Stream #16: Technology, Innovation and Supply Chain Management

Competitive Session

Identifying drivers of supply chain vulnerability: An integrative framework

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ABSTRACT: *Supply chain risk management (SCRM) is an evolving field of research and practice. Considering the increasing fragmentation, and in some cases, dispersion of the SCRM literature in terms of identifying supply chain vulnerabilities, we seek to develop an integrative framework that unifies the global supply chain risk criteria scattered throughout the extant literature. Accordingly, we identify 58 key supply chain risk indicators and categorize them into 10 thematic groups. The constructs and measures included in this framework have been developed upon identifying and eliminating gaps in addressing a holistic risk identification framework in the most prominent scholarly literature on global SCRM.*

Keywords: Supply chain risk management, risk identification, supply chain vulnerability, unified framework

INTRODUCTION

Since the beginning of the 21st century, managing risks in supply chains has become an increasingly critical topic, widely debated in both research and practice alike (Zsidisin & Wagner, 2010; Sodhi, Son, & Tang, 2012). There are many reasons behind the growing interest surrounding Supply Chain Risk Management (SCRM), including the globalization and ever-increasing outsourcing of manufacturing processes to countries with lower production costs and complex technological advancements (Christopher & Peck, 2004; Wagner & Bode, 2008; Wagner & Neshat, 2010; Thun & Hoenig, 2011), all contributing towards the increasing vulnerability of modern supply chains. Moreover, it has been argued over the past few years that the severity and frequency of supply chain disruptions has been steadily on the rise (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Ritchie & Brindley, 2007). According to the annual 'Supply Chain Resilience 2013' report conducted by the UK Business Continuity Institute (Glendon & Bird, 2013), 75% of the respondents were affected by at least one source of supply chain risk and 15% experienced loss of more than one million Pounds in 2012-2013. There are also numerous cases of vulnerabilities in supply chains that culminated in significant losses over the past years (e.g., Jüttner, 2005; Blackhurst, Scheibe, & Johnson, 2008; Rao & Goldsby, 2009). Therefore, identification of the full

spectrum of supply chain risks is vital for assuring transparency among supply chain partners, thereby providing an effective tool for supply chain vulnerability (SCV) evaluation.

Despite the attempts to develop a risk identification framework capable of categorizing the abundant yet scattered supply chain risk factors, prior approaches focus on either upstream or downstream risks in supply chains (e.g., Zsidisin & Smith, 2005; Wu, Blackhurst, & Chidambaram, 2006) or provide a limited view of the overall impending risks that global supply chains might encounter (e.g., Kleindorfer & Saad, 2005; Bogataj & Bogataj, 2007). Additionally, in their attempt to discern research gaps in the realm of SCRM, Sodhi et al. (2012, p. 9) state the need for 'defining the spectrum of types of supply chain risks that require responses' in order to reveal hidden aspects of risks in SCRM frameworks. Overall, despite a number of recent efforts towards building a unified supply chain vulnerability identification framework, there has been little consensus among researchers on the fundamental principles of designing such framework (O. Tang & Musa, 2011; Sodhi et al., 2012).

In light of the above, the main objective of this paper is to review the extant literature in order to design a unified framework for identifying the sources of supply chain vulnerability. This framework can contribute towards advancing theory and practice in the growing field of SCRM.

The rest of the paper is organized as follows. Next, we review the SCRM literature to render a holistic review of the main risk identification frameworks debated so far by the researchers. After investigating the gaps in the literature, we then present a unified SCV framework and discuss the main features of its risk constructs and risk measures. Finally, we conclude by illuminating several directions for future studies in the SCRM area considering the recent trends including sustainability practices in supply chains.

RISK IDENTIFICATION AND CATEGORIZATION IN THE LITERATURE

Our approach in developing the unified SCV framework is that we initially looked for risk identification frameworks of global supply chains presented in all the relevant SCRM articles and published between

2000-2014 in top-tier journals in Operations and Supply Chain Management. The publications considered for this purpose are mainly ranked A and A* journals in the ABDC list. We further narrowed the literature to the most cited frameworks for our SCV framework in order to maximize construct validity and achieve parsimony. Table 1 reveals the outcome of these efforts.

Insert Table 1 about here

According to Table 1, Chopra and Sodhi (2004) in their acknowledged framework of global supply chain risks identification discuss nine distinct risk categories. By presenting a holistic review of risks in supply chains, they suggest it could help towards 'proactively managing' disruptions, hence reducing the vulnerability of supply chains that could cost the embedded companies millions of dollars. Despite their attempts to capture the main risks triggering supply chain disruptions, the nature of 'relations' between supply chain members has been overlooked. Opportunistic behavior of suppliers (Hallikas, Virolainen, & Tuominen, 2002; Hallikas, Karvonen, Pulkkinen, Virolainen, & Tuominen, 2004; Spekman & Davis, 2004) or changes in the preferences of customers (Sodhi & Lee, 2007) are few examples that indicate the shortcomings of the framework designed by Chopra and Sodhi (2004). In another categorization of global supply chains risks, Kleindorfer and Saad (2005) suggest operational risks, natural hazards, and social and political instabilities as the main causes of disruptions in supply chains. However, they do not incorporate supply and demand risks in their final conceptual model for risk mitigation and management purposes.

Looking at more recent articles that present risk identification frameworks, Thun and Hoenig (2011) overlook the effects of inventory risks such as 'bullwhip effect' (Lee, 1997; Sodhi & Lee, 2007; Manuj & Mentzer, 2008) or financial risks of supply chain members (Christopher & Peck, 2004; O. Tang & Musa, 2011) to name just a few. Additionally, despite the fact that Tummala and Schoenherr (2011) cover the inventory risks in their rather comprehensive supply chain risk framework, they fail to take volatilities in market and customer behavior (Van der Vorst & Beulens, 2002; Wu et al., 2006) or financial risks of supply chain members into consideration.

Considering the limitations of the existing frameworks to come up with a comprehensive model of supply chain risks, we attempt to present a unified SCV framework that could address the highlighted shortcomings and offer a more comprehensive picture of the antecedents of vulnerabilities in supply chains.

THE PROPOSED FRAMEWORK

Methodology

Adopting systematic approach to the review of the literature creates a firm foundation for advancing knowledge (Webster & Watson, 2002). An integrative review is a systematic approach that '… synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated' (Torraco, 2005, p. 356). Following this logic, we applied the integrative approach proposed by Torraco (2005) and extended by (Yorks, 2008) to develop a new framework for identifying and classifying risks in supply chain management literature. First, we asked the questions of is there a need for an integrative review, and if so, what type of review is necessary? Having identified the gap in the existing literature, the type of review was chosen to be taxonomical or conceptual classification of constructs. This type is suitable when the study is aimed '… to classify previous research…' and subsequently to '… lay the foundation for new theorizing' (Torraco, 2005, p. 363). Next, we selected the representative literature by defining qualifying criteria, i.e. supply chain risk frameworks published from 2000 to 2014 in the ABDC list of A and A* journals. Boundaries of the field were defined by organizing the review around a coherent conceptual structuring of the topic specified by the first and second author and agreed upon by the third and fourth author. Finally, the style of synthesis and write up was set to represent a taxonomy that transcends the current frameworks and is capable to inspire future research to converge into a more fine-grained direction.

To sum up, the proposed SCV framework is derived from 97 articles published in top 20 journals in the field of Operations and Supply Chain Management. Our analysis reveals 58 risk factors (i.e. risk measures) in 10 thematic groups as illustrated in Table 2. The process of classifying risk indicators into

larger groups was conducted by the first and second authors to achieve inter-coder agreement and discussed with the third and fourth authors to achieve a satisfactory level of internal consistency and construct validity.

Insert Table 2 about here

Category 1: Customer behavior

The volatility of customer preferences in a global market of products and services is known to be one of the main reasons behind SCV over the recent years (Peck, 2005; Sodhi & Lee, 2007; Braunscheidel & Suresh, 2009). This has resulted in a strategic shift of modern organizations towards a better understanding and accounting for customer needs and market trends and towards assuring compatibility of supply chain processes (Zsidisin, 2003b; Wagner & Neshat, 2010). On the other hand, globalization and the emergence of new competitive markets are among the main reasons behind the increase in the bargaining power of customers (Finch, 2004). For example, customers nowadays are more prone to shifting from one manufacturer or service provider to another if not satisfied with the quality of products and/or the level of customer care (Hallikas et al., 2002). Additionally, financial instability of customers is known to be another pivotal source of SCV, which might potentially cause adverse events including inability of customers to address contractual obligations, payment delays or debts (Wagner & Bode, 2009). Supply chains are exposed to this kind of risk both internally and externally. For instance, if a member of supply chain does not fulfill its financial obligations towards suppliers, this would cause an internal risk for suppliers and consequently for the overall supply chain. The same could happen if the customers in the market are not willing or able to buy the final products of supply chain.

Category 2: Distribution-Transportation

Flawless distribution and transportation performance may have a significant share in supply chain cost savings (Gunasekaran, Patel, & McGaughey, 2004; Zsidisin, Ellram, Carter, & Cavinato, 2004). A

number of articles in the SCRM literature discuss the adverse events that result in logistics inefficiencies including: delivery failures such as cargo losses (Spekman & Davis, 2004; Blos, Quaddus, Wee, & Watanabe, 2009), incidents such as theft or vehicle crashes (Norrman & Jansson, 2004), delays (Zsidisin, 2003b), improper logistics planning and technical problems that cause additional transportation costs (Zsidisin et al., 2004), and finally 'flawed consignments' (Jüttner & Ziegenbein, 2009, p. 205). Moreover, the transportation costs, which are the primary concern of distributors, are directly affected by energy prices (Asbjørnslett, 2009; Klibi & Martel, 2012).

Category 3: Economic-Financial

Financial risks and economic instability have received considerable attention in SCRM literature (few references). More specifically, researchers have discussed currency fluctuations (Zsidisin, 2003b; Zsidisin et al., 2004; Sodhi & Lee, 2007; Christopher, Mena, Khan, & Yurt, 2011), inflation (Manuj & Mentzer, 2008; Burtonshaw-Gunn, 2009), and recession (Blos et al., 2009) as some influential factors that could affect the performance of supply chain members and pose risks to the management of supply chains.

Additionally, well-established and powerful newcomers in the market might bring a number of economic and financial threats such as an increased degree of competition by lowering their profit margins, superior customer relationship solutions, and other strategic advantages (Sodhi & Lee, 2007; Wagner & Bode, 2008). The next decisive criterion in this risk group relates to financial disruptions, including bankruptcy (Wagner & Johnson, 2004; Schmitt & Singh, 2012), rise in labor and investment costs (C. S. Tang, 2006), and financial difficulties of suppliers or customers (O. Tang & Musa, 2011). Restraining international trade policies as a result of adoption of protective measures such as tariffs on important goods or protectionism by countries like China might lead to further instability of economic and financial markets (Jiang, 2002; Bello, Lohtia, & Sangtani, 2004).

Category 4: External environment

Environmental risks have been widely debated in the literature (e.g., Chopra & Sodhi, 2004; Christopher & Peck, 2004; Sodhi & Lee, 2007; Christopher et al., 2011). We categorize environmental hazards into two major groups of man-made and natural hazards. The man-made hazards are the threats that dispose supply chains to war, terrorism, sabotage, pollution, unrest, etc. (Chopra & Sodhi, 2004; Finch, 2004; Jüttner, 2005). Natural hazards, on the other hand are comprised of risks in which human actions are not included such as earthquake, epidemic/pandemic phenomena, flood, draught, tsunami, etc. (Norrman & Jansson, 2004; Rao & Goldsby, 2009; Tummala & Schoenherr, 2011).

Additionally, constant changes in the social and political environment of a given country (Kleindorfer & Saad, 2005; O. Tang & Musa, 2011), regulatory obstacles (Wagner & Bode, 2008; Christopher et al., 2011), and bureaucracy (Autry & Sanders, 2009; Ponomarov & Holcomb, 2009) are the risk factors that also could have negative impacts on the performance of supply chains and scare away the investments that are required for sustained business growth in countries.

Category 5: Human resources

The review of the literature indicates that the risks related to human resources have been rather neglected in the frameworks for supply risk identification/evaluation. Jiang, Baker, and Frazier (2009) argue that supplier-labor problems might expose supply chains to three major risk types i.e. financial, operational and reputation risks. In the SCRM literature, Kleindorfer and Saad (2005, p. 53) imply to 'human-centered issues' such as 'strike' and 'fraud' for managing risks that are related to human resources. However, their focus is centered on man-made disasters which were earlier. Similarly, Chopra and Sodhi (2004, p. 54) consider 'labor dispute' in a general risk group of 'disruptions' along with other environmental risks such as 'natural disasters', 'war and terrorism', etc. Accordingly a large number of studies have considered limited aspects of this concept including 'labor strikes' or 'labor disputes' (Norrman & Jansson, 2004; Yang, Aydin, Babich, & Beil, 2009; Tummala & Schoenherr, 2011) without discussing the numerous causes of this event.

Moreover, firms' obligations towards their stakeholders and more specifically their employees through the prism of corporate social responsibility should not be overlooked (McWilliams & Siegel, 2001; Basu & Palazzo, 2008). Hence, in terms of risks associated with human resources in global supply chains, violation of labor and human rights could be considered as pivotal risk (Maloni & Brown, 2006). We therefore classified these factors as two general groups of causes (e.g., human rights violation, conflicts and dissatisfaction of employees) and effects (e.g., loss of key employees, labor shortages or turnovers).

Category 6: Information system

The primary consideration of major supply chains regarding the information systems is to procure necessary information for the effective operation of the supply chain and to maintain the confidentiality of information (Finch, 2004). Disruptions in information processing or breach of confidential of information in supply chains might be caused by several reasons such as information system breakdowns in more systematic networks or 'systems risk' (Sodhi & Lee, 2007, p. 1431) and disruptions in IT systems and security settings (Spekman & Davis, 2004; O. Tang & Musa, 2011). Inappropriate use of shared information by supply chain members and the irresponsibility of firms to share necessary information in supply chains would constrain the knowledge sharing throughout the supply chain. Another major issue, which has been discussed in the context of information systems is the effect of information asymmetry (C. S. Tang, 2006; Bogataj & Bogataj, 2007) that subsequently causes the bullwhip phenomenon (Chopra & Sodhi, 2004; Matook, Lasch, & Tamaschke, 2009) as discussed earlier. Overall, a secured and updated information system in supply chains could build mutual trust between supply members, nurture and reinforce a ground upon which they share information and knowledge, and thus leading to a better visibility of critical data in supply chains.

Category 7: Operational-Technical

Usually when some technical or operational errors occur for a specific supplier, the other dependent members of the supply chain on that specific supplier would also suffer the consequences (Jüttner, 2005). This could cause millions of dollars of losses in large companies or have detrimental effects for small

firms (e.g., Norrman & Jansson, 2004; Sodhi et al., 2012). The operational disruptions are comprised of machinery breakdowns (Wagner & Bode, 2008; Tummala & Schoenherr, 2011) and technical problems in manufacturing processes, obsolete and fragile infrastructure, and material and work flow structure (Chopra & Sodhi, 2004). Identifying and applying technological advancements in supply chains (Zsidisin, 2003b; Sodhi & Lee, 2007; Matook et al., 2009) are other sources of concern mainly in high-tech industries (Sodhi, 2005; Blos et al., 2009). Supply chains should be able to adopt the relevant technological solutions in order to assure flexibility when facing sudden changes (Hendricks & Singhal, 2005). Moreover, operational and technical inefficiencies of supply chains might result in additional costs, delays and further process breakdowns (Kleindorfer & Saad, 2005; Blos et al., 2009).

Category 8: Quality

The concept of 'Quality' in SCRM has not been heretofore sufficiently challenged by the researchers. Quality-related risks in the SCRM literature are considered merely as 'Quality problems' (Zsidisin, 2003a, p. 220), 'Poor quality or yield at supply source' (Chopra & Sodhi, 2004, p. 54), or 'Supplier quality problems' (Wagner & Bode, 2006, p. 310).

Based on the supply chain quality management literature (e.g., Lin, Chow, Madu, Kuei, & Pei Yu, 2005; Robinson & Malhotra, 2005; Foster Jr, 2008), we define five critical measures for quality control of suppliers including functionality, reliability, efficiency, maintainability and profitability of goods and services that are the end results of supply chains. Certain standards should also be followed in every other aspect of the SCV framework. For instance increasing the functionality and efficiency of products needs a flawless operational and technical process. Consequently a qualified product is the final result of a qualified system that is behind controlling the system i.e. supply chain. Supply chain quality management (SCQM) is comprised of numerous variables such as customer focus, quality practices, supplier relations, leadership, HR practices, business results, safety, and etc. (Foster Jr, 2008). In this study, we focus on more general measures to eliminate the complexity of the SCV framework.

Category 9: Quantity-Inventory

The main objective of mitigating this group of risk is to meet the customer demand An accurate projection of overall demand that is compatible with the actual demand and organizing a coordinated supply chain towards meeting these demands could be cost saving and beneficial for supply chains (Wagner & Bode, 2006; Niranjan, Wagner, & Bode, 2011). In order to meticulously plan for the quantity of products to be manufactured, supply chains need to have valid information of demands, their production capacity and inventory levels, otherwise excess or limited capacity could ultimately cause financial losses for the supply members (Hendricks & Singhal, 2005; Sodhi & Lee, 2007). The 'Quantity-Inventory' risk group deals with the prerequisites for production in supply chains. The first key necessity of production is 'material' that could be provided directly by market or by suppliers. On one hand, considering the short product life-cycle and the falling prices of the product in the market, excess inventory is the 'killer combination' for many companies (Chopra & Sodhi, 2004, p. 58). On the other hand, insufficient quantity of receivables either from market or suppliers could also have adverse outcomes on the manufacturing process while experiencing volatilities in demand (Peck, 2005). Inability to recognize the pipeline inventory is argued to be the main cause of over-ordering, shortage of inventory and dysfunctional behavior in supply chains (Niranjan et al., 2011). In addition to the accurate information of demand and the supply chain performance, sufficient energy levels are also required and their shortages would be problematic for manufacturing.

Category 10: Supplier-Partner relations

The relations between members of a supply chain are the outcomes of how successfully managers could overcome risks in the other 9 risk groups. For example, communication problems in supply chains that are caused by an inefficient information system could result in other groups of risks such as excess or insufficient inventory (Christopher & Lee, 2004). Enabling collaboration in supply chains has been argued to facilitate improvements in performance and assure sustainability of the overall supply chain and distinct supply chain partners (Sahin & Robinson, 2002; Swink, Narasimhan, & Wang, 2007). (Angerhofer & Angelides, 2006, p. 283) position the objective of a collaborative supply chain as 'to gain

competitive advantage, by improving overall performance through taking a holistic perspective of the supply chain'.

Despite an increasing number of studies that explore the success factors of supply chain collaboration, integration, and coordination as discussed above, the lack of trust between supply chain partners (Zsidisin & Ritchie, 2009) is a major issue, which subsequently might become the main cause behind opportunistic behavior (Spekman & Davis, 2004; Seiter, 2009) or violations in the intellectual property rights (Sodhi & Lee, 2007; Manuj & Mentzer, 2008; Wagner & Bode, 2008; Oke & Gopalakrishnan, 2009) by members of global supply chains. On an opposite pole, buyer-supplier relationships can become ineffective due to the risks stemming from overconfidence in suppliers which in turn lean to actions such as the adoption of the single sourcing strategy (Zsidisin et al., 2004; Wagner & Bode, 2006; Thun & Hoenig, 2011). Loss of key suppliers in this situation will automatically result in the interruption of key business processes potentially resulting in the financial and reputational damages due to breaking contractual obligations and inability to satisfy customer demand.

It is worth mentioning that not all the identified risk measures and constructs are evenly dispersed along supply chains and might affect operation in either upstream or downstream or both sides of supply chains with diversities in severity and frequency of occurrence. This could be considered as a subject for future research.

DISCUSSION AND CONCLUSION

In this study we reviewed the extant literature since 2000 surrounding SCRM risk identification frameworks. After detecting and analyzing the risk dimensions discussed within each article, we proposed a unified SCV framework comprised of 10 risk constructs and 58 risk measures. We shed light on areas that have been overlooked by previous scholars such as 'Quality', 'Human resources', and 'Supplier-partner relations' by tracing the risks associated with each area back to their roots and subsequently including those roots in the framework.

However, the unified SCV framework presented in this article is rather general and it requires delving deeper into some of the constructs and measures or adding or subtracting new risk sources. For instance, according to the rapidly growing field of sustainability in global supply chains , the 'External environment' risk construct could not be constrained to mere natural, legal, or human-related hazards that might affect supply chains, rather environmental impacts of supply chains such as their carbon footprints, product life cycle, production process, and etc. (Sarkis, 2003; Seuring & Mueller, 2008) should also be taken into consideration while planning for risk mitigation practices. Moreover, corporate social responsibility of global supply chains that we discussed earlier as part of risks associated with labor, is also concerned with a number of other factors including suppliers' social responsibilities, value creation for customers, fair trade, animal welfare, and etc. (Maloni & Brown, 2006; Andersen & Skjoett-Larsen, 2009).

Additionally, 'Supplier-partner relations' in supply networks might include a variety of risks, identified as manufacturing/service triads (Choi & Hong, 2002; Choi & Wu, 2009; Li & Choi, 2009), and has received increasing attention by the researchers for the past few years. In the context of triads, scholars discuss that risks emerged and propagated in supply networks are different in nature when triadic relations of buyer-supplier-customer, buyer-supplier-supplier, or buyer-supplier-supplier are studied as building blocks of supply networks. This could render the traditional risk identification processes in the SCRM field with a new network perspective instead of individualism.

Finally, it is strongly suggested that the future research investigate the interrelations of risk constructs that have been proposed in the SCV framework by conducting empirical researches. This might reveal invaluable insights into how diverse types of risk could instigate other risk groups and how intense is the impact of each of the risk constructs on supply chain resilience. The latter might also differ depending on the type of industry under investigation.

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Table 1: Review of the Literature on SCV Drivers

Author(s)/Year	Book/Journal title	Main Aspects of the Framework
Jüttner, Peck, and Christopher (2003)	International Journal of Logistics Research and Applications	Environmental risks Network risks Organizational risks
Christopher and Peck (2004)	The International Journal of Logistics Management	Internal to the firm (Process and control risks) External to the firm but internal to the supply chain network (Demand and supply risk) External to the network (Environmental risk)
Spekman and Davis (2004)	International Journal of Physical Distribution and Logistics Management	Risks associated with the flows of material, information, and cash Risks associated with security Risks associated with opportunistic behavior Risks associated with corporate social responsibility
Chopra and Sodhi (2004)	MIT Sloan Management Review	Disruptions Delays Systems Forecast Intellectual Property Procurement Receivables Inventory Capacity
Hallikas et al. (2004)	International Journal of Production Economics	Demand risks Customer-delivery risks Cost and pricing risks Resources-specific risks Development-specific risks Flexibility-specific risks
Peck (2005)	International Journal of Physical Distribution and Logistics Management	Product/process risks Assets/infrastructure risks Risks associated with organizations and inter-organizational networks Environmental risks
Kleindorfer and Saad (2005)	Production and Operations Management	Operational contingencies Natural hazards earthquakes, hurricanes, and storms Terrorism and political instability
Wagner and Bode (2006)	Journal of Purchasing and Supply Management	Demand-side risks Supply-side risks Catastrophic risks
Wu et al. (2006)	Computers in Industry	Internal controllable risks Internal partially controllable risks Internal uncontrollable risks External controllable risks External partially controllable risks External uncontrollable risks
Bogataj and Bogataj (2007)	International Journal of Production Economics	Supply risk Process, production, or distribution risk Demand risk Control risk Environmental risk
Ritchie and Brindley (2007)	An emergent framework for supply chain risk management and performance measurement	Risks specific to external environment Industry-specific risks Risks specific to supply chain configuration Partner-specific risks Node-specific risks
Wagner and Bode (2008)	Journal of Business Logistics	Demand-side risks Supply-side risks

Author(s)/Year	Book/Journal title	Main Aspects of the Framework	
		Regulatory, legal and bureaucratic risks Infrastructure risks Catastrophic risks	
Manuj and Mentzer (2008)	Journal of Business Logistics	Supply Risks Demand Risks Macro Risks Competitive Risks	Operational Risks Security Risks Policy Risks Resource Risks
Manuj and Mentzer (2008)	International Journal of Physical Distribution and Logistics Management	Supply risks Operational risks Security Risks	Demand risks Currency risks
C. S. Tang and Tomlin (2008)	International Journal of Production Economics	Supply risks Demand risks Behavioral risks	Process risks Intellectual property risks Political/social risks
Rao and Goldsby (2009)	International Journal of Logistics Management	Framework risks Problem-specific risks Decision making risks	
Trkman and McCormack (2009)	International Journal of Production Economics	Exogenous risks Endogenous risks	
C. S. Tang and Tomlin (2009)	Supply Chain Risk	Supply risks Demand risks Intellectual property risks Political risks	Process risks Rare-but-Severe Disruption Risks Behavioral risks Social risks
Wagner and Neshat (2010)	International Journal of Production Economics	Demand-side risks Supply-side risks Structural risks	
Christopher et al. (2011)	Supply Chain Management: An International Journal	Supply risk Environmental and sustainability risk Process and control risk Demand risk	
Thun and Hoenig (2011)	International Journal of Production Economics	External supply chain risks Internal supply chain risks	
Tummala and Schoenherr (2011)	Supply Chain Management: An International Journal	Demand risks Disruption risks Inventory Risks Supply risks Sovereign risks	Delay risks Manufacturing breakdown risks Physical plant risks System risks Transportation risks

Table 2: The proposed unified SCV framework

Risk Constructs	Risk Measures
Customer behavior	*Increasing bargaining power of customers* *Variation of customer preferences* *Uncertain payment behavior of customers* *Customer independency on products and services* *Low confidence level towards products and services* *Low profit margin gained from customers*
Distribution-Transportation	*Additional transportation costs caused by technical malfunctions* *Fuel price fluctuations* *Cargo losses/damages/delays/thefts* *Financial failures of distributors/transport providers* *Faulty product consignments*
Economic-Financial	*Unfavorable macroeconomic conditions* *Financial competitions* [a] *Financial disruptions* [b] *Excessively risky investment portfolio* *Low financial stability of suppliers/customers* *Excessive protectionism*
External environment	*Health/safety risk* *Man-made hazards* *Natural hazards* *Legal risks*
Human resources	*Labor shortages* *Labor turnover* *Rate and gravity of workplace (Management-Employee) conflicts* *Human and labor rights violation* *Low level of employee satisfaction*
Information system	*Information flow insecurity* *Unjustified investments on information systems* *Misuse of critical information* *Information distortion of supply tiers* *Insufficiency of real-time and updated information* *Obsolete information system and IT infrastructure*
Operational-Technical	*Technical breakdowns and process disruptions* *Inflexible production system* *Infrastructure fragility* *Inefficient work/material/information flow* *Lack of technical innovation* *Loss of control over supply chain's processes*
Quality	*Low product functionality* *Low product reliability* *Low products durability* *Issues with products maintenance* *Low level of after-sale services* *Decreasing brand credibility*
Quantity-Inventory	*Capacity fluctuations* *Demand uncertainty* *Energy shortage* *Information shortage* *Supply shortage*

	Inaccurate demand forecasts
Supplier-Partner relations	*Buyer-supplier communication problems* *Intellectual property fraud* *Cultural differences* *Opportunistic tendencies of suppliers* *Insolvency (suppliers/partners)* *Loss of key suppliers/partners* *Low confidence level between supply chain partners* *Single sourcing*

[(a)] *Price distinctions and lowering profit margins by competitors*
[(b)] *Loss of market share, stock value decrease, bankruptcy, and rise in labor cost*