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Managing Supply Chain Risk – Role of IT/IS

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MANAGING SUPPLY CHAIN RISK – ROLE OF IT/IS

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Abstract

Measures aimed at making supply chains more efficient and responsive have also made them more vulnerable and exposed to disruptions. These measures include increased off-shoring and outsourcing of manufacturing and product development activities, contract manufacturing, global sourcing, lean operations with reduced inventories, centralised distribution and warehousing, reduction of supplier base and tightly integrated supply chains. In addition to this increased sensitivity of supply chains, a significant increase in the frequency and number of events leading to major disruptions, and their magnitude is forcing organizations to take supply chain risk more seriously. This paper discusses the concept of supply chain risk, supply chain risk management, its dimensions and the role of information technologies in general, and enterprise systems in particular. It will discuss the challenges faced by business organizations in leveraging existing and future information technologies and systems and their double-edged role. While industry reference models have the potential to internalise supply chain risk management processes, their ability in identification and mitigation of the supply chain risk is limited and depends upon other IT-dependent factors, such as information visibility, trust, security of intellectual property information, ability to collect snapshots of demand, inventory and capacity at key nodes in the supply chain, and the sense and respond capability of the organization to deal with material flow disruptions.

Keywords: Supply chain risk, Information technologies, Enterprise systems, SCOR.

Introduction

In the past decade, supply chain management has become a key competitive weapon for organizations and many large and small organizations have developed and implemented strategies to improve their supply chain performance. While the majority of these efforts focused on the improvement of cost efficiencies, organizations have generally underplayed the risks from supply chain disruption and paid less attention to the effectiveness of their supply chains (Hendricks & Singhal 2005). Though classic solutions, such as excess capacities, built-in slack in delivery times, and excess margins to cover costs of returns, have been deployed for minimizing supply chain risk in the past, they are not considered reliable in an environment dominated by Just-In-Time (JIT), off-shoring and outsourcing of business processes and globalised supply chains. Information technologies in general have played a major role and complemented these traditional solutions. By facilitating improved visibility of information and integration of processes, information technologies in general, and the current suite of enterprise systems in particular, are expected to play an important role in managing the supply chain risk.

In addition, the industry standard process reference models, such as the SCOR (Supply Chain Operations Reference) model, have facilitated standardization of processes and information across the supply chain and contributed to improvements in supply chain performance. While the contribution of these information technologies and industry-standard process reference models to the efficiencies of the supply chains are well identified in the literature, their ability to contribute to the identification and mitigation of supply chain risks is not known. This paper reports on a study investigating the role of an enterprise systems-en36+abled environment and the implementation of a SCOR model in managing the supply chain risk. It presents a brief review of the literature on supply chain risk management and the role of information technologies in managing the risk and identifies gaps in the literature. It will then discuss the research model, the methodology adopted in the study and the preliminary findings and implications.

Literature Review and Context

Managers are increasingly challenged to address a variety of opportunities and risks at both operational and strategic levels. Risk is studied in various disciplines, such as accounting, finance, information technology and operations (Cucchiella & Gastaldi 2006). Risk is defined as the likelihood for an uncommon event to happen, and the negative effects this event will have on the organization (Khan & Burnes 2007). Risk therefore depends on the probability of the event, the number of possible

outcomes, the significance of these outcomes (Mitchell 1995, Khan & Burnes 2007) and the pathway that leads to the event (Ritchie & Brindley 2007). It is debatable whether risk is subjective or objective and whether it is positive or negative. If it is subjective, it is dependent on the values and standings of the organization and managed on an individual basis; if it is objective it would be possible to develop general structured tools to measure and manage risk (Khan & Burnes 2007). In general risk management literature, risk is almost always considered as something negative (Mitchell 1995, Harland et al 2003) and managing risk is considered equivalent to minimizing risk. In addition to the concept of its measurability, its relationship to uncertainty is also an issue.

Absence of precise meanings and interpretations in the general literature on risk and its application to the supply chain risk management area makes it hard to transfer the wide range of risk management tools available in the general literature to supply chain risk management (Khan & Burnes 2007). Suggesting that supply chain risk stems from variations in information, material and product flow, Gaonkar and Viswanadham (2007) defined risk in the supply chain as the distribution of the loss resulting from the variation in possible supply chain outcomes, their likelihood and their subjective value. Thus, the supply chain risk affects both upstream and downstream operations in the supply chain and can be expressed as a product of the probability of disruption and the impact of such disruption.

Significance of supply chain risk

Relatively unstable operating environment and increasingly sensitive supply chains mean that modern supply chains are more vulnerable than ever. There has been an increase both in the potential for disruptions and in their magnitude (Elkins et al 2005). There has been a long-term upward trend in the number of catastrophic events and the amount of economic and insured losses since 1950 (Munich Re 2007). Thus, external environmental factors that are outside the control of the organization, as well as internal factors, have made the supply chains vulnerable and sensitive to disruptions.

Globalization of markets and increased competitive pressure has compelled firms in almost all industries to make their supply chains efficient and more responsive. By outsourcing and off-shoring manufacturing, and research and development activities, reducing inventories by Just-in-time strategies, reducing supplier base, single sourcing, and by collaborating more intensely with other partners in the supply chain, companies have achieved lean and efficient supply chain processes (Gaonkar & Viswanadhan 2007, Fisher 1997, Lee 2002). Outsourcing manufacturing operations, focusing on reducing inventories and excess capacities and single sourcing, together with globalization and complexity in today's interconnected supply chains, have made companies more vulnerable to disturbances in the supply chain (Harland et al 2003, Cousins et al 2004, Zsidisin 2003). Supply chain disruptions can also adversely affect the stock price and shareholder value of an organization (Hendricks & Singhal 2005). The leaner and more integrated a supply chain, the more vulnerable it is (Faisal et al 2006). In fact, today's supply chains are more vulnerable than ever to major disruptions (Wagner & Bode 2008).

Types of Supply chain risk

To be able to evaluate and manage risk in supply chain, it is important to understand the different types of risks that can occur, where they stem from, which events make them occur and what drives them. Several authors have classified the risks in supply chains differently ─ while some have classified according to the sources of risk, others have used causes, or sources of uncertainty, as explained below.

Problems in supply chain result from a variety of incidents, such as natural disasters, labor disputes, economic instability in suppliers, actions from competing companies, instability in infrastructure, new technologies, etc. (Chopra & Sodhi 2004, Gaonkar & Viswanadham 2007, Kumar & Viswanadham 2007, Faisal et al 2006). Ritchie and Brindley (2007) define seven different sources of risk in supply chain – environment characteristics, industry characteristics, supply chain configuration, supply chain members, organization's strategy, problem specific variables and decision making unit. Similarly, Wagner and Bode (2008) divide supply chain risk sources into five groups – supply side, demand side, regulatory, legal/bureaucratic, infrastructure and catastrophic. Chopra and Sodhi (2004) divide risks into nine different groups – disruptions, delays, systems, forecast, intellectual property, procurement, receivables, inventory and capacity. Cucchiella and Gastaldi (2006) classify risk according to sources of uncertainty – available capacity, manufacturing yield, supplier quality, internal organization, competitor action, information delays, stochastic cost, political environment, customs regulations and price fluctuations. Gaonkar and Viswanadham (2007) classify risk according to the events leading to risk – deviation, disruption and disaster. It is possible to design a robust supply chain that is protected against deviation and disruption, but it is impossible to be immune to disaster. Zsidisin (2003)

classify supply chain risk based on the characteristics on which it depends – item, market and supplier characteristics.

Several entities in a supply chain may have goals that are conflicting with each other and therefore may pose higher risk to the supply chain (Ritchie & Brindley 2007). Actions taken by individual members to protect themselves against disruptions in the chain may hide the problems until they become serious (Gaonkar & Viswanadham 2007). Poor communication across the supply chain makes it harder to manage problems at an early stage. Importantly, what could easily have been solved or avoided if discovered at an early stage may grow to a major disruption further down the chain. This can not only affect the processes, but also has a negative impact on the relations among the member entities in the supply chain. A well developed IT system is crucial to avoid these problems. Studies connecting supply chain risk to information technologies/systems are very limited (Finch 2004).

Risk in supply chain is a relatively new area of research and is not well understood (Khan & Burnes 2007). There are, however, some studies on supply chain risks. For example, Hendricks and Singhal (2005) have evaluated the impact of supply chain risk on company's performance. Serious disruptions in supply chain resulted in 10% fall in share price and 40% fall in the general firm performance (Hendricks & Singhal 2005). A study by Wagner and Bode (2008), however, noted that disruption in the supply chain has a very low impact on overall performance. They argued that the impact on the supply chain is highly overestimated, especially the risk that stems from uncommon, catastrophic events, such as natural disasters and terrorism attacks. It is important to notice the difference in the dependent variable chosen by these two contrasting studies. While Hendricks and Singhal (2005) used company's share market value as the dependent variable, Wagner and Bode (2008) measured the impact of supply chain disruptions on overall supply chain performance.

While Hendricks and Singhal (2005) base their study on companies already affected by disruption (therefore excluding the probability of disruption occurring), Wagner and Bode (2008) use a random sample of companies in Germany from which to collect data. Even though the disruption to the supply chain might be short in duration, the study observed that its effect is felt strongly on the company's ability to recover (Wagner & Bode 2008). Wagner and Bode (2008) have operationalised the supply chain risk construct essentially from its sources – supply side, demand side, infrastructure, regulatory/legal and bureaucratic, and catastrophic risks. They observed that the demand side and supply side risks contribute to negative supply chain performance, while the other three risks (infrastructure, regulatory and catastrophic) have no clear negative impact on supply chain performance. Importantly, this study confirms previous research in supply chain management that stressed the importance of supply and demand coordination for achieving supply chain performance (Kleindorfer & van Wassenhove 2004). While some past studies discussed various types of risks (Johnson 2001, Cucchiella & Gastaldi 2006, Gaonkar & Viswanadham 2007, Ritchie & Brindley 2007, Kleindorfer & Saad 2005), others provided general guidelines for managing the supply chain risk (Chopra & Sodhi 2004, Craighead et al 2007, Zsidisin et al 2005). However, the influence of these mitigation strategies on the relationship between supply chain risk and supply chain performance were not studied in the past.

Managing supply chain risk

Even though risk in the supply chain has been discussed in the past, only recently have companies started taking action to manage risk. Deloitte and Touche (2004) and Tang (2006) defined supply chain risk management as the process that involves controlling, monitoring and evaluating supply chain risk and optimizing actions to prevent disruption and/or to quickly recover from disruption. The work with supply chain risk management is still in an early stage and is often driven by a few single enterprises; it would, however, be of benefit for all parts of the supply chain to mitigate risk (Ritchie & Brindley 2007).

There are many possibilities for managing risk. (Kumar & Viswanadham 2007) note that, even though each project is unique, the supply chain is often similar and built on a general basis. It is therefore possible and useful to develop a management system for managing risk in the supply chain. Some authors argue that supply chain risk management is a systematic approach that describes all the relevant disruptions along with appropriate actions and roles and responsibilities (Gaonkar & Viswanadham 2007). Risk management systems generally follow three basic steps – identification of the risks, estimation of their probabilities and significance. Based on this, a decision is made about the risks that are acceptable. Finch (2004) identified five major components in risk management – risk identification, analysis, reduction, transfer and acceptance, and monitoring. Faisal et al (2006) describes risk management as a process of understanding the risks and minimizing their impact on the company. Thus, risk management involves identification, assessment

and quantification of potential supply chain disruption and developing strategies to eliminate, mitigate and/or transfer the risk and build resilience. The objective is to control the organization's exposure to risk, reduce its negative impact and build the ability to recover.

There are two approaches to managing the supply chain risk – preventive and interceptive (Finch 2004) or proactive and reactive. In addition to these two, organizations also try to avoid, eliminate or transfer the risk. While preventive or proactive risk management strategies focus on reducing the company's exposure to different types of risks and preventing the occurrence of risks, interceptive or reactive risk management strategies deal with the consequences of the disruption and involves developing actions to minimize the damage when a disruption has occurred and to quickly recover. Though preventive risk management is useful, it can never completely protect the company from risk (Gaonkar & Viswanadham 2007). Organizations try if possible to avoid or eliminate risk with the help of management strategies. Alternatively, companies may try to simply transfer the risk to other members in the supply chain. Though this strategy does not completely minimize the risk, it will at least shift the responsibility of mitigating that risk to another member in the supply chain, who may have better expertise to deal with those issues. For example, many organizations outsource some of the operations at the supply side and/or at the demand-side to a more competent external partner and thereby minimize their supply chain risk significantly.

Managing risk in the supply chain differs from general risk management. Risks in the supply chain often are interconnected, and actions to decrease one risk often lead to the increase of another risk (Chopra & Sodhi 2004). Management has to balance these actions so that the total risk is minimized, without affecting the company's performance. Risks are also interconnected vertically through the supply chain, which means that risk management within one company might affect other companies in the chain. (Ritchie & Brindley 2007) argue that a risk in the supply chain affects all parts in the chain, upstream as well as downstream, and therefore should be managed through cooperative actions among the parts of the chain. Even though they find evidence for a trend towards more cooperative management responses in supply chains, this work is still in an early phase. In the same way, Gaonkar and Viswanadham (2007) argue that the supply chain has to be managed at three different levels: strategic, tactical and operational, where operational refers to process-level, tactical is company level and strategic refers to management of external partners and parts of the supply chain. They also mean that risk can occur on different levels: single company level, network level, industrial level or environmental level, and that risks have to be managed at these levels as well.

To mitigate this risk the companies in the supply chain have to trust each other, share information frequently and have collaborative relationships. (Faisal et al 2006) find that this situation is rather rare in today's supply chains, especially among manufacturing small and medium sized companies. Furthermore Ritchie and Brindley (2007) suggest that agreement on common performance standards, effective communication and a close partnership are also important to mitigate this risk.

Disruptions are likely to occur, big or small, with higher or lower impact. Organizations need to be well prepared to meet frequent risks with lower impact. Typically organizations do not have any plans to deal with the less likely risks that may have a major impact on the company, while they are well prepared to meet frequent risks (Chopra & Sodhi 2004). The most significant ways companies protect themselves against supply chain disruptions today include systematized and controlled handling of orders and order status, maintaining excess capacities, inventories, and safety margins in time and capacities (Gaonkar & Viswanadham 2007, Chopra & Sodhi 2004). These are inefficient and resource consuming ways of managing risk and there are more effective tools and strategies for managing the supply chain risk that could be deployed.

Certain paths in the supply chain are of higher risk than others because of the higher likelihood of disruption and/or higher impact. It therefore makes sense to deploy resources where the risk is high. Faisal et al (2006) have identified trust among supply chain partners, collaborative relationships, information sharing and knowledge about risks as key variables that influence a company's ability to manage supply chain risk. Strategic risk planning, corporate social responsibility and aligning incentives and revenue sharing policies are found to be other variables that are dependent upon the key variables mentioned earlier. In addition, agility in the supply chain, risk sharing and information security are other variables that are important, though with less influence (Faisal et al 2006). It is argued that supply chain agility not only allows firms to respond efficiently and effectively to unanticipated changes, but also works as a risk mitigation strategy in managing the unanticipated and actual disruptions in a supply chain (Kleindorfer & Saad 2005, Chopra & Sodhi 2004). Supply chain agility is considered an

important factor in risk mitigation as well as in response (Braunscheidel and Suresh 2009).

Different types of tools used to manage risk in the supply chain are mentioned in the literature. Many of them are general frameworks and need further development or specification to be useful tools for supply chain managers. For example, Gaonkar and Viswanadham (2007) proposed a framework, based on mathematical models, for management of disruptions and another for management of deviations, both in a preventive way. Kumar and Viswanadham (2007) suggested a framework for an IT enabled case-based decision system to handle risks in the supply chain and Chopra and Sodhi (2004) offered a general approach for supply chain managers to work with risks. Kumar and Viswanadhan (2007) suggested the use of IT to capture information from former cases with similar risks and make them available to managers to learn and apply.

Ritchie and Brindley (2007) proposed strategies for supply chain risk management that include risk insurance, information sharing, relationship development, agreed performance standards, regular joint reviews, joint training and development programs, joint pro-active assessment and planning exercises, developing risk management awareness and skills, joint strategies, inter-partnership structures, and relationship marketing initiatives. They have provided a framework to classify and manage risks and demonstrated with two case studies how their framework can help mitigate these risks.

Chopra and Sodhi (2004) suggest a strategy for companies to manage supply chain risks in two steps: "stress testing" and "tailoring". Stress testing means identifying the company's and its supply chain's properties, such as key processes/suppliers/customers, logistics, inventory, capacity etc, and then presenting a number of "what if" scenarios, questioning what will happen and what actions could be taken in case of disturbance in the supply chain (Chopra & Sodhi 2004). This will help managers and other key personnel in the organization to identify critical risks, actions that could be taken to prevent these risks and how risks interfere with the company. In addition, they will help them to see which risks are not so crucial and not worth the cost of managing. It is then left to the manager to decide which preventive actions to take and how to prepare the company for risks.

IT and supply chain risk - challenges

Information technologies play a key role in managing the supply chain in this digital age. It is argued that a well developed information and logistics network (Gaonkar & Viswanadham 2007) and increased visibility throughout the supply chain (Christopher & Lee 2004) will help in mitigating supply chain risk. Information systems that deliver effective information sharing and compatibility among all partners, and monitoring of the supply chain processes are considered important requirements for managing supply chain risk (Rhee et al 2006). Unfortunately, the current crop of information systems, including the enterprise systems do not have adequate capability (Rhee et al 2006).

Managing the risk typically involves mapping the supply chain, measuring the risk of critical nodes in the supply chain network, identifying appropriate risk reduction mechanisms for high-risk nodes and deploying specific actions to mitigate the risk at these nodes, including initiating inventory visibility systems and deploying collaborative processes with key supply chain partners. Buffering the firm with excess inventories and resources is one of the easiest strategies companies adopt to mitigate supply chain risk. In addition, using two or more suppliers for critical inputs, providing additional resources that will offer greater flexibility to react to disruptions, and cushioning the planned lead times to allow a greater buffer for response are other strategies companies adopt for reducing the risk in their supply chains. Information technologies and systems such as enterprise systems and Radio Frequency identification (RFID) are used to manage risk in the supply chain.

ERP systems are packaged software solutions that are configurable information systems integrating information and information-based processes within and across functional areas in an organization. They were originally intended to replace a multitude of legacy systems. Even though the latest versions are now 'web-enabled,' the emphasis is still on the integrated architecture. This lack of open component based ERP system architecture in a dynamic supply chain management context may become its weakness. Concerted moves by almost all the major software vendors towards open integration technologies, acceptance of XML standards for document exchange and conversion have extended their capability. In addition, with a steady move towards web services standards and service-oriented architecture for technology, process and information integration, it now appears feasible to extend that capability further to deal with external partners and achieve supply chain efficiencies.

Technologies such as Web services would allow applications interactions across organizational boundaries economically and incrementally. With Service Oriented Architecture

(SOA) as its underlying philosophy, Web services are expected to transform the inter-organizational business transactions in future (Padmanabhuni et al 2005) These Web services, designed to support application-to-application interaction without human assistance, can be accessed by disparate devices from handheld devices to large servers. In the supply chain management context, flexibility in business processes is critical. Web services that allow loose coupling of business processes mean that the organization can mix and match their offerings without making large investments in change management (Moitra & Ganesh 2005).

While information and process visibility is a key benefit of implementing an integrated information system such as an enterprise system, a lack of advanced decision support capabilities, lack of process flexibility in adapting to changing supply chain configurations, inadequacies of technology interfaces to extend the enterprise systems, and lack of trust between supply chain partners appear to be constraining the visibility and therefore the firm's ability to mitigate and manage the supply chain risk.

ERP system is a strong backbone to an organization and delivers information ubiquity. If it is not fully exploited, it may become a strategic disadvantage in a network based economy dominated by supply chains. Business organizations must manage the visibility, velocity and variability of information across the supply chain efficiently and effectively by the depth, quality and timeliness of information enabled by the ERP environment. While collaboration between various supply chain partners is the key requirement to achieve visibility, the efficiency of collaboration is restricted by non-integrative environments and the lack of process standards.

Moves by various industry groups and organizations towards development and acceptance of process management standards for different industries are expected to make process and information integration between partners in the supply chain easier. Some of the process activity standards popular in the industry are 'SCOR' (Supply Chain Operations Reference Model by Supply Chain Council) for manufacturing supply chains, DCOR/VCOR (Design Chain Operations Reference model for Design and Value Chain Operations Reference Model for Value Chains), eTOM for the telecom industry, ITIL (Information Technology Infrastructure Library) for information technology industry, and SEI (Software Engineering Implementation) capability maturity model for the software industry.

In the supply chain management context, in addition to the SCOR model, Supply Chain Management Institute's SCM framework developed by the Global Supply Chain Forum, Supply Chain Consortium's Best Practice framework and APQC (American Productivity and Quality Council) Process Classification framework (PCF) are some of the commonly used supply chain management frameworks. These frameworks are expected to establish a common language for communicating ideas, concepts, methodologies, measurement and practices and to document supply chain activities and thereby increase the visibility and understanding of the information.

These frameworks are expected to make process and information integration between the enterprises easier (Davenport 2005) and thereby enhance visibility. Recent developments of modern business process modelling and management tools, such as PetriNets, eBRL, and several workflow modelling tools and languages, are also expected to improve process visibility compared to previous frameworks. Thus, increased visibility of the processes and information across the supply chain will help organizations to reduce risk and mitigate its effect. By quickly identifying the disruption and therefore being able to rapidly react and take action to prevent the disruption from impacting customers, increased visibility will help manage the supply chain risk better.

Research directions and conclusions

Existing information systems and technologies can be leveraged for identification, assessment and mitigation of supply chain risk. For example, standardization of business processes and information across supply chains will help in identifying the potential risk in the supply chain.

Information technologies play an important role in managing supply chains, both in delivering efficiencies as well as in managing the supply chain risk through improved visibility and information sharing and collaboration. The following research questions are therefore identified:

1. What is the importance of supply chain risk for supply chain managers and IT managers?
2. How is supply chain risk identified and managed in Australian organizations?
3. What is the role of information technologies such as enterprise systems in managing the supply chain risk?
4. What is the role of the Supply Chain Operations Reference (SCOR) model and/or other reference models in managing the supply chain risk?
5. What is the role of these emerging technologies such as Service oriented architecture and Web services?
6. What is the influence of traditional control

variables such as trust, information management practices, process management maturity, IT infrastructure management capability, change management, industry structure, competition, supply chain structure and organizational size?

Despite the huge potential and significant benefits put forward by consultants and academics, business organizations are in a very early stage in developing and executing strategies for managing supply chain risk. Other than some large organizations, there are no significant organizations in the Australasian region that have integrated supply chain risk management into their strategic planning process.

The aim of this research study is exploratory; research and theory are at a formative stage and the phenomenon is not well understood. Even though literature on general risk management is abundant, it is predominantly based on mathematical modelling. By adopting multiple theoretical lenses and by applying the knowledge of managing risk in other areas, the proposed research is also aligned with Yin's (2004) recommendation to explore and test alternative explanations in different contexts. A multi-case research design, based upon literal replication logic is necessary at the early stages. Recognizing the nascent stage of the research and the limited number of organizations contemplating and strategizing supply chain risk management, selection of cases could be purposeful (Huberman & Miles 2002) and must cover organizations and industry sectors that are active in implementing supply chain risk management strategies. A combination of qualitative and quantitative methodology is useful in answering the several research questions.

While information visibility and sharing of information are considered important in managing the supply chain risk, the risk to the firm's intellectual property when information is shared in an extended enterprise with supply chain partners is a challenge. How can you minimize the supply chain risk without leaking strategic information through increased visibility? How do you differentiate the sharing of information about the production plans and products with the information about your new products and product development? With many information and process management aspects now outsourced, this risk may further jeopardize the company's ability to maintain the security of its information.

For many firms, there is an ongoing tension between information security and information sharing in the supply chain context and it is a challenge to the ability of the firms to collaborate. Trust is another important challenge in managing the supply chain risk. Improved visibility of the processes and information across the supply chain is expected to improve trust among partners. Sharing information about the products, promotions, production plans, sales and operations plans, and transportation and distribution planning is important in building trust. Creating information visibility in terms of information sharing, enabled by information technology, may act like an enabler in building and improving trust. But if this is not supported by consistent execution, this high level of visibility may erode trust among partners and jeopardize their relationships and collaboration.

Supply chain risk management continues to be important to researchers in the supply chain management field as well as for information systems scholars. The double-edged role played by information technologies in identification and mitigation of the risk across the supply chain along with the traditional challenges such as trust, strategy execution, leveraging existing technologies and processes, and supply chain agility continue to throw new challenges to researchers and practitioners.

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