

Supply Chain Risk Management: Literature Review and Future Research

Iwan Vanany, Sepuluh Nopember Institute of Technology (ITS), Indonesia

Suhaiza Zailani, Universiti Sains, Malaysia

Nyoman Pujawan, Sepuluh Nopember Institute of Technology (ITS), Indonesia

ABSTRACT

Supply chain risk management has increasingly becoming a more popular research area recently. Various papers, with different focus and approaches, have been published since a few years ago. This paper aims to survey supply chain risk management (SCRM) literature. Paper published in relevant journals from 2000 to 2007 are analysed and classified into five categories: conceptual, descriptive, empirical, exploratory cross-sectional, and exploratory longitudinal. We also looked at the papers in terms of the types of risks, the unit of analysis, the industry sectors, and the risk management process or strategies addressed. The literature review will provide the basis for outlining future research opportunities in this field.

Keywords: literature survey; supply chain risk management

INTRODUCTION

The practitioners and scholars believe that the effective supply chain management has become an important enabler to improve organization performance and valuable way of securing competitive advantage (Chirderhouse et al, 2003; Li et al, 2006). The intensifying business competition since 1990s has forced companies to improve efficiency in many aspects of their business. On the other hand, the increasing uncertainty requires them to spend more resources to anticipate for demand, supply, as well as internal uncertainties for better sustainability of their supply chain. Interestingly, such an

increasing uncertainty is not solely induced by the external business environments, but also due to increasing complexity of the supply chain structure and varying mechanism initiated by the supply chains in their business. The trend of companies outsourcing their activities to outside parties has certainly created a new source of uncertainty. The chance of having a delay in raw materials delivery is increasing if a company relies to outside parties to do most of the inbound logistics activities. Likewise, the trend of supply base reduction has exposed some companies to more risks than the associated benefits.

Risk and uncertainty has always been an important issue in supply chain management. Earlier literature consider risks in relation to supply lead time reliability, price uncertainty, and demand volatility which lead to the need for safety stock, inventory pooling strategy, order split to suppliers, and various contract and hedging strategies (see Tang (2006a) for an excellent review of various quantitative models considering supply chain risk). Although supply chain management has always had a strong emphasis on risk, the notion of supply chain risk management has gained an increasing popularity in recent years due to increasing supply chain complexity, including the use of global contract manufacturers and suppliers. Faisal et al (2006b) and Tang (2006a) believe that effective supply chain risk management (SCRM) has become a need for companies nowadays. Companies like Ericsson (Norrman and Jansson, 2004) and Nokia (Li et al, 2006), have long realized the need for an effective risk management in their supply chain operations.

According to Chopra and Sodhi (2004), the supply chain risks could be in the form of delays of materials from suppliers, large forecast errors, system breakdowns, capacity issues, inventory problems, and disruptions. Another classification is provided by Tang (2006a) who categorized supply chain risks into operations and disruptions risks. The operations risks are associated with uncertainties inherent in a supply chain, which include demand, supply, and cost uncertainties while disruption risks are those caused by major natural and man-made disasters such as flood, earthquake, tsunami, and major economic crisis.

Numerous articles on supply chain risk management have been published in the last 20 years, the oldest being the article by Kraljic in 1983 (Paulsson, 2004). An attempt to review articles on supply chain risk management was done by Paulsson (2004). The author classified the articles using three dimensions: the unit of analysis, type of risk, and risk handling. From our observation, there are many more SCRM articles published since the appearance of Paulsson's review, making it beneficial to pro-

vide a more up to date review to include more recent articles. Tang (2006a) reviewed SCRM articles, but he focused on quantitative models. The author classified articles according to four basic supply chain areas: supply management, product management, information management, and demand management. The purpose of this paper is to provide an extensive literature review on supply chain risk management. In particular, we aim to:

- Classify SCRM articles according to their approach and methodologies
- Discuss opportunities for future research

REVIEW METHODOLOGY

Search Methodology

In this paper, we did exhaustive search of the articles related to supply chain risk management. We collected articles published from 2000 to 2007, focusing on risk management issues pertinent to manufacturing and supply chain management. There are two reasons for not including papers published prior to 2000. First, although traditionally risk and uncertainty have always been an important issue related to supply chain management literature, the term "supply chain risk" is relatively new to the literature. Our search in two major literature databases (Science Direct and Emerald Online) using a keyword "supply chain risk" revealed no result for papers published prior 2000. Second, the issue of supply chain risk management has gained much attention after a series of events having major impacts on supply chain, including fire in one of the Ericsson's supplier in New Mexico in 2000 that led Ericsson to a loss of about 400 million Euros, insolvency of one of Land Rover's supplier in 2001 causing this company to lay off 14000 workers, and certainly the tragic terrorists attack on the World Trade Center on September 11, 2001 causing major supply chain problems to the world (Norrman and Jansson, 2004; Paulsson, 2004; Tang, 2006b).

The literature search was done through various electronic databases, including Science Direct, Emerald Fulltext, EBSCO, ABI/INFORM Global Pro-quest, and Inderscience. The keyword used for the search was “supply chain risk”. This search revealed nine articles in Science direct (abstract, title, and keywords), 30 articles in Emerald, 5 articles in EBSCO (abstract, title, and keywords), 10 articles in Inderscience, and 154 in ABI/inform Global Pro-quest academic database (full text documents and scholarly journals, including peer-reviewed) in August 2007. A total of 208 articles were found. After looking at the types of articles, we discarded those not belong to refereed journal articles such as prefaces, editorial notes, book review, and interview. Finally, we ended up with 82 relevant articles to be reviewed in this paper.

Classifications

A total of 82 articles (from 39 journals in 5 journal databases) have been reviewed. Thirty eight percent of the SCRM articles have been published in the following four journals.

- International Journal of Physical Distribution & Logistics Management
- International Journal of Production Economics
- European Journal of Operations Research
- Production and Operations Management

It is interesting to note here that the SCRM articles are published in so many different journals, indicating the multi-disciplinary nature of the problem. In table 1, the distribution of articles published in various years and the publishing journals are shown. The International Journal of Physical Distribution & Logistics Management has much more articles on SCRM than other journals as it published two special issues (volume 34 (5) and volume 34 (9), both in 2004), covering this issue. Other well known journals, such as the Journal of Operations Management, have also called papers for a special

issue on SCRM, suggesting that the distribution of SCRM papers among relevant journals would be more even in the future. As depicted in figure 1, the number of articles is generally increasing during the period of 2000 – 2006 and there is a big jump from 2004, indicating that the research on SCRM attracts attentions of many researchers.

ANALYSIS OF RESULTS

Methodologies

Different methodologies used by various researchers are divided into five categories, according to Malhorta and Grover (1998) which include conceptual, descriptive, empirical, exploratory cross-sectional and exploratory longitudinal. The distribution of supply chain risk management papers according to the various methodologies is shown in Figure 2. As it is shown, almost half of the papers applied the descriptive approach in their methodology. In the second place is the empirical research, and is by far lower than the two are conceptual and exploratory researches. The descriptive and empirical researches together account for 80% of the methodologies used.

The conceptual is meant to represent a research methodology that describes basic/fundamental concepts on supply chain risk management. In this classification, most papers propose a conceptual methodology for managing supply chain risks. For example, Cucchiella and Gastaldi (2006) developed a framework for the management of uncertainty in the supply chain in order to minimize firm risks. The authors employed a risk option approach to increase firm's flexibility as a means for dealing with uncertainty within a supply chain. Some papers in this category also clarify some matters related to supply chain and supply chain risk management, including their definition. Peck (2006) examined the term supply chain, supply chain management, and then the fusion of supply chain management with risk. The author then argued that the supply chain risk should

Table 1. Distribution of articles by years and journals

Journal	2000	'01	'02	'03	'04	'05	'06	'07	Total
Automatica							1		1
Business Process Management Journal							1		1
California Management Review		1							1
Chemical Engineering Science						1			1
Computers in Industry							1		1
European Journal of Industrial Engineering								1	1
European Journal of Operational Research						1		3	4
Industrial Management & Data Systems							1		1
International Journal of Electronic Customer Relationship Management								1	1
International Journal of Integrated Supply Management						1			1
International Journal of Logistics Economics and Globalization								2	2
International Journal of Logistics Management					1	1	1		3
International Journal of Logistics systems and Management							1		1
International Journal of Logistics: Research and Applications				1			1		2
International Journal of Management and Enterprise Development								1	1
International Journal of Manufacturing Technology and Management								1	1
International Journal of Operations & Production Management							1	1	2
International Journal of Physical Distribution & Logistics Management			1	1	11	2	1		16
International Journal of Production Economics			1		2		4		7
International Journal of Production Research						2			2
International Journal of Retail & Distribution Management						1			1
International Journal of Risk Assessment and Management								2	2
Journal of Enterprise Information Management							1		1
Journal of Manufacturing Technology Management							1		1
Journal of Operations Management							1		1
Journal of Purchasing & Supply Management				1		1	1		3
Journal of Supply Chain Management				1		1			2
Management Decision	1								1
Manufacturing & Service Operations Management					1				1
McKinsey Quarterly								1	1
MIT Sloan Management Review					1	1			2
Production and Operations Management						4			4
Risk Management					1		1		2

table continued on following page

Table 1. continued

Strategic finance							1		1
Supply Chain Management	1				1				2
Supply Chain Management Review						1			1
Supply Chain Management: An International Journal					2		1		3
The International Journal of Management Science					1				1
Transportation Research Part E: Logistics & Transportation Review						1		1	2
Total	2	1	2	4	21	18	20	14	82

Figure 1. Number of articles of supply chain risk management in 2000-2007 periods

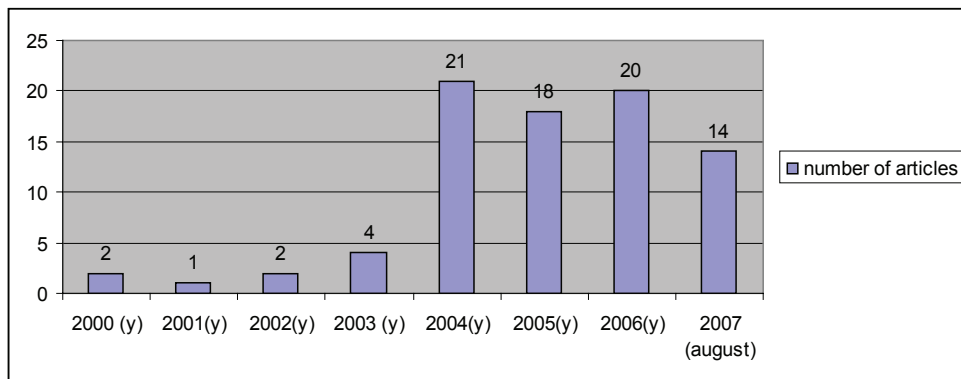
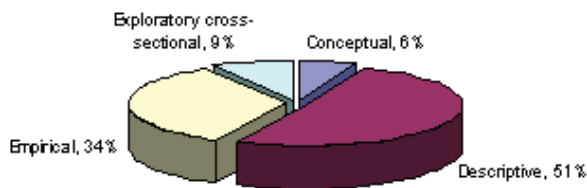


Figure 2. Research methodology used in SCRM articles



not be addressed solely within a functional SCM perspective, but required cross-functional concerns.

Descriptive is a methodology that describes, formulates, and develops model in supply chain risk management. For example, there are models that have been developed as a supply chain management framework that include identification, analysis, and prioritizing mitigation actions. Some popular tools such as failure

mode and effect analysis (FMEA) and analytical hierarchy process (AHP) have been used for this purpose. Wu et al (2006) and Gaudenzi and Borghesi (2006) for example applied the AHP model, Sinha et al. (2004) applied the FMEA approach, and Cucciella and Gastaldi (2007) applied the real option model. Some authors also developed mathematical models to analyse risk behaviour in supply networks (for example Nagurney and Matspura, 2005; Nagurney et al, 2005).

Empirical is a methodology in which the data for study is taken from existing database, case study, literature review, and taxonomy or typology approaches. Some of the studies in this category are in the form of a survey study involving practitioners as respondents. Zsidisin and Ellram (2003) did a survey involving respondents of purchasing professional associated with the Institute for Supply Management™ (ISM). The authors investigated the concept of agency theory within the context of supply risk management.

Juttner et al. (2003) conducted a field research involving interviewees from manufacturing companies, retail sectors, and logistics service providers. The researchers first interviewed the companies' representatives separately for each company and then they were invited for a focus groups discussion. The study seek to identify future research agenda and then to clarify the concept as well as to propose a working definition for supply chain risk management.

Exploratory cross-sectional is a methodology where the information is collected at one point in time. Peck (2005) proposed a framework, based on the results of the exploratory study, for analyzing the scope and dynamics of supply chain risks. The framework is consisted of four levels of supply chain elements, i.e., value stream / product / processes, asset and infrastructure dependencies, organizations and inter-organizational networks, and then the environment. The author argues that a robust or resilient supply chain can not be done by merely good design and management of supply chain processes, but should also taking into account the system more widely to include the other three levels.

Exploratory longitudinal is a survey methodology where the data collection is done at two or more points over time in the same organizations. We found no paper applying this methodology. The fact that the supply chain risk management has just received much attention quite recently could be an explanation for why this methodology has not been applied in this field.

Industry Sectors

SCRM articles appear to be spread over many industrial sectors. Most of the applications have been in the electronics and aerospace sectors. It is understandable that the supply chain risk management has been mostly applied to the electronic sector. As suggested by Sodhi (2005), the electronic industry is prone to risk due to short product life cycle and high demand uncertainty. Ericsson supply chain risk management model (Norrman and Jansson, 2004) which was developed after a fire at its sub-supplier is one of the mostly discussed cases in the supply chain risk literature. The aerospace on the other hand is exposed to risk due to its complexity. The product complexity as well as the supply chain structure complexity brings much risks and uncertainty to the aerospace sector. Sinha et al. (2004) developed a framework for mitigating supply chain risks in an aerospace industry. The authors suggest that such risks as lack of common terminology among supply chain players, conflict in OEM requirements, and lack of raw materials are examples of risks that could happen in this sector. To a lesser extent, supply chain risk management have also addressed the automotive, telecommunication, semiconductors, machinery and machine tools, metal industry, and other sectors. Table 2 presents the classification of the papers according to the industry sectors where they are applied. Based on scale of the companies, the SCRM are mostly biased toward large rather than small and medium enterprises.

Unit of Analysis

We also categorized the papers from the perspective of the unit of analysis following Norrman and Lindroth (2004). The unit of analysis describes the complexity of the entities from which the supply chain risks are viewed. This paper uses the level of complexity from a single logistic activity to a supply network. Logistics is that part of SCM process that plans and control between the points of internal company such as: traffic and transportation, warehousing

and storage, industrial packaging, etc (Coyle et al, 1992). Thus, risks can be evaluated from a single supply chain function such as procurement, planning, transport, warehouse, etc. Dyadic relations represent a relationship between two organizations within a supply chain. For example, the relationship between a manufacturing company and one of its suppliers can be considered as a dyadic relation. The supply chain, on the other hand, is considered here as a set of three or more entities which work together to produce and deliver products from sources to customers (Mentzer et al, 2001). The most complex unit of analysis is the supply network. Choi and Krause (2006) define supply networks as "all inter-connected companies that exist upstream to any one company in the value system".

Our categorization shows that most SCRM literature addresses a supply chain as a unit of analysis followed by a dyadic relationship in the second place. We found only one article which exclusively looking at risk from solely a single logistic activity, i.e., Wilson (2007). The author investigates the effect of transportation disruptions on supply chain performance using system dynamics simulation. Although there are many articles, which looked at only one side of the supply chain (e.g., supply risk or inbound risks), we consider them to fall within a dyadic relationship as some risk sources are from other organizations (e.g. from supplier). On the other extreme, we also found only limited articles looking at risks within a supply network. The complexity of the structure and relationships obviously prevents ones to be able to capture a network when addressing supply chain risks. Table 3 shows the categorization of papers according to the unit of analysis, excluding those papers which do not use any unit of analysis in their study.

Types of Risks

There are various types of supply chain risks. Chopra and Sodhi (2004) categorized supply chain risks into disruptions, delays, systems, forecast, intellectual property, procurement,

receivables, inventory, and capacity. In the aerospace industry, Sinha et al. (2004) classified four areas of risks which include standards, supplier, technology, and practices. In each of these four areas, there is a number of supply chain risks that could happen. Finch (2004) classified risks into three broad categories which include the three levels of coverage: application level, organizational level, and inter-organizational level. At the application level, the risks include natural disasters, accidents, deliberate acts, data/information security risks, and management issues. At the organizational level, such risks as legal and strategic changes in decisions could happen, while at the inter-organizational level, there are possible uncertainty from the outside of the organization which could pose risks. Other classification of risks can be found in other articles, including for example Mason-Jones and Towill (1998), Juttner et al (2003), Peck (2005).

Following the classification in Norrman and Lindroth (2004), we categorize the type of risks addressed in the SCRM papers into operational accidents, operational catastrophes, and strategic uncertainty. The operational accidents are those affecting the operational process or resources related to logistics/supply chain, such as fires, truck accidents, machine failures, labor strikes, etc (Norrman and Lindroth 2004). Most companies are facing day-to-day operational accidents, but the frequency of those risks happening depends on how good they manage supply chain risks. Operational catastrophes are risks associated with rare and difficult to predict events, but once occurred; they have severe impacts on the company. Such risks as natural disaster, socio-political instability, economic disruptions, and terrorist attacks are examples of operational catastrophes. Finally, the strategic uncertainties are the type risks that are generally difficult to address and affect the company not at the operational level, but strategically. The strategic uncertainty could be in the form volatile demand, supplier default/bankruptcy, increasing competition, market constraint, and technology change.

Table 2. Classification of industry sectors

Industry sectors	Articles (see references)	Count
Electronics (Cellular phone, computer, etc)	Zsidisin et al (2000), Hallikas et al (2002), Papadakis (2003), Zsidisin (2003a) (2), Zsidisin (2003a), Zsidisin et al (2004) (2), Appelqvist and Gubi (2005), Sodhi (2005), Zsidisin et al (2005a), Choi and Krause (2006), Ojala and Hallikas (2006), Papadakis (2006)	14
Aerospace	Zsidisin et al (2000), Zsidisin (2003a), Zsidisin (2003b), Sinha et al (2004), Zsidisin et al (2004), Blackhurst et al (2005), Juttner (2005), Peck (2005), Zsidisin et al (2005a), Zsidisin and Smith (2005)	10
Automotive industry	Zsidisin (2003b), Svensson (2004a), Svensson (2004b), Blackhurst et al (2005), Hallikas et al (2005), Juttner (2005), Berry and Collier (2007),	7
Telecommunications	Zsidisin et al (2000) (2), Agrell et al (2004), Norrman and Jansson (2004), Zsidisin et al (2005a)	5
Semiconductor	Zsidisin et al (2000) (2), Zsidisin (2003a), Zsidisin et al (2004)	4
Industry sectors	Articles (see references)	Count
Machinery and machine tools	Atkinson (2004), Mills and Cemek (2004), Faisal et al (2006b)	3
Metal industry	Hallikas et al (2002), Hallikas et al (2004), Ojala and Hallikas (2006)	3
Textile and garment industry	Brun et al (2006), Faisal et al (2006b)	2
Chemicals and pharmaceutical industry	Blackhurst et al (2005), Juttner (2005), Kleindorfer and Saad (2005)	3
Film industry	Watson (2004)	1
Medical and dental devices	Gaudenzi and Borghesi (2006)	1
Packaging industry	Atkinson (2004)	1
Toys industry	Faisal et al (2006a)	1
Other industry (leather, office equipments, tobacco, agricultural, construction, marine transport, and commerce/trading, third party logistics (3PL) providers, cosmetics	Allen and Schuster (2004), Mills and Cemek (2004), Blackhurst et al (2005) (2), Hendricks and Singhal (2005), Nagurney et al (2005), Sheffi and Rice (2005) (2), Faisal et al (2006b), Choy et al (2007), Cucciella and Gastaldi (2007),	11
Total		66*

Note: * While 82 articles were reviewed, there are papers without application to any sector

Certainly, each company would have a different set of typical risks. In aggregate terms, there is a common pattern in the types of risks the companies/supply chains are facing. For example, the operational catastrophes are less likely to happen compared to the other two types. However, recently the operational

catastrophes are happening with an increasing rate, making it a necessity for companies to have well prepared mitigation strategies for this type of risks. We witness increasingly more frequent natural disasters, which cause operational catastrophes in recent years, including for example the earthquake, tsunami, floods,

Table 3. Unit of analysis

Unit of Analysis	Articles (see references)	Count
Single Logistics Activities	Wilson (2007)	1
Company Logistics	Giaglis et al (2004), Kleindorfer and Saad (2005)	2
Dyadic Relations	Zsidisin et al (2000), Johnson (2001), Hallikas et al (2002), Svensson (2002), Zsidisin (2003a), Giunipero and Eltantawy (2004), Sinha et al (2004), Svensson (2004a), Watson (2004), Zsidisin et al (2004), Rao et al (2005), Towill (2005), Zsidisin and Smith (2005), Giunipero, et al (2006), Wu et al (2006)	15
Supply chain	Ritchie and Brindley (2000), Juttner et al (2003), Papadakis (2003), Zsidisin (2003b), Agrell et al (2004), Allen and Schuster (2004), Atkinson (2004), Barry (2004), Cavinato (2004), Chopra and Sodhi (2004), Christopher and Lee (2004), Christopher and Peck (2004), Finch (2004), Mills and Cemek (2004), Norrman and Jansson (2004), Qi et al (2004), Spekman and Davis (2004), Svensson (2004b), Appelqvist and Gubi (2005), Blackhurst et al (2005), Guillen et al (2005), Hendricks and Singhal (2005), Juttner (2005), Peck (2005), Sheffi and Rice (2005), Sodhi (2005), Zsidisin et al (2005b), Atkinson (2006), Beasley (2006), Brun et al (2006), Chen, et al (2006), Chen and Seshadri (2006), Cucchiella and Gastaldi (2006), Faisal et al (2006a), Faisal et al (2006b), Gaudenzi and Borghesi (2006), Papadakis (2006), Peck (2006), Sutton (2006), Tang (2006a), Wagner and Bode (2006), Wilding and Humphries (2006), Choy et al (2007), Faisal et al (2007b), Krishnan and Shulman (2007), Ritchie and Brindley (2007)	46
Supply network	Hallikas et al (2004), Hallikas et al (2005), Nagurney et al (2005), Nagurney and Matsypura (2005), Choi and Krause (2006), Glickman and White (2006), Ojala and Hallikas (2006), Cucchiella and Gastaldi (2007), Goh et al (2007), Li and Chandra (2007)	10
Total		74

etc. Table 4 shows the types of risks addressed in the SCRM literatures.

As table 4 shows, operational accidents and strategic uncertainty are discussed in about the same number of papers, while the operational catastrophe has received relatively less attention. Interestingly, only 7 papers addressed all three types of risks (Juttner et al. (2003), Zsidisin (2003a), Christopher and Peck (2004), Norrman and Jansson (2004), Peck (2005), Wagner and Bode (2006), Wu et al (2006)). Certainly, it would be interesting to develop more analysis to see if different types of risks are associated with different industry sectors. For example, one would think that the strategic uncertainty could be very much a concern of innovative industries as product life cycles are becoming shorter and shorter with rapid technology development. On the other hand, operational accidents could be

associated with low awareness of internal risks which is often attributable to weak management systems. The future studies should attempt to look at a more detailed level the typical risks each industry sector is facing.

Risk Management Process and Strategies

Risk management processes refer to the stages a supply chain or a company could follow to reduce the supply chain risks. It normally involves such activities as identifying supply chain risk events, assessing the probabilities and the severity of impacts, prioritizing the risk event to be dealt with and developing actions for mitigating risks or planning for backup actions. In the identification stage, one may use various techniques or tools to list various

Table 4. Type of risks

Type of risks	Articles (see references)	Count
Operational accidents	Zsidisin et al (2000), Svensson (2002), Juttner et al (2003), Zsidisin (2003a), Zsidisin (2003b), Allen and Schuster (2004), Atkinson (2004), Chopra and Sodhi (2004), Christopher and Peck (2004), Finch (2004), Mills and Camek (2004), Norrman and Jansson (2004), Sinha et al (2004), Spekman and Davis (2004), Zsidisin et al (2004), Appelqvist and Gubi (2005), Hallikas et al (2005), Hendricks and Singhal (2005), Nagurney et al (2005), Nagurney and Matsyura (2005), Peck (2005), Rao et al (2005), Sodhi (2005), Zsidisin et al (2005a), Zsidisin and Smith (2005), Choi and Krause (2006), Cucchiella and Gastaldi (2006), Gaudenzi and Borghesi (2006), Papadakis (2006), Wagner and Bode (2006), Wu et al (2006), Berry and Collier (2007), Wilson (2007)	17
Operational catastrophes	Juttner et al (2003), Papadakis (2003), Zsidisin (2003a), Barry (2004), Chopra and Sodhi (2004), Christopher and Peck (2004), Norrman and Jansson (2004), Spekman and Davis (2004), Hendricks and Singhal (2005), Juttner (2005), Kleindorfer and Saad (2005), Peck (2005), Sheffi and Rice (2005), Zsidisin et al (2005a), Papadakis (2006), Tang (2006a), Wagner and Bode (2006), Wu et al (2006),	10
Strategic uncertainty	Johnson (2001), Hallikas et al (2002), Juttner et al (2003), Zsidisin (2003a), Zsidisin (2003b), Agrell et al (2004), Christopher and Lee (2004), Christopher and Peck (2004), Giaglis et al (2004), Giunipero and Eltantawy (2004), Norrman and Jansson (2004), Qi et al (2004), Watson (2004), Zsidisin et al (2004), Blackhurst et al (2005), Guillen et al (2005), Hallikas et al (2005), Peck (2005), Rao et al (2005), Sheffi and Rice (2005), Sodhi (2005), Towill (2005), Chen et al (2006), Chen and Seshadri (2006), Choi and Krause (2006), Cucchiella and Gastaldi (2006), Faisal et al (2006b), Gaudenzi and Borghesi (2006), Ojala and Hallikas (2006), Tang (2006a), Wagner and Bode (2006), Wu et al (2006), Choy et al (2007), Tapiero (2007)	24
Total		51

risk events that possibly occur in the supply chain. Most of the techniques at this stage are qualitative in nature. Brainstorming within the research team or which include experts from industry are common practices that have been used at the identification stage (see Hallikas et al., 2002; Zsidisin, 2003b; Norrman and Jansson, 2004; Sinha et al. 2004; Wu et al, 2006 for examples of articles using brainstorming). Some models have also been used to assist in identifying supply chain risks at this stage, such as IDEF0 (Sinha et al, 2004) and AHP (Wu et al, 2006). Some other tools such as Fault Tree Analysis (FTA) and Event Tree Analysis (ETA), which have been used in technical areas such as maintenance, have not been popularly used in the supply chain risk management.

In the assessment stage, a number of approaches are possible including brainstorming,

process mapping, risk impact analysis, and scenario planning. A popular model used in the assessment stage is the failure mode and effect analysis (FMEA) where we can assign a priority list to each risk based on the multiplication of the probability of occurrence and the severity of the impact caused. Some authors have developed an innovative model for supply chain risk management where assessment is a critical stage within it. For example, Norrman and Jansson (2004) described a model called ERMET (Ericsson Risk Management Evaluation Tools). Brun et al (2006) described another model called SNOpAck (Supply Network Opportunity Assessment Package).

In assessing supply chain risks, authors use different scales. Some authors (Hallikas et al, 2002; Norrman and Jansson, 2004) use a 1 – 4 scale while Hallikas et al (2004) use

a 1 – 5 scale. Each number corresponds to a verbal definition. For example, in defining the magnitude of impacts (severity), the values of 1, 2, 3, 4, and 5 represent low, medium, high, very high, catastrophic impacts respectively. Zsidisin (2003b) and Sheffi and Rice (2005) only use two levels, i.e., high and low, to assess the magnitude of risks.

Mapping the risks into a graph or a matrix could be useful in the analysis stage. Such visualization is particularly desirable to assist management in a company communicating risks internally as well as to other parties within the supply chain. The traffic light analysis such as the one presented by Norrman and Jansson (2004) is a good visualization of risks. They use colors to highlight the different magnitude of risks and hence, prioritization can be easily judged from the colors.

The risk management involves the course of actions to consider in order to reduce the risks. This can be done by reducing the probability of occurrence, the severity of impacts, or both. Generally, risk management involves such options as transferring it to or sharing it with other parties, accepting it as it is, or avoiding the risks. Transferring risk to other parties is a common supply chain management practices nowadays. An example would be the outsourcing / subcontracting practices where some types of supply chain risks are transferred to the parties providing the products or services. Some global players outsource the whole production processes to outside parties which automatically means that such a company does not need to deal with labor and production facility problems. Risk sharing maybe developed in terms of a joint collaboration for risks involving two or more parties in a supply chain. Juttner et al (2003) suggested that cooperation with supply chain partners is one of the mitigation strategies for supply chain risks. The cooperation can be in terms of joint efforts to improve supply chain visibility and understanding, joint efforts to share risk related information, and joint efforts to prepare supply chain continuity plans. Dropping specific products, geographical markets,

suppliers, or customers can be considered as a way to avoid risks.

One major action that each company should do is to develop an alternative plan or contingency plan to mitigate the supply chain risks. Such an alternative, which is also called as business continuity management (Juttner et al, 2003), is developing well in the area of supply chain risk management recently. According to Norrman dan Lindroth (2004), business continuity planning / business continuity management (BCP/BCM) cover wider scopes than the supply chain risk management. BCP/BCM includes crisis management, disaster recovery, business recovery, and contingency planning which are often not considered to be the main focuses of supply chain risk management.

As presented by table 5, the SCRM articles address the four general risk management processes well.

CONCLUDING REMARKS AND OUTLINES OF FUTURE STUDIES

We have presented a classification of articles on supply chain risk management (SCRM) published in recent journal papers based on the classification methodology of Malhorta and Grover (1998). The review shows that SCRM is a rapidly growing area since a few yeas ago. Papers on supply chain risk management address various types of supply chain risks and authors developed various risk classifications. In this paper we follow the classification of Norrman and Lindroth (2004) where the supply chain risks are categorized into operational accidents, operational catastrophes, and strategic uncertainty. Understanding the types of risks and their probability of occurrence as well as the associated impacts is a starting point for companies to develop effective risk management strategies. From methodological point of view, most published papers were based on empirical and descriptive, while very few based on exploratory research.

Table 5. Stages of risk management process

Stages of risk management process	Articles (see references)	Count
Risk identification/ analysis	Hallikas et al (2002), Zsidisin (2003b), Cavinato (2004), Finch (2004), Hallikas et al (2004), Norrman and Jansson (2004), Sinha et al (2004), Juttner (2005), Wu et al (2006)	9
Risk assessment	Zsidisin et al (2000), Hallikas et al (2002), Zsidisin (2003b), Finch (2004), Hallikas et al (2004), Norrman and Jansson (2004), Sinha et al (2004), Zsidisin et al (2004), Juttner (2005), Kleindorfer and Saad (2005), Sheffi and Rice (2005), Gaudenzi and Borghesi (2006), Sutton (2006), Wu et al (2006), Berry and Collier (2007), Li and Chandra (2007), Li and Hong (2007), Burn et al (2006)	18
Risk management	Ritchie and Brindley (2000), Zsidisin et al (2000), Johnson (2001), Chopra and Sodhi (2004), Christopher and Peck (2004), Finch (2004), Giunipero and Eltantawy (2004), Hallikas et al (2004), Norrman and Jansson (2004), Sinha et al (2004), Hallikas et al (2005), Juttner (2005), Kleindorfer and Saad (2005), Sheffi and Rice (2005), Sodhi (2005), Atkinson (2006), Cucchiella and Gastaldi (2006), Gaudenzi and Borghesi (2006), Ojala and Hallikas (2006), Peck (2006), Berry and Collier (2007), Faisal et al (2007a), Faisal et al (2007b), Iakovou et al (2007),	24
Business continuity management	Juttner et al (2003), Norrman and Jansson (2004), Juttner (2005), Sheffi and Rice (2005), Zsidisin et al (2005a), Zsidisin, et al (2005b), Peck (2006)	7

Since supply chain risk management is still in the infancy stage and the need for better supply chain risk management is high, this field will continue to be placed on top list of future research agenda. We discuss here a number of possible research opportunities in this area.

The first agenda is related to the use of technology in relation to supply chain risk management. As suggested by several authors (Atkinson, 2004; Giunipero and Eltantawy, 2004; Tang, 2006a; Wilson, 2007), the use of technology such as RFID and ERP will become an important facet of supply chain risk management. More research should be conducted to learn how technologies could be used to mitigate risks in a supply chain. In general, the use of information technology could improve information visibility across the supply chain. Certainly, with better ability to see what is happening in the upstream and downstream stages of the supply chain, each player would be able to anticipate for delay in delivery of materials, swings in demand, act of competitors, and even for some disruption risks. How technology could contribute to

the management of supply chain risks, would technology also pose other supply chain risks, how technology can be used to monitor supply chain risks are among interesting questions to answer in future studies.

Zsidisin (2003b) suggests that managerial perception of risk from different perspectives is an area for future research. It is indeed important to understand what different people in an organization or across different organizations within a supply chain perceive about supply chain risks. Different perception about supply chain risks from marketing and from operations could pose a conflict in deciding what mitigation actions to choose in an organization. Likewise, as suggested by Zsidisin (2003b), if sales representatives perceive risks in a similar manner than the purchasing professionals in a supply chain relationship, then strategies to manage the risk in that link could be created within the dyadic relationship and may be easier to implement due to the similar perception from both sides. Certainly, it would be interesting to explore differences and similarities in perceptions toward supply chain risks inside an organization and across organizations in a supply chain.

Another fertile area of research is decision making process related to supply chain risk management. Risk management process is a complex issue that could involve risky decision making processes. Some papers suggest that risk management may involve such decision as risk transfer (for example using outsourcing), risk sharing (through joint collaboration for risks), and risk avoidance (through, for example hedging currency). From our observation, there is no paper that has a focus on decision making process for selecting the best course of action in dealing with supply chain risk management. Deciding which options to choose among various possible alternatives such as risk transfer, risk sharing, or any types of risk mitigation strategies could be a difficult decision making problem within a supply chain. Cucchiella and Gastaldi (2006) present a real option model for risk management. Application of other decision making models for making risk management decision is an interesting research topic for the future. As Juttner et al (2003) suggest, guiding supply chain trade-off decision making is an important agenda for future research in supply chain risk management. Standard decision making models such as the AHP or ANP could be further explored for decision making application in supply chain risk management.

To the best of our knowledge, there is no paper that specifically addresses collaborative risk management in the supply chain. In contrast, the discussions on collaborative planning and forecasting (for example through CPFR initiatives) or other collaborative schemes (such as in the context of quality control as presented in Tapiero 2007) are gaining more attention in the literature. Future research should then be expanded to explore how collaborative risk management between companies in a supply chain could work. The possible research could be the design of a framework for collaborative risk management and various possible schemes for collaborative risk management between organizations in a supply chain.

Research on supply chain risk management that attempts to compare strategies to manage risk or to create a robust supply chain

across different sectors is still limited. Juttner et al (2003) also suggest that it is important to develop risk management approaches for specific supply chains / industries. To enable this, it is necessary to first understand different types of risks that are dominant in different supply chains / industry sectors. Generally, it is conceivable that the types of risks, and then the appropriate mitigation actions, vary with supply chains / industry sectors. For example, in the electronic sectors, the competitions due to many players and the rapid development of technology force products to have shorter life cycle. These pose various supply chain risks such as forced markdown prices and inventory obsolescence. In the pharmaceutical industry, on the other hand, long product development time (time to market) could be a major issue related to supply chain risk management. Thus, it would be important to expand supply chain risk management research into these issues.

REFERENCES

- Agrell, P. J., Lindroth, R., & Norrman, A. (2004). Risk, information and incentives in telecom supply chains. *International Journal of Production Economics*, 90(1), 1-16.
- Allen, S. J., & Schuster, E. W. (2004). Controlling the risk for an agricultural harvest. *Manufacturing & Service Operations Management*, 6(3), 225-236.
- Appelqvist, P., & Gubi, E. (2005). Postponed variety creation: case study in consumer electronics retail. *International Journal of Retail & Distribution Management*, 33(10), 734-748.
- Atkinson, W. (2004). Tagged: the risks and rewards of RFID technology. *Risk Management*, 51(7), 12-19.
- Atkinson, W. (2006). Supply chain management: new opportunities for risk managers. *Risk Management*, 53(6), 10-15.
- Barry, J. (2004). Supply chain risk in an uncertain global supply chain environment. *International Journal of Physical Distribution & Logistics Management*, 34(9), 695 - 697.
- Beasley, M., Chen, A., Nunez, K., & Wright, L. (2006). Working hand in hand: balanced scorecards

- and enterprise risk management. *Strategic Finance*, 87(9), 49-57.
- Berry, A. J., & Collier, P. M. (2007). Risk in supply chains: exploratory case studies in the automotive industry. *Int. J. of Risk Assessment and Management*, 7(8), 1005-1026.
- Blackhurst, J., Craighead, C. W., Elkins, D., & Handfield, R. B. (2005). An empirically derived agenda of critical research issues for managing supply-chain disruptions. *International Journal of Production Research*, 43(19), 4067-4081.
- Bogataj, D., & Bogataj, M. (2007). Measuring the supply chain risk and vulnerability in frequency space. *International Journal of Production Economics*, 108(1-2), 291-301.
- Brun, A., Caridi, M., Fahmy, S. K., & Ravelli, I. (2006). Value and risk assessment of supply chain management improvement projects. *International Journal of Production Economics*, 99(1-2), 186-201.
- Cavinato, J. L. (2004). Supply chain logistics risks: from the back room to the board room. *International Journal of Physical Distribution & Logistics Management*, 34(5), 383-389.
- Chen, H., Chen, J., & Chen, Y. (2006). A coordination mechanism for a supply chain with demand information updating. *International Journal of Production Economics*, 103(1), 347-361.
- Chen, Y.-J., & Seshadri, S. (2006). Supply chain structure and demand risk. *Automatica*, 42(8), 1291-1299.
- Childerhouse, P., Hermiz, R., Mason-Jones, R., Popp, A., & Towill, D. R. (2003). Information flow in automotive supply chains-identifying and learning to overcome barriers to change. *Industrial Management & Data System*, 103(7), 491-502.
- Choi, T. Y., & Krause, D. R. (2006). The supply base and its complexity: implications for transaction costs, risks, responsiveness, and innovation. *Journal of Operations Management*, 24(5), 637-652.
- Chopra, S., & Sodhi, M. S. (2004). Managing risk to avoid supply-chain breakdown. *MIT Sloan Management Review*, 46(1), 53-61.
- Choy, K. L., Li, C.-L., So, S. C. K., Lau, H., Kwok, S. K., & Leung, D. W. K. (2007). Managing uncertainty in logistics service supply chain. *Int. J. of Risk Assessment and Management* 7(1), 19-43.
- Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. *International Journal of Physical Distribution & Logistics Management*, 34(5), 388-396.
- Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management*, 15(2), 1-13.
- Coyle, J. J., Bardi, E. J., & Langley, C. J. (1992). *The management of business logistics*: West publishing, St Paul.
- Cucchiella, F., & Gastaldi, M. (2006). Risk management in supply chain: a real option approach. *Journal of Manufacturing Technology Management*, 17(6), 700 - 720.
- Cucchiella, F., & Gastaldi, M. (2007). Risk management in a globalised cosmetic firm. *Int. J. of Logistics Economics and Globalisation*, 1(1), 21-33.
- Faisal, M. N., Banwet, D. K., & Shankar, R. (2006a). Mapping supply chains on risk and customer sensitivity dimensions. *Industrial Management & Data System*, 106(6), pp.878-895.
- Faisal, M. N., Banwet, D. K., & Shankar, R. (2006b). Supply chain risk mitigation: modeling the enablers. *Business Process Management Journal*, 12(4), 535 - 552.
- Faisal, M. N., Banwet, D. K., & Shankar, R. (2007a). Quantification of risk mitigation environment of supply chains using graph theory and matrix methods. *European J. Industrial Engineering*, 1(1), 22-39.
- Faisal, M. N., Banwet, D. K., & Shankar, R. (2007b). Supply chain risk management in SMEs: analysing the barriers. *Int. J. of Management and Enterprise Development* 4(5), 588-607.
- Finch, P. (2004). Supply chain risk management. *Supply Chain Management: An International Journal*, 9(2), 183 - 196.
- Gaudenzi, B., & Borghesi, A. (2006). Managing risks in the supply chain using the AHP method. *International Journal of Logistics Management*, 17(1), 114-139.
- Giaglis, G. M., Minis, I., Tatarakis, A., & Zeimpekis, V. (2004). Minimizing logistics risk through real-time vehicle routing and mobile technologies: Research

- to date and future trends. *International Journal of Physical Distribution & Logistics Management*, 34(9), 749-766.
- Giunipero, L., Handfield, R. B., & Eltantawy, R. (2006). Supply management's evolution: key skill sets for the supply manager of the future. *International Journal of Operations & Production Management*, 26(7), 822-844.
- Giunipero, L. C., & Eltantawy, R. A. (2004). Securing the upstream supply chain: a risk management approach. *International Journal of Physical Distribution & Logistics Management*, 34(9), 698 - 713.
- Glickman, T. S., & White, S. C. (2006). Security, visibility and resilience: the keys to mitigating supply chain vulnerabilities. *Int. J. of Logistics Systems and Management* 2(2), 107 - 119.
- Goh, M., Lim, J. Y. S., & Meng, F. (2007). A stochastic model for risk management in global supply chain networks. *European Journal of Operational Research*, 182(1), 164-173.
- Guillen, G., Mele, F. D., Bagajewicz, M. J., Espuna, A., & Puigjaner, L. (2005). Multiobjective supply chain design under uncertainty. *Chemical Engineering Science*, 60(6), 1535-1553.
- Hallikas, J., Karvonen, I., Pulkkinen, U., Virolainen, V.-M., & Tuominen, M. (2004). Risk management processes in supplier networks. *International Journal of Production Economics*, 90(1), 47-58.
- Hallikas, J., Puumalainen, K., Vesterinen, T., & Virolainen, V.-M. (2005). Risk-based classification of supplier relationships. *Journal of Purchasing & Supply Management*, Vol. 11 Page: 72-82.
- Hallikas, J., Virolainen, V.-M., & Tuominen, M. (2002). Risk analysis and assessment in network environments: A dyadic case study. *International Journal of Production Economics*, 78(1), 45-55.
- Hendricks, K. B., & Singhal, V. R. (2005). An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of the Firm. *Production and Operations Management*, 14(1), 35-52.
- Iakovou, E., Vlachos, D., & Xanthopoulos, A. (2007). An analytical methodological framework for the optimal design of resilient supply chains. *Int. J. of Logistics Economics and Globalisation*, 1(1), 1-20.
- Johnson, M. E. (2001). Learning from toys: Lessons in managing supply chain risk from the toy industry. *California Management Review*, 43(3), 106-127.
- Juttner, U. (2005). Supply chain risk management: Understanding the business requirements from a practitioner perspective. *International Journal of Logistics Management*, 16(1), 120-141.
- Juttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: Outlining an Agenda for future research. *International Journal of Logistics: Research and Applications*, 6(4), 197-210.
- Kleindorfer, P. R., & Saad, G. H. (2005). Managing disruption risks in supply chains. *Production and Operations Management*, 14(1), 53-68.
- Kraljic, P. (1983). Purchasing must become supply management. *Harvard Business Review*, 61(5), 109-117.
- Krishnan, M., & Shulman, J. (2007). Reducing supply chain risk. *McKinsey Quarterly*(1), 10-13.
- Li, J., & Hong, S.-J. (2007). Towards a new model of supply chain risk management: the cross-functional process mapping approach. *Int.J.Electronic Customer Relationship Management*, 1(1), 91-107.
- Li, S., Ragu-Nathan, B., Ragu-Nathan, T. S., & Rao, S. S. (2006). The impact of supply chain management practices on competitive advantage and organizational performance. *The International Journal of Management Science (Omega)*, 34, 107-124.
- Li, X., & Chandra, C. (2007). Efficient knowledge integration to support a complex supply network management. *Int. J. of Manufacturing Technology and Management* 10(1), 1-18.
- Malhotra, M. K., & Grover, V. (1998). An assessment of survey research in POM: from constructs to theory. *Journal of Operations Management*, 16, 407-425.
- Mason-Jones, R., & Towill, D. R. (1998). shrinking the supply chain uncertainty cycle. *control*, 17-22.
- Mentzer, J. T., DeWitt, W., Keebler, J. S., & Min, S. (2001). Defining supply chain management. *Journal of Business Logistics*, 22(2), 1-25.
- Mills, J. F., & Camek, V. (2004). The risks, threats and opportunities of disintermediation: A distributor's

- view. *International Journal of Physical Distribution & Logistics Management*, 34(9), 714-727.
- Nagurney, A., Cruz, J., Dong, J., & Zhang, D. (2005). Supply chain networks, electronic commerce, and supply side and demand side risk. *European Journal of Operational Research*, 164(1), 120-142.
- Nagurney, A., & Matsypura, D. (2005). Global supply chain network dynamics with multicriteria decision-making under risk and uncertainty. *Transportation Research Part E: Logistics and Transportation Review*, 41(6), 585-612.
- Norrman, A., & Jansson, U. (2004). Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. *International Journal of Physical Distribution & Logistics Management*, 34(5), 434 - 456.
- Norrman, A., & Lindroth, R. (2004). Categorization of supply chain risk and risk management. In C. Brindley (Ed.), *Supply chain risk*: Ashgate Publishing Limited.
- Ojala, M., & Hallikas, J. (2006). Investment decision-making in supplier networks: Management of risk. *International Journal of Production Economics*, 104(1), 201-213.
- Papadakis, I. S. (2003). On the sensitivity of configure-to-order supply chains for personal computers after component market disruptions. *International Journal of Physical Distribution & Logistics Management*, 33(9/10), 934-950.
- Papadakis, I. S. (2006). Financial performance of supply chains after disruptions: an event study. *Supply Chain Management: An International Journal*, Vol. 11(No. 1), pp.25-33.
- Paulsson, U. (2004). Supply chain risk management. In C. Brindley (Ed.), *Supply chain risk* (pp. 79-96). Burlington: Ashgate Publishing Limited.
- Peck, H. (2005). Drivers of supply chain vulnerability: an integrated framework. *International Journal of Physical Distribution & Logistics Management*, 35(3/4), 210-232.
- Peck, H. (2006). Reconciling supply chain vulnerability, risk and supply chain management. *International Journal of Logistics: Research and Applications*, 9(2), 127-142.
- Qi, X., Bard, J. F., & Yu, G. (2004). Supply chain coordination with demand disruptions. *The International Journal of Management Science*, 301-312.
- Rao, U. S., Swaminathan, J. M., & Zhang, J. (2005). Demand and production management with uniform guaranteed lead time. *Production & Operations Management*, 14(4), 400-412.
- Ritchie, B., & Brindley, C. (2000). Disintermediation, disintegration and risk in the SME global supply chain. *Management Decision*, 38(8), 575 - 583.
- Ritchie, B., & Brindley, C. (2007). Supply chain risk management and performance: A guiding framework for future development. *International Journal of Operations & Production Management*, 27(3), 303-322.
- Sheffi, Y., & Rice, J. B. (2005). A Supply Chain View of the Resilient Enterprise. *MIT Sloan Management Review*, 47(1), 41-52.
- Sinha, P. R., Whitman, L. E., & Malzahn, D. (2004). Methodology to mitigate supplier risk in an aerospace supply chain. *Supply Chain Management: An International Journal*, 9(2), 154 - 168.
- Sodhi, M. S. (2005). Managing demand risk in tactical supply chain planning for a global consumer electronics company. *Production and Operations Management*, 14(1), 69-79.
- Sorensen, L. B. (2005). How risk and uncertainty is used in supply chain management: a literature study. *Int. J. of Integrated Supply Management*, 1(4), 387-409.
- Spekman, R. E., & Davis, E. W. (2004). Risky business: expanding the discussion on risk and the extended enterprise. *International Journal of Physical Distribution & Logistics Management*, 34(5), 414 - 433.
- Sutton, S. G. (2006). Extended-enterprise systems' impact on enterprise risk management. *Journal of Enterprise Information Management*, 19(1/2), 97-114.
- Svensson, G. (2002). A conceptual framework of vulnerability in firms' inbound and outbound logistics flows. *International Journal of Physical Distribution & Logistics Management*, 32(1/2), 110-134.
- Svensson, G. (2004a). Interactive vulnerability in buyer-seller relationships: a dyadic approach.

- International Journal of Physical Distribution & Logistics Management*, 34(7/8), 662-682.
- Svensson, G. (2004b). Key areas, causes and contingency planning of corporate vulnerability in supply chains: A qualitative approach. *International Journal of Physical Distribution & Logistics Management*, 34(9), 728.
- Tang, C. S. (2006a). Perspectives in supply chain risk management. *International Journal of Production Economics*, 103(2), 451-488.
- Tang, C. S. (2006b). Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics: Research and Applications*, 9(1 March), 33-45.
- Tapiero, C. S. (2007). Consumers risk and quality control in a collaborative supply chain. *European Journal of Operational Research*, 182(2), 683-694.
- Towill, D. R. (2005). The impact of business policy on bullwhip induced risk in supply chain management. *International Journal of Physical Distribution & Logistics Management*, 35(8), 555 - 575.
- Wagner, S. M., & Bode, C. (2006). An empirical investigation into supply chain vulnerability. *Journal of Purchasing and Supply Management*, 12(6), 301-312.
- Watson, G. (2004). Uncertainty and contractual hazard in the film industry: managing adversarial collaboration with dominant suppliers. *Supply Chain Management*, 9(5), 402-409.
- Wilding, R., & Humphries, A. S. (2006). Understanding collaborative supply chain relationships through the application of the Williamson organisational failure framework. *International Journal of Physical Distribution & Logistics Management*, 36(4), 309-329.
- Wilson, M. C. (2007). The impact of transportation disruptions on supply chain performance. *Transportation Research Part E: Logistics and Transportation Review*, 43(4), 295-320.
- Wu, T., Blackhurst, J., & Chidambaram, V. (2006). A model for inbound supply risk analysis. *Computers in Industry*, 57(4), 350-365.
- Zsidisin, G. A. (2003a). A grounded definition of supply risk. *Journal of Purchasing & Supply Management*, 9, 217-224.
- Zsidisin, G. A. (2003b). Managerial perceptions of supply risk. *Journal of Supply Chain Management*, 39(1), 14-25.
- Zsidisin, G. A., & Ellram, L. M. (2003). An agency theory investigation of supply risk management. *Journal of Supply Chain Management*, 39(3), 15-27.
- Zsidisin, G. A., Ellram, L. M., Carter, J. R., & Cavinato, J. L. (2004). An analysis of supply risk assessment techniques. *International Journal of Physical Distribution & Logistics Management*, 34(5), 397-413.
- Zsidisin, G. A., Melnyk, S. A., & Ragatz, G. L. (2005a). An institutional theory perspective of business continuity planning for purchasing and supply management. *International Journal of Production Research*, 43(16), 3401-3420.
- Zsidisin, G. A., Panelli, A., & Upton, R. (2000). Purchasing organization involvement in risk assessments, contingency plans, and risk management: An exploratory study. *Supply Chain Management: An International Journal*, 5(4), 87-197.
- Zsidisin, G. A., Ragatz, G. L., & Melnyk, S. A. (2005b). Managing the 'dark side' of supply chain management. *Supply Chain Management Review*, March, 46-52.
- Zsidisin, G. A., & Smith, M. E. (2005). Managing Supply Risk with Early Supplier Involvement: A Case Study and Research Propositions. *Journal of Supply Chain Management*, 41(4), 44.

Iwan Vanany is an associate professor of manufacturing system at Department of Industrial Engineering, Sepuluh Nopember Institute of Technology (ITS), Surabaya, Indonesia. He received his bachelor and master of engineering degree in industrial engineering from Sepuluh Nopember Institute of Technology. His research interests are in supply chain management, RFID application and planning, and performance measurement. He has presented about 4 papers relating with supply chain management in international conferences.

Suhaiza Hanim is an associate professor of operations management in the School of Management, Universiti Sains Malaysia. She received a PhD and Msc from Lancaster University, and a BS degree from Universiti Pertanian Malaysia. Suhaiza's primary research interests are in the areas of operations and production management, product and service quality management and productivity. She has published in International Journal of Benchmarking, International Journal of Operations and Production Management, OR Insight, International Journal of Information Management, Sasin Journal of Management, and Asian Academy of Management Journal. She is also co-author of the Spring Print Prentice Hall books, Operations and Production Management. Suhaiza is a member of OR Society in UK. She teaches management science, materials management, productivity and quality control courses at both the undergraduate and postgraduate level.

Nyoman Pujawan is a professor of supply chain engineering at the Department of Industrial Engineering, Sepuluh Nopember Institute of Technology (ITS), Surabaya, Indonesia. He received a first degree in industrial engineering from ITS, Indonesia, master of engineering in industrial engineering from Asian Institute of Technology (AIT) Bangkok, Thailand, and PhD in management science from Lancaster University, UK. His papers have been published in the International Journal of Production Economics, European Journal of Operational Research, Production Planning and Control, International Journal of Operations and Quantitative Management, International Journal of Integrated Supply Management, and International Journal of Logistics Systems and Management.