (about sales forecast, production plans, order tracking and tracing, delivery status, stock level)	0.766
Developing collaborative approaches with key suppliers (e.g. supplier development, risk/revenue sharing, long-term agreements)	0.821
Joint decision making with key suppliers (about product design/modifications, process design/modifications, quality improvement, and cost control)	0.778
System coupling with key suppliers (e.g. vendor managed inventory, just-in-time, Kanban, continuous replenishment)	0.669
Customer Integration (Cronbach's α = 0.881, Joreskog ρ = 0.885, AVE = 0.658, CFI = 1.000)	
Sharing information with key customers (about sales forecast, production plans, order tracking and tracing, delivery status, stock level)	0.845
Developing collaborative approaches with key customers (e.g. risk/revenue sharing, long-term agreements)	0.855
Joint decision making with key customers (about product design/ modifications, process design/modifications, quality improvement, and cost control)	0.779
System coupling with key customers (e.g. vendor managed inventory, just-in-time, Kanban, continuous replenishment)	0.756
Internal Integration (Cronbach's α = 0.890, Joreskog ρ = 0.865, AVE = 0.617, CFI = 0.913)	
Sharing information with purchasing department (about sales forecast, production plans, production progress, and stock level)	0.776
Joint decision making with purchasing department (about sales forecast, production plans, and stock level)	0.817
Sharing information with sales department (about sales forecast, production plans, production progress, and stock level)	0.780
Joint decision making with sales department (about sales forecast, production plans, and stock level)	0.791
Supply Chain Risk Management (Cronbach's α = 0.871, Joreskog ρ = 0.864, AVE = 0.613, CFI = 0.970)	
Preventing operations risk (e.g. select a more reliable supplier, use clear safety procedures, preventive maintenance)	0.754
Detecting operations risks (e.g. internal or supplier monitoring, inspection, tracking)	0.824
Responding to operations risks (e.g. backup suppliers, extra capacity, alternative transportation modes)	0.803
Recovering from operations risks (e.g. task forces, contingency plans, clear responsibility)	0.788
Quality Performance (Cronbach's α = 0.791, Joreskog ρ = 0.792, AVE = 0.655)	
Conformance quality	0.801
Product quality and reliability	0.818
Flexibility Performance (Cronbach's α = 0.736, Joreskog ρ = 0.736, AVE = 0.583)	
Volume flexibility	0.788
Mix flexibility	0.738
Delivery Performance (Cronbach's α = 0.817, Joreskog ρ = 0.843, AVE = 0.729)	
Delivery Speed	0.861
Delivery Reliability	0.846
Customer Service (Cronbach's α = 0.720, Joreskog ρ = 0.726, AVE = 0.571)	
Product assistance/support	0.807
Customer service quality (e.g. training, information, help-desk)	0.700
Operational Performance (Cronbach's α = 0.830, Joreskog ρ = 0.829, AVE = 0.549, CFI = 0.986)	
Quality Performance	0.783
Flexibility Performance	0.688
Delivery Performance	0.768
Customer Service Performance	0.710

AVE = Average variance extracted, CFI= Comparative fit index, SFL = Standardized factor loadings.

Convergent validity measures the convergence or similarity between the items measuring the same construct, indicating that all items in the construct measure the same construct (Bagozzi et al., 1991). For establishing convergent validity, the factor loadings and AVE for all items of each construct were assessed. For the proposed model, the factor loadings of all items exceed the value of 0.60 (Hair et al., 2013) and the values of AVE of all constructs are above 0.05 (Chin, 1998; Fornell and Larcker, 1981) thus satisfying the conditions of convergent validity. With regard to unidimensionality, CFI values of all constructs exceeded the value of 0.90, hence indicating the unidimensionality of the constructs (Bagozzi et al., 1991).

Table 4
Correlations among constructs.

Constructs	SCRM	SI	II	CI
Supplier Integration (SI)	0.643			
Internal Integration (II)	0.529	0.663		
Customer Integration (CI)	0.546	0.750	0.526	
Operational Performance (OP)	0.481	0.309	0.255	0.263

SCRM = Supply Chain Risk Management.

Discriminant validity of the constructs indicates the extent to which each construct and its indicators are different from other constructs and their indicators. For establishing discriminant validity, the values of squares inter construct correlation between all pairs of constructs should be less than the values of AVE of individual constructs in each pair, which happens to be the case in our model thus providing evidence for discriminant validity of the proposed constructs (Segars and Grover, 1993) as shown in Table 4.

Furthermore, through extensive pretesting of the questionnaire and the active involvement of practitioners, the relevance of instruments was ensured and thereby content validity is addressed. Additionally, for this study, IMSS VI data from the sixth iteration was used, which implies that the research instruments used in IMSS VI have been established and known to researchers as demonstrated by a number of publications employing different versions of the survey.

4.4. Structural model analysis

For testing the structural model, we carried out CB-SEM analysis using AMOS (version 22) modeling software. Results of SEM showed that the structural model provide satisfactory fit (χ^2/d. f. = 2.96, CFI = 0.958, GFI = 0.937, AGFI = 0.921, TLI = 0.952, RMSEA = 0.046, IFI = 0.958) (Hu and Bentler, 1999).

The results of path coefficients of the structural model are shown in Fig. 2. The effects of supplier integration on SCRM ($\beta = 0.426$, $p < 0.001$) and customer integration on SCRM ($\beta = 0.134$, $p < 0.05$) are positive and significant thus bearing support for H_1 and H_2. The path from internal integration to risk management practices is significant ($\beta = 0.177$, $p < 0.001$), thus supporting H_3. The effect of risk management practices on operational performance is also significant ($\beta = 0.481$, $p < 0.001$) indicating support for H_4. Finally, the relationship between both control variables and the dependent variable is insignificant.

Additionally, following Bollen (1989), we tested the appropriateness of operationalization of operational performance as a second-order construct. We compared the model with the one in which the second order construct is replaced by four first-order constructs (i.e., delivery, flexibility, quality, and customer service performance). We also added new paths from risk management practices to each of the first order performance constructs. The overall fit indices of the revised model (χ^2/d. f. = 5.298, CFI = 0.898, GFI = 0.887, AGFI = 0.860, TLI = 0.886, RMSEA = 0.065, IFI = 0.899) were inferior to those of the original model hence providing support for second order operationalization of operational performance at structural model level. Furthermore, the value of target coefficient (T), which is the ratio of chi square values of first order factor model with second order factor model, is found to be 0.97, which further supports the second order specification of operational performance construct.

For testing multiple mediations and calculating estimated values of specific indirect effects we adopted AMOS Bayes estimation and resampling method using user defined estimate (Arbuckle and Wothke, 1999; Chen and Hung, 2016; Gaskin, 2016). Multiple mediator effects can be tested individually as well as simultaneously. However,

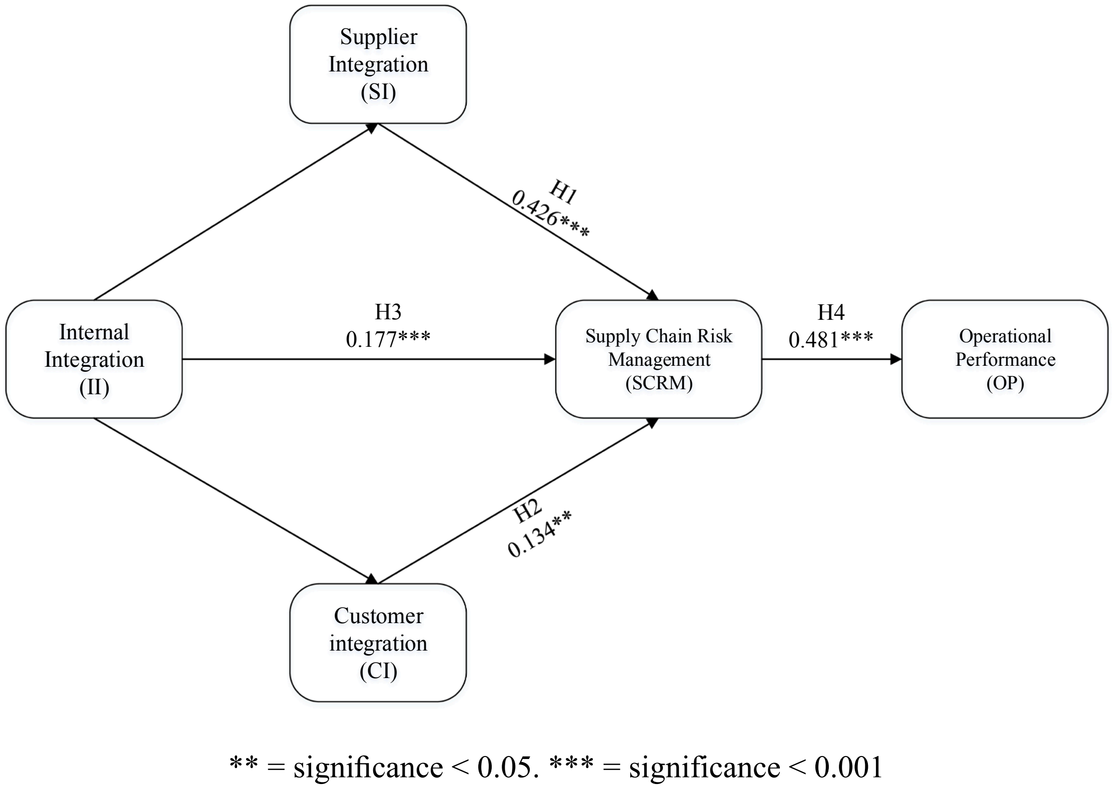


Fig. 2. Results for direct hypothesis.

Table 5
Bootstrapping results for mediation tests.

Hypothesis	IV	MV	DV	Direct Effect	Indirect Effect of IV on DV	SE of indirect effect	95% CI for mean indirect effect
H_5	II	SI	SCRM	0.177***	0.228***	0.042	0.150–0.314
H_6	II	CI	SCRM	0.177***	0.057**	0.027	0.040–0.112
H_7	II	SCRM	OP	0.159***	0.030***	0.013	0.130–0.055
H_8	SI	SCRM	OP	0.075	0.083***	0.024	0.050–0.132
H_9	CI	SCRM	OP	0.018	0.024**	0.013	0.007–0.049

IV: Independent Variable, DV: Dependent Variable, MV: Mediating Variable, II: Internal Integration, SI: Supplier Integration, CI: Customer Integration, SCRM: Supply Chain Risk Management, SE: Standard Error, CI: Confidence Interval.
Note: *** = p-value < 0.001, ** = p-value < 0.05.

simultaneous testing provides the advantage of learning whether the effect of one mediator and other mediator is independent or not (Chen and Hung, 2016). Following Chen and Hung (2016), we preferred this approach because of its high efficiency, ease of use and high flexibility as compared to other traditional tools of testing multiple mediations. The bootstrapping method generating 5000 resamples was used with bias corrected confidence intervals (95%) in order to obtain more powerful confidence interval limits for indirect effects and their significance (Preacher and Hayes, 2008).

As there were multiple indirect paths from internal integration to SCRM, we separated the indirect effects using user defined estimate (Gaskin, 2016) for testing H_5 and H_6. The results of bootstrapping analysis are summarized in Table 5. The results show that the indirect effects of internal integration on risk management practices through supplier integration (at $p < 0.001$) and customer integration (at $p < 0.05$) are significant. In case of both mediators, the direct effects of internal integration on risk management practices are also significant thus suggesting partial mediation effects of supplier and customer integration between the relationship of internal integration and SCRM, supporting hypothesis H_5 and H_6.

The results of mediation test for H_7 to H_9 using estimates of indirect and direct effects are presented in Table 5. The results show that indirect effects from internal, supplier and customer integration to operational performance are significant (at $p < 0.001$) thus supporting H_7, H_8, and H_9. The direct effect of internal integration is also significant thus suggesting partial mediation effects of SCRM between internal integration and operational performance. However, the direct effect of both supplier and customer integration on operational performance is insignificant thus suggesting full mediation effects of SCRM in the relationship between supplier and customer integration and operational performance.

4.5. Robustness check

We took several steps to minimize potential biases from our study and to validate our model and findings. Firstly, we addressed the bias resulted from the common method (Antonakis et al., 2014; Guide and Ketokivi, 2015) through both procedural and statistical remedies. Secondly, late-response bias was checked to address potential bias due to variation in the respondents' motivation (Damali et al., 2016). Thirdly, in our model SCI is regarded as the enabler of SCRM and not the other way around. However, a possibility exists that there might be a reverse causality issue between SCI and SCRM, leading to inconsistent and biased results (Guide and Ketokivi, 2015; Liu et al., 2016). To address this potential reverse causality issue, we conducted

Durbin-Wu-Hausman augmented regression, as suggested by Davidson and MacKinnon (2009) and employed by various researchers (Dong et al., 2016; Narayanan et al., 2015; Sluis and De Giovanni, 2016). We used international sourcing strategy level with suppliers and customers as an instrumental variable as it is correlated with SCI (Danese et al., 2013) but not with SCRM. We selected a two item scale measuring the level of international sourcing strategy with suppliers and level of international distribution strategy with customers on a five point Likert scale: (1 = none, 5 = high). We ran a Stage 1 model with SCI as dependent variable and predicted residual of Stage 1 model. We then included this residual in a Stage 2 model with SCRM as a dependent variable. The beta coefficient of residual in the second stage was insignificant ($\beta = 0.063$, $p > 0.05$) indicating that, in our setting, reverse causality was not a concern. Hence, it can be concluded that the results are unlikely to be influenced by causality bias.

Lastly, to validate the robustness of our model we ran a measurement invariance test of the constructs by using CFA approach (Steenkamp and Baumgartner, 1998). We first split the data into two geographically determined groups: i.e. 'Asia and South America' and 'Europe and North America'. The unconstrained CFA model run with two groups in a measurement model and yielded a satisfactory fit (χ^2/d. f. = 1163.39/522, CFI = 0.947, GFI = 0.907, AGFI = 0.884, TLI = 0.939, RMSEA = 0.036). All factor loadings were above 0.70 and significant ($p < 0.01$) with the exception of one item of SCRM (factor loading: 0.66 and significant at $p < 0.01$), thus it can be concluded that all constructs across the two groups exhibit satisfactory configural invariance. Additionally, to test the significance of $\Delta\chi^2$ between the unconstrained and constrained multigroup models a χ^2 test was used. Regression weights of all items across the two groups were fixed for the constrained CFA model. The result of the constrained CFA model remained satisfactory (χ2/d. f. = 1174.84/538, CFI = 0.948, GFI = 0.906, AGFI = 0.886, TLI = 0.942, RMSEA = 0.036) and $\Delta\chi^2$ was significant ($\Delta\chi^2 = 11.442$, Δd.f = 16) was significant (at $p < 0.01$) thus providing additional support for configural invariance of the measurement model.

5. Discussion

All of our hypothesized direct and mediated relationships are supported by large scale empirical data. Interestingly, findings of the empirical analysis suggest full mediation effects of SCRM in the relationship between supplier and customer integration and operational performance. The results of all hypotheses are summarized in Table 6.

This study presents valuable insights into the information processing aspect of SCRM. SCRM is an information intensive process, implementation of which highly depends on acquiring and timely utilizing the relevant information, thus necessitating attention to the information aspect of managing risks (Fan et al., 2017). Some recent studies elaborate on the information aspect of SCRM. For example, Fan et al. (2017) proposed a supply chain risk information processing system and examined its inner mechanism, organizational antecedents and performance outcomes. Shou et al. (2018) argued that SCRM should be complemented with supplier integration to access reliable and timely information. While, existing studies in the literature have explored some information related practices e.g. information sharing, information management, supply chain risk information and supplier integration (Fan et al., 2017; Kauppi et al., 2016), however, studies that focus on the holistic processes of information sharing, absorption of collected information and its appropriate implementation via investing in information processing capability are relatively scant. In this study, we build on IPT to argue that for efficient SCRM a firm may need to develop integrative practices within the firm as well as with key supply chain partners i.e. suppliers and customers. We maintain that as SCRM is an information intensive process it requires an information processing mechanism to acquire accurate information, process it and implement it on a timely basis. For that purpose, we identify SCI as a relevant antecedent of SCRM and suggest that the three dimensions of SCI namely supplier, customer, and internal integration, serves as a mechanism for acquiring, processing, absorbing and timely implementing reliable information, hence enabling effective SCRM. The findings of this study are consistent with our initial theorization that internal, supplier and customer integration facilitate SCRM by allowing information sharing, information processing and implementation of relevant information within the firm as well as across supply chain. By doing so this paper complements the earlier qualitative research arguing for the positive effects of integrative practices on SCRM (Kleindorfer and Saad, 2005; Zhu et al., 2017).

Table 6
Hypotheses result.

Hypothesis	Result
H_1: Supplier integration → SCRM	Supported
H_2: Customer integration → SCRM	Supported
H_3: Internal integration → SCRM	Supported
H_4: SCRM → Operational performance	Supported
H_5: Internal integration → Supplier integration → SCRM	Supported
H_6: Internal integration → Customer integration → SCRM	Supported
H_7: Internal integration → SCRM → Operational performance	Supported
H_8: Supplier integration → SCRM → Operational performance	Supported
H_9: Customer integration → SCRM → Operational performance	Supported

This study empirically determines that integrative practices of internal integration, supplier integration, and customer integration have a direct positive effect on SCRM and that SCRM positively impacts operational performance. Also, supplier integration and customer integration positively mediate the relationship between internal integration and SCRM. The findings of the study suggest that integrative practices with both key suppliers and customers seem to be equally important for facilitating SCRM process. External supplier and customer integration serves as external routines to collect reliable and accurate information improving visibility and responsiveness therefore, regarded as key enablers for the effectiveness of SCRM. This extends the existing literature, considering only supplier integration while neglecting the importance of customer integration for mitigation of risk (Shou et al., 2018).

Most of the existing empirical studies ignore the role of internal integration in mitigation of risk via effective risk management (e.g., Kauppi et al., 2016; Shou et al., 2018; Wiengarten et al., 2016). While external supplier and customer integration provides channels for timely and accurate information acquisition, firms need an information processing capability to absorb and exploit the knowledge gained from external sources. We argue that the absorption and application of the knowledge gained from the external environment depend on internal information processing capability, which comes from internal integration. We maintain that internal integration i.e. facilitating cooperation and information sharing among internal functions must lead any interfirm collaboration for effective risk management (Kleindorfer and Saad, 2005) and it is arguably the basis of SCI (Wong et al., 2011). The results of our study show that internal integration positively impacts SCRM both directly as well as through the partial mediation effect of supplier and customer integration. This implies that internal integration can mitigate risks in supply chains directly as well as with the help of supplier and customer integration. This finding is in line with the existing theory that internal integration is the base of external integration capabilities (Flynn et al., 2010; Huo, 2012). This also suggests that supplier and customer integration are reinforcing capabilities for efficient SCRM.

Existing theoretical studies have suggested performance benefits for firms via implementing SCRM (e.g. Manuj et al., 2014; Thun and Hoenig, 2011). In the extant literature, the main arguments for SCRM having a positive impact on a firm's performance is through lowering operations accidents and prevention of disruptions in supply chains (Ritchie and Brindley, 2007; Thun and Hoenig, 2011; Manuj et al., 2014). However, generally, the implementation of SCRM require additional costs and upfront investment for excess inventories, back up suppliers, extra capacities and capabilities (Bode and Wagner, 2015; Colicchia and Strozzi, 2012; Kauppi et al., 2016) which may weaken firm performance especially in constantly changing and uncertain business environment. The findings of this study suggest that investing in information processing capability for mitigating risk is more relevant and beneficial than investing in reducing information processing needs.

The importance of SCRM as a mediator between internal, supplier and customer integration and operational performance is highlighted in this research. In line with Fabbe-Costes and Jahre (2008), our findings support the argument that a high level of integration does not necessarily improve performance and as in tightly coupled systems accidents become inevitable (Perrow, 1984), firms need to develop SCRM processes to mitigate risk and improve performance. Interestingly findings of this study suggest full mediation effect of SCRM in the relationship between supplier and customer integration and operational performance, whereas partial mediation effect of SCRM is found in the relationship between internal integration and operational performance. These findings of the study potentially explain the mixed results on the relationship between SCI and operational performance in the existing literature (Devaraj et al., 2007). Supplier and customer integration may not directly contribute to operational performance but are supported by SCRM in improving operational performance. This reflects the importance of SCRM for both upstream and downstream integrative activities in the dynamic and uncertain business environment. The finding also reflects that while internal integration has a direct positive impact on operational performance, SCRM further strengthens the positive impact via partial mediation.

5.1. Theoretical implications

In the supply chain literature, information processing perspective has been proposed as a highly relevant theoretical lens to inspect SCRM issues (Fan et al., 2017), therefore, deserving more research. Drawing on IPT, this study contributes to the SCRM literature by extending the information processing aspect of SCRM and examining its supply chain antecedents and performance consequences. Moreover, this study contributes to the literature by empirically examining the interrelationship between firm's integration practices and SCRM and their impact on operational performance. To the best of our knowledge, there are very few studies in SCRM literature that focus on empirical investigation of the role of integrative practices in mitigating supply chain risks and improving performance. By doing so this study seeks to address the call in the literature to test the effect of SCI on the effectiveness of SCRM and consequently on performance outcomes (Chaudhuri et al., 2018). The findings of the study suggest that integration with both key suppliers and customers is equally important for facilitating SCRM process. This finding extends the existing literature, which mainly focuses on the importance of supplier integration and ignores the role of customer integration for mitigation of risk (Li et al., 2015; Shou et al., 2018). Furthermore, the results reveal that internal integration forms the base on which supplier and customer integration builds for effective risk management and enhanced performance.

The extant literature on SCRM as well as SCI regards internal integration as of high significance. Among the ten principles of managing risks proposed by Kleindorfer and Saad (2005), the first and foremost suggest that internal integration must precede any interfirm interfaces. Schoenherr and Swink (2012), in their study on retesting and extending the arcs of integration, highlighted internal integration as a source of a firm's capability to effectively transform, absorb, and exploit the information gained through external integration. Wong et al. (2011) argued that internal integration provides the basis for SCI as it removes functional barriers and enables real-time information sharing and cooperation across internal functions. Despite of its high significance in both SCRM and SCI literature much of the existing empirical research has overlooked internal integration in relation to SCRM, focusing only on supplier (Kauppi et al., 2016; Li et al., 2015; Shou et al., 2018) and/or customer integration (Chaudhuri et al., 2018; Wiengarten et al., 2016). Inclusion of internal integration along with external supplier and customer integration seeks to address the research gap by proposing a holistic framework demonstrating the effects of all three (supplier, customer, internal) dimensions of SCI on SCRM and performance outcomes. Overall, the results of this study suggest that SCRM benefits from the information processing capability of the firm, which is rooted in internal information sharing and integration capabilities that subsequently build supplier and customer information sharing and integration capabilities.

This study also highlights the mediating effects of SCRM between SCI and operational performance. In doing so, the findings of the study potentially explain the mixed results between SCI and operational performance in the existing literature (Devaraj et al., 2007) and addresses the role of SCRM in explaining the link between integration and performance (Bagchi et al., 2005). The findings reflect that supplier and customer integration improve operational performance through the full mediation of SCRM (rather than directly contributing to operational performance). This suggests that SCRM reduce the potential risks stemming from the higher integration and dependency on suppliers and customers and minimize the possible risk of disruption propagation and amplification along the supply chain. Thus, firms having higher upstream and downstream integration should invest in adequate SCRM processes to gain operational benefits.

5.2. Managerial implications

This study offers several insights for managers. Firstly, it suggests that to manage supply chain risk, managers need to embrace information processing perspective, as SCRM is an information intensive process. Managers should appreciate the importance of integrative practices for mitigating supply chain risks. Key supply chain partners are a source of external environment information which is a critical input for firm's sense making process especially in risk prone situations, while cross-functional integration among different departments act as information processing capability for absorbing, processing and timely implementation of information for responding to changes in the external environment. Poor connection with key supply chain partners would have a cascading effect on firms' information sharing process whereas poor internal integration within the firm would affect the processing and timely utilization of information gathered from external integration. Hence, supply chain managers should develop integrative practices within the firm as well as with key supply chain partners to manage risk and enhance operational performance. Additionally, this paper finds that SCRM meditates the relationship between SCI and operational performance suggesting that the potential negative effects of higher integration on operational performance can be reduced through SCRM. Thus, SCI and SCRM simultaneously play an important role in enhancing operational performance.

6. Limitations and future research

The findings and limitations of this study suggest important avenues for future research. The first limitation of this study is the use of single-respondent and self-reported data. While the results of both Harman's single factor test and CFA marker technique suggest that common method bias (CMB) is not a serious concern, however, future studies are suggested to obtain data from multiple respondents within each firm to minimize potential CMB. Secondly, although we have made efforts to minimize endogeneity bias, both conceptually by explaining our research point of departure (i.e. SCI enables SCRM) and quantitatively (by checking for reverse causality), endogeneity can probably never be completely eliminated from empirical analysis (Guide and Ketokivi, 2015; Ketokivi and McIntosh, 2017). In this regard, future studies are suggested to use experiments or longitudinal analysis where endogeneity could be tested more rigorously. Thirdly, this study has employed cross sectional data for empirical investigation, which has kept this research from examining the dynamic aspects of the proposed associations. Future research may use case based research or longitudinal data to study the associations between SCI, SCRM, and performance. Fourthly, future research may extend the information processing perspective of SCRM by regarding it as an information intensive process. The role of all three elements of SCI in this regard is crucial for sharing, accumulating, processing, absorbing and implementing information for effective SCRM. In this regard, future research can analyze different contextual factors that may affect the association between SCI and SCRM e.g. intense competition, turbulent vs. non turbulent industry, manufacturing vs. services sector. Fifthly, as an attempt to explain the mixed findings in the literature regarding the effect of SCI on operational performance, this study finds partial mediation effect between internal integration and performance and full mediation effect of SCRM between supplier and customer integration and performance. This opens a new direction in the existing SCI literature and future research may further explore the role of SCRM in explaining the SCI and operational performance relationship. Finally, to explore the generalizability of this research, future research may investigate the proposed relationships in other industrial sectors besides manufacturing.

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