

**SUPPLY CHAIN RISK MANAGEMENT:
OUTLINING AN AGENDA FOR FUTURE RESEARCH**

Uta Jüttner, Helen Peck*, Martin Christopher

CCLT, Cranfield School of Management, Cranfield University

*Correspondence: Helen Peck, Cranfield School of Management, Cranfield University,
Cranfield, Bedford, MK43 8SG, United Kingdom; Tel: +44 1234 751122; Fax: +44
1234 751806; E-mail:h.peck@cranfield.ac.uk

Acknowledgement

The research reported in this paper is part of a wider UK government-funded programme of research into Supply Chain Risk and Resilience, undertaken by Cranfield School of Management for the Department for Transport.

SUPPLY CHAIN RISK MANAGEMENT: OUTLINING AN AGENDA FOR FUTURE RESEARCH

Abstract

In recent years the issue of supply chain risk has been pushed to the fore, initially by fears related to possible disruptions from the much publicised 'millennium bug'. Y2K passed seemingly without incident, though the widespread disruptions caused by fuel protests and then Foot and Mouth Disease in the UK, and by terrorist attacks on the USA have underlined the vulnerability of modern supply chains.

Despite increasing awareness among practitioners, the concepts of supply chain vulnerability and its managerial counterpart supply chain risk management are still in their infancy. This paper seeks to identify an agenda for future research and to that end the authors go on to clarify the concept of supply chain risk management and to provide a working definition. The existing literature on supply chain vulnerability and risk management is reviewed and compared with findings from exploratory interviews undertaken to discover practitioners' perceptions of supply chain risk and current supply chain risk management strategies.

SUPPLY CHAIN RISK MANAGEMENT: OUTLINING AN AGENDA FOR FUTURE RESEARCH

INTRODUCTION

On an individual firm basis, companies have been aware of the need for risk management and contingency planning for some considerable time and there exists a wide body of literature from such diverse fields as economics (e.g. Kahnemann and Tversky, 1979; Tversky and Kahnemann, 1992), finance (e.g. Smith et al., 1990), strategic management (e.g. Bettis and Thomas, 1990; Simons, 1999) and international management (e.g. Miller, 1992; Ting, 1988).

Recent events have vividly demonstrated that a disruption affecting an entity anywhere in the supply chain can have a direct effect on a corporation's ability to continue operations, get finished goods to market or provide critical services to customers. Organisations that think they have managed risk have often overlooked the critical exposures along their supply chains. As noted by Braithwaite and Hall (1999), supply chains that run to hundreds if not thousands of companies over several tiers present significant risk. Some writers suggest that the domino effects of disruptions in supply chains might have been exacerbated in the last decade (Christopher and Lee, 2001; McGillivray, 2000; Engardio, 2001). In an analysis of the inventory problems recently facing the US electronics and telecoms industry, Engardio (2001) points out that the "boasts" of flexible manufacturing and Just-in-Time supply chains have disguised some of the risks involved. He projects hefty writedowns for "whomever ends up

stuck with the inventory hot potato”. In a similar vein, Svensson (2002) stresses that JIT issues have been explored in many different aspects but vulnerability issues remain largely unexplored. Also, an executive at a US distribution giant stresses the lack of ownership in highly integrated supply chains, where “the finger pointing is likely to get faster” and risks of product obsolescence, inventories and a lack of responsiveness to peaks and troughs in end customer demand become even more troublesome (Souter 2000).

Given the widely acknowledged vulnerabilities of today's complex supply chains, one might expect the concept to have a clear meaning and a rich tradition of empirical findings and managerial approaches. On the contrary, a close examination of the literature reveals that only recently can a more systematic and structured approach to conceptualise vulnerabilities and supply chain risks be traced (e.g. Harland and Brenchley, 2001; Norrman and Lindroth, 2002; Svensson 2000 and 2002; Sheffi, 2002; Johnson, 2001; Zsidisin et. al., 2000). This article seeks to further that interest by providing a framework and foundation for systematically exploring the concept of risk management in supply chains. The purpose of this paper is to delineate the domain of risk management in supply chains, to provide an operational definition and to outline an agenda directing future research. We draw on the literature in risk management and supply chain management and compare, contrast and supplement it with the preliminary analysis of empirical findings from exploratory semi-structured field interviews.

RESEARCH METHODOLOGY

In order to tap the “mental” maps and experiences of supply chain professionals, a discovery-oriented, practitioner-based approach was applied, with semi-structured interviews being the primary method of data collection (Zaltman et al., 1982; Yin, 1989). In addition, because the

purpose of the study was theory construction (i.e. eliciting constructs and research issues), it was important to capture a wide range of experiences and perspectives in the course of the data collection. Therefore, a purposive or “theoretical” sampling plan (Glaser and Strauss, 1967) was used to ensure that the sample included managers with responsibilities in supply chain management and risk management in industrial, consumer and service industries (see Table 1).

Table 1: Industry sectors represented in the field research

Manufacturing Companies	Retail Companies	Logistics Service Provider
<ul style="list-style-type: none"> ▪ Aerospace ▪ Automotive ▪ Brewing ▪ Building Supplies (SME) ▪ Capital Equipment ▪ Cosmetics ▪ Groceries (packaged foods) ▪ Cleaning Products (household) ▪ Healthcare ▪ Packaging (pharmaceutical) ▪ Tobacco 	<ul style="list-style-type: none"> ▪ Grocery ▪ Apparel ▪ Cosmetics ▪ Seasonal Gifts 	<ul style="list-style-type: none"> ▪ Management Consultancy ▪ Freight Forwarding ▪ Shipping ▪ Third Party Logistics

To maintain a level of consistency between interviewees and researchers, an outline protocol was developed. However, given the overall paucity of literature directly addressing supply chain vulnerability and risk management, care was taken not to be too prescriptive. The questions and issues were to be treated only as discussion starters. The interviews typically lasted one to one and a half hours and were, where possible, conducted at the interviewees’ premises. These interviews were supplemented by focus groups held at Cranfield University as part of a Supply Chain Vulnerability Conference held in April 2002. This tended to result in better overall quality of discussions and enabled some supporting documentary evidence to

be collected. In most cases the primary contact would be a senior logistics/supply chain manager. Managers with responsibility for business continuity and risk management, procurement, or IT were amongst those who also attended. Interviews were tape recorded with the informants' prior agreement, then transcribed and summarised for analysis using thematic coding. Cross-case analysis elicited the overarching factors of interest and drew together the emerging themes in supply chain risk management (Miles and Huberman, 1994).

SUPPLY CHAIN RISK MANAGEMENT: THE CONCEPT AND ITS BASIC CONSTRUCTS

In defining the concept of supply chain risk management, we suggest that it is relevant to distinguish four basic constructs: supply chain risk sources, risk consequences, risk drivers and risk mitigating strategies. These constructs help us not only to probe the concept, but provide a basis for synthesising the emergent themes and issues for future research.

Supply Chain Risk Sources and Risk Consequences

In the popular, practitioner-oriented risk management literature (eg. Goldberg et al., 1999), as well as among our managers interviewed, the uses of the term 'risk' can be confusing because it is perceived as a multidimensional construct (Zsidisin forthcoming). On the one hand, it is used to refer to uncertain internal or external, environmental variables that reduce outcome predictability. In this sense, 'risk' actually refers to a source of risk and uncertainty, such as 'political risks' and 'market risks' or, from a supply chain view, 'the volatility of customer demand'. On the other hand, the term risk is also used when referring to the consequences of

risks, ie to the potential outcome indicators. In this sense, the terms ‘operational risks’, ‘human risks’ or ‘risks to customer service levels’ are consequences of risks becoming events.

In defining the concept of supply chain risk management, we suggest to adopt the definition provided by March and Shapira (1987) and define ‘risk’ as “the variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective values” (p. 1404). From our supply chain perspective, these uncertain variations or disruptions affect the flows of information, materials or products across organisation borders (LaLonde, 1997). For the purpose of our research, supply chain risks hence comprise “*any risks for the information, material and product flows from original supplier to the delivery of the final product for the end user.*” In simple terms, supply chain risks refer to the possibility and effect of a mismatch between supply and demand. ‘Risk sources’ are the environmental, organisational or supply chain-related variables which cannot be predicted with certainty and which impact on the supply chain outcome variables. Risk consequences are the focused supply chain outcome variables like e.g. costs or quality, ie the different forms in which the variance becomes manifest.

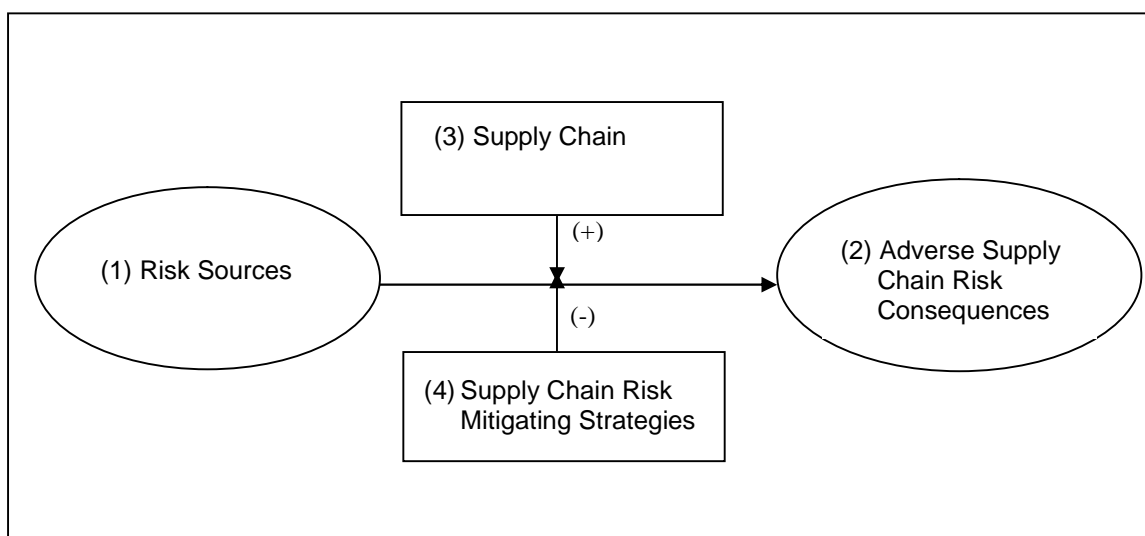
Supply Chain Risk Drivers and Risk Mitigating Strategies

Among practitioners, risk taking is generally perceived as an integrated and inevitable part of management (March and Shapira, 1987). In their view, risk taking equals decision making under uncertainty and hence any strategic choice has certain risk implications. For supply chain contexts, Braithwaite and Hall (1999) emphasise that the relationship between corporate strategy, risk and the implications for supply chain management are poorly understood and in need of further exploration.

In defining the concept of supply chain risk management, we make a distinction between supply chain risk drivers and risk mitigating strategies.

Several writers propose that some of the influences on contemporary supply chain management in the last decade, such as for example the globalisation of supply chains or the trend towards outsourcing, have exacerbated the risk exposure as well as the impact of any supply chain disruption (Christopher and Lee, 2001; McGillivray, 2000; Engardio, 2001). Since competitive pressures are often the drivers of risk, Svensson (2002) uses the term “calculated risks” (p. 119) that a company takes in order to improve competitiveness, reduce costs, and increase or maintain profitability. Risk mitigating strategies on the other hand are those strategic moves organisations deliberately undertake to mitigate the uncertainties identified from the various risk sources (Miller, 1992). The four, interrelated basic constructs of supply chain risk management are summarised in the following figure.

Figure 1: Supply chain risk management - the basic constructs



From this structure, the terms supply chain vulnerability and supply chain risk management can be derived: Supply chain vulnerability is “the propensity of risk sources and risk drivers to outweigh risk mitigating strategies, thus causing adverse supply chain consequences”. Whereas from a single firm perspective, the adverse consequences affect a firm’s goal accomplishment (Svensson, 2002, p. 112), in a supply chain context, they jeopardise the supply chain’s ability to effectively serve the end customer market. Supply chain risk management aims to identify the potential sources of risk and implement appropriate actions to avoid or contain supply chain vulnerability. Consequently, it can be defined as: “the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole.”

A FRAMEWORK DIRECTING FUTURE RESEARCH IN SUPPLY CHAIN RISK MANAGEMENT

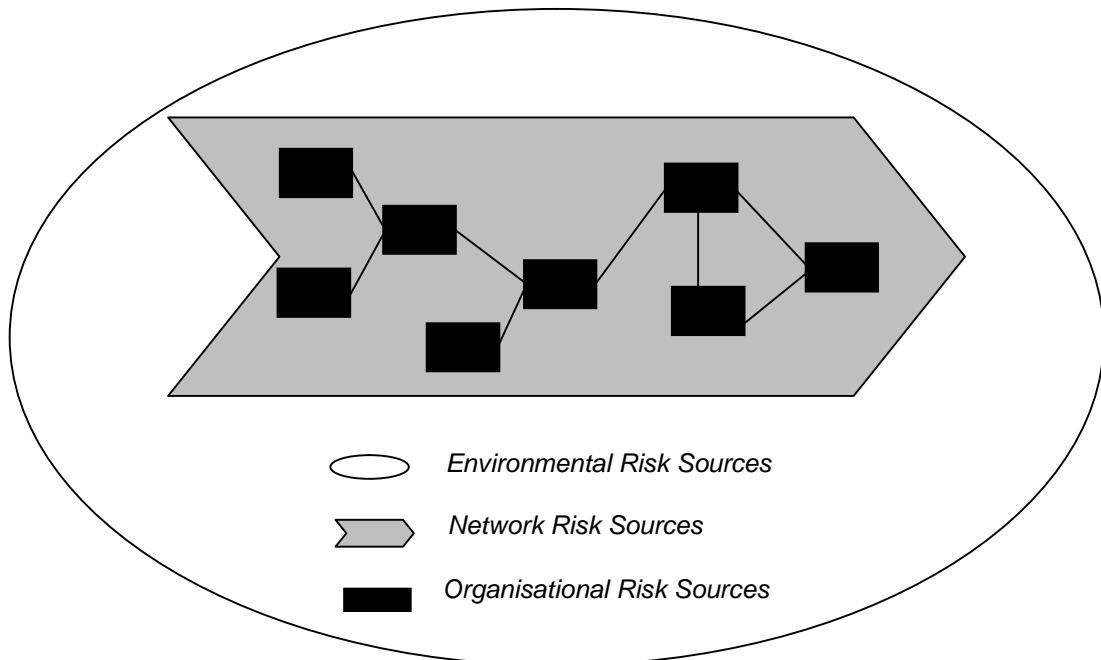
The four basic constructs of the supply chain risk management concept enable us to identify the related critical aspects of the managerial concept: (1) Assessing the risk sources for the supply chain; (2) identifying the risk concept of the supply chain by defining the most relevant risk consequences (3) tracking the risk drivers in the supply chain strategy and (4) mitigating risks in the supply chain. Whereas these critical aspects could be taken as sequential steps in a managerial process, we acknowledge the embryonic stage of the field and put them forward as a structure guiding future research. Hence, we will now proceed by structuring our literature

review and field findings along these basic dimensions, outlining the positive and normative research issues related to them.

(1) Assessing the Risk Sources for the Supply Chain

In the literature, various ways of categorising sources of risk coexist (e.g. Miller, 1992; Goldberg et al., 1999). The classification clarifies the relevant dimensions of potential disruptions faced by organisations in supply chains and provides the basis for risk assessment. Based on the literature review and fieldwork findings, we suggest that supply-chain relevant risk sources fall into three categories: Environmental risk sources, network-related risk sources and organisational risk sources (see Figure 2).

Figure 2: Risk sources in supply chains



Environmental risk sources comprise any uncertainties arising from the supply chain-environment interaction. These may be the result of accidents (e.g. fire), socio-political actions (e.g. fuel protests or terrorist attacks) or acts of God (e.g. extreme weather or earthquakes). Organisational risk sources lie within the boundaries of the supply chain parties and range from labour (e.g. strikes) or production uncertainties (e.g. machine failure) to IT-system uncertainties. Network-related risk sources as the third category arise from interactions between organisations within the supply chain. Whatever damage is caused by suboptimal interaction between the organisations along the chain is attributable to network-related risk sources. In this sense, environmental and organisational uncertainties are risk sources 'to' the various links in the supply chain and network-related uncertainties are risk sources 'of' the various links (Das and Teng, 1998). We distinguish between three different types of network-related risk sources: lack of ownership, chaos and inertia (Christopher and Lee, 2001):

Lack of ownership

Lack of ownership risk sources in supply chains result from blurring boundaries between buying and supplying companies in the chain. Triggered by trends such as outsourcing and concentration on core competencies, the increased use of manufacturing, distribution and logistics partners leads to a complex network of business relationships with confused lines of responsibilities. The risks often result in inventory costs due to product obsolescence, markdowns or stock-outs, which are passed on among the organisations in the supply chain.

Chaos

The complexity forces of a supply chain can drive 'chaos effects' in supply chains. These chaos effects result from over-reactions, unnecessary interventions, second-guessing, mistrust, distorted information throughout a supply chain or simply from a lack of supply chain understanding amongst its organisations. The well-known bullwhip effect, which describes increasing fluctuations of order patterns from downstream to upstream supply chains, is an example of such chaos (Lee et al., 1997).

Inertia

Finally, the supply chain is exposed to inertia risks, i.e. a general lack of responsiveness to changing environmental conditions and market signals. Especially in global supply chains flexibility is often sacrificed for cost reduction. Consequences can be the inability to react to competitor moves, shifting customer demand or to any other unpredicted event arising from environmental or organisational risk sources.

Network-related risk sources form an integrated part of the network design and structure and can either absorb or amplify the impact of events arising from environmental or organisational risk sources. Similarly, as the construction of a building is decisive in terms of the disruptive impact of an earthquake, the network structure of a supply chain influences the supply chain effect of events arising for example from environmental risk sources.

In the literature as well as among our interviewees, it has been emphasised that implementing a supply chain-wide risk assessment is a complex and difficult task. Gilbert and Gips (2000) stress that while it may be feasible to assess risks at a supplier's supplier, it gets less practical

and more expensive to analyse the exposure of a supplier of a supplier's supplier. Knowing where to stop may be difficult. Still, it is known that risk perception shapes the decision makers' risk behaviour (Sitkin and Weingart, 1995) and blank spots on the map of potential risk sources increase the supply chain's vulnerability. Similarly, there was a consensus in the interviews that network-related risks are an important and so far neglected source of risk. Especially in the light of the increasing complexity of today's supply networks, interviewees felt that the visibility and control appears to be thinning beyond the next tier of related organisations. Network-related risk sources, however, cannot be dealt with through 'tried and trusted' risk assessment tools. Instead, identifying network-risks requires a thorough understanding of the supply network's structure, flows, operational dynamics and complexities. Traditional tools like supply chain mapping or critical path analysis (e.g. Scott and Westbrook, 1991) have to be developed further in order to become effective tools supporting the network risk assessment. It appeared that most of the companies tended to define and manage their supply chains by product or channel type, reflecting a view of supply chains being a series of vertically integrated linear processes that converge or diverge at a single given point. This view overlooks much of the complexity of the network and horizontal interactions between the product-focused supply chains.

To summarise, the findings from the literature review as well as our interviews indicate two issues to be addressed by future research: first, understanding risk assessment along the chain and developing more practicable approaches to guide the process and second, investigating risk implications of different network structures and developing effective tools for identifying network-related risks.

(2) Defining the Supply Chain Risk Concept and Adverse Risk Consequences

Adverse risk consequences can become manifest in any outcome measure and the literature provides extensive lists, ranging from financial consequences through reputation damage to health and safety concerns (e.g. Goldberg et al., 1999; Harland and Brenchley, 2001). The consequences focused in a specific supply chain context form the managers' supply chain 'risk concept'. Our findings from exploratory discussions provide tentative evidence that systematic differences in the risk concepts could be dependent on the specific supply chain and/or industry context (see also Pablo, 1999). In addition, the prominent risk concept of managers appears to impact on the approach they apply to manage risks. The outcome variables focused on ranged from commercial (eg. risks associated with stockouts or high levels of inventory) to risk to life and/or political ramifications.

At one end of the spectrum were acutely commercially focused fast moving consumer goods companies, particularly those selling through conventional retail channels. For these organisations, the need to be price competitive makes operational efficiency a constant pressure. These organisations were continually seeking to lower inventories as a means to become more responsive and demand-driven, but the competitive and commercial risk consequences like lost sales due to non-availability were serious concerns. Interestingly, the managers of consumer good companies also appeared to be relatively insensitive to incidents with very low probabilities but potentially catastrophic outcome. In their supply chain risk management approach, they seem to concentrate on "atomistic" risk sources (Svensson,

2000), ie disruptions caused by the direct supplier and/or customer (e.g. a direct supplier going bankrupt) with minor or moderate consequences. Some of these organisations were even reluctant to use the term risk when referring to their situation. Closer to the other end of the spectrum of potential risk concepts were the supplier of critical health products and an aerospace company. Quality was a critical concern for both. The attitude of the latter towards supply chain risk management was deeply rooted in its engineering heritage and the philosophy of Total Quality Management, together with a vivid awareness of the worse case consequences of failure. This overriding awareness is also reflected in the responsibility for risk management, which formally lies with the company board, although in practice the scope of risk management tends to be narrow and to be confined to a compliance with the minimum statutory requirements. Supply chain wide risk management on the other hand is not yet recognised as a key element in business continuity planning.

These findings from the field research bear some correspondance with a classification of risk types proposed by Norrman and Lindroth (2002). They suggest a distinction be made between operational accidents, operational catastrophes and strategic uncertainties, based on probability and severity of the risk consequences. Moreover, looking at the literature we find that the approaches put forward for risk management can also be categorised along those focused risk consequences. On the one hand, a number of contributions can be traced which look primarily at operational accidents, which – if not planned for – can turn into operational catastrophes. The main emphasis within this body of literature is on risk assessment, business continuity planning and crises management (e.g. Ericson, 2001; Hellweg, 2002; Hoffman, 1998; Zsidisin et. al., 2000). On the other hand, an emerging stream of works looks at the

strategic uncertainties such as e.g. future investments into relationship specific resources (e.g. Das and Teng, 1998; Smith and Zsidisin, 2002), the risk implications of new supply network configurations (e.g. Hall, 1999) or supply chain capacity investments (e.g. Norrman and Lindroth, 2002). Here, a main managerial implication appears to be the reduction of uncertainty associated with these strategic decisions, rather than minimising its detrimental impact through e.g. continuity planning.

In summary, our findings provide tentative evidence that the risk concept of organisations impacts on the 'scope' of supply chain risk management and the approach practitioners apply to manage risks. A research opportunity from this finding is to investigate risk management in different supply chains and/or industries and apply a contingency perspective. From a contingency perspective, research attention lies on exploring which risk concept is relevant in particular industries to particular supply chains (Baird and Thomas, 1990). Instead of trying to assume a kind of average overall picture, the view of supply chain and industry-specific risk concepts appears to be more promising in aiding managers to assess and manage risks in their supply chains.

(3) Identifying the Risk Drivers of the Supply Chain Strategy

Whilst risk has always been present in the process of reconciling supply with demand, there are a number of factors that have emerged in the last decade or so which might be considered to have increased the level of risk. These include: (1) a focus on efficiency rather than

effectiveness; (2) the globalisation of supply chains; (3) focussed factories and centralised distribution; (4) the trend to outsourcing and (5) the reduction of the supplier base. All these risk drivers are changes to the structure of modern supply chains and impact directly on network-related risk sources. Through the trends of globalisation and outsourcing, the complexity of supply chain structures increases. Rather than a neat sequence of value-adding stages, dynamic network shapes become the reality (Braithwaite and Hall, 1999). The supply network structure describes lateral and horizontal inter-linkages, reverse loops or two-way exchanges encompassing the upstream and downstream activities within and among the supply chain organisations (Lamming et al., 2000). A supply network brings with it risks from all related network sources, namely uncertainties due to lack of ownership, chaos and inertia (Christopher and Lee, 2001). Some of the other risk drivers like e.g. the reduction of the supplier base and the trend towards efficiency rather than effectiveness lead to more integrated supply chains. This too, increases the likelihood of disruptions caused by suboptimal interaction between the supply chain organisations primarily through lack of ownership in highly integrated supply chain processes.

Most of the supply chain managers taking part in the research were aware of the risk drivers embedded in their supply chain strategies. Many of the supply chain disruptions reported, were clearly caused by these drivers or at least exacerbated by them. Examples include the detrimental effects of a fire in a centralised warehouse, the bankruptcy of the sole supplier of a key component or a critical system failure, which was compounded by the company's prior move into a 3rd party environment. Still, whilst the drivers are recognised as competitive pressures with risk implications, it appears that the implications are often sorted out on an ad

hoc basis as organisations 'go along'. What seems to be missing is a more proactive approach where risk implications are anticipated at an earlier stage. This is amplified by often split responsibilities for supply chain and risk management. In one organisation, we interviewed jointly the supply chain manager and the risk manager. It was striking how for the first half of the interview the supply chain manager elaborated on the company's achievements in restructuring the supply chain over the last years to make it more effective. He concluded by stating that it might now be time to scrutinise the robustness of the optimised supply network. From there on, the risk manager took over and explained about the 'near misses' and risk exposures of the company. At the end of the interview, both confirmed how mutually beneficial the discussion had been and how vital a closer cooperation between supply chain and risk management was. Similarly, in another company, the risk manager responsible for auditing the supply chain partners' risk exposure and preparedness, criticised his lack of influence over strategic purchasing decisions.

To summarise, furthering our understanding on the role of risk in supply chain strategy development and implementation processes is an important research issue. Strategic choices and design decisions may build specific vulnerabilities into a supply chain. Thus, processes and tools need to be developed helping managers to anticipate and track not only the benefits but also the attendant risks for their supply chains.

(4) Mitigating Risks for the Supply Chain

From a single organisation view, Miller (1992) distinguishes five generic strategies companies undertake in order to mitigate risk, four of which can be adapted to supply chain contexts: (1) avoidance, (2) control, (3) cooperation and (4) flexibility. The following table summarises examples of these mitigating strategies applied among our organisations interviewed:

Table 2: Risk mitigating strategies in supply chains

Avoidance	<ul style="list-style-type: none"> • Dropping specific products/geographical markets/supplier and/or customer organisations
Control	<ul style="list-style-type: none"> • Vertical integration • Increased stockpiling and the use of buffer inventory • Maintaining excess capacity in productions, storage, handling and/or transport • Imposing contractual obligations on suppliers
Cooperation	<ul style="list-style-type: none"> • Joint efforts to improve supply chain visibility and understanding • Joint efforts to share risk-related information • Joint efforts to prepare supply chain continuity plans
Flexibility	<ul style="list-style-type: none"> • Postponement • Multiple sourcing • Localised sourcing

Avoidance

Avoidance occurs when risks associated with operating in a given product market or geographical area are considered to be unacceptable (Miller, 1992, p. 322). From a supply chain perspective, avoidance can be related to products/geographical markets and/or supplier and customer organisations. A company could drop specific products, suppliers or geographical markets if supply is seen to be unreliable.

Control

Companies may seek to control contingencies from the various risk sources, rather than passively treat uncertainties as constraints within which they must operate (Miller, 1992, p.

323). Not surprisingly, control strategies were most widespread amongst the organisations interviewed. Examples in supply chains include vertical integration, increased stockpiling and the use of buffer inventory or maintaining excess capacity in production, storage, handling and/or transport or finally, imposing contractual requirements on suppliers.

Cooperation

Compared with control initiatives, cooperative responses involve joint agreements, rather than unilateral control, as a means of achieving uncertainty reduction (Miller, 1992, p. 323). From a supply chain perspective, the focus is on joint agreements among organisations in the supply chain to improve supply chain visibility and understanding, to share information on exposures to specific risk sources and finally, to prepare joint business continuity plans. Whereas cooperative risk mitigation strategies were applied by many of the organisations interviewed, it is mainly restricted to initiatives with key suppliers.

Flexibility

Unlike the strategic moves of control, which attempt to increase the predictability of contingencies from the various risk sources, flexibility increases responsiveness while leaving the predictability of factors unchanged (Miller, 1992, p. 324). One supply chain example is postponement, where companies delay the decision to make, configure, label or ship a product to a particular destination. Postponement reduces their dependence on forecasts and increases the ability to respond to variability or even disruptions in demand. A second supply chain example is multiple sourcing, which one manager classified as the traditional form of

managing risk through spreading risk. Finally, a third supply chain example is localised sourcing with its short lead-times and potential for quick responses.

Our literature review and fieldwork findings suggest that risk mitigating strategies in supply chains have to be investigated in conjunction with the risk drivers. Together, they build on several supply chain trade-off decisions summarised by Sheffi (2002) (1) Repeatability versus unpredictability, ie trading the benefits of repeatable processes against the cost of a lack of flexibility; (2) the lowest bidder versus the known supplier; (3) centralisation versus dispersion decisions in production and distribution; (4) collaboration versus secrecy, ie while sharing more information on e.g. the results of risk audits would better place organisations to manage supply chain risks, it could also deter potential customers or weaken the bargaining position; (5) redundancy versus efficiency, ie managing the conflict between excess capacity in a supply chain and the efficiency-focused lean paradigm aiming at the elimination or reduction of waste. A final, maybe paramount supply chain trade-off decision is between 'managing risk and delivering value'. This is the trade-off between the extra costs related to most of the mitigating strategies and the total costs of supply as a main principle of contemporary supply chain management.

Handling trade-off decisions was a highly relevant issue for the managers interviewed. In the literature, some authors are suggesting strategies that are designed specifically to balance some of the trade-off decisions. For example, Sheffi (2002) suggests holding strategic emergency stocks to be used only in the case of extreme disruptions. In addition, he suggests dual sourcing as a strategy where offshore suppliers are used for the bulk of the procurement

volume and local suppliers in the case of disruptions. Whereas both strategies are very plausible, our interviews have pointed at some difficulties in implementing them. For strategic emergency stocks, deciding whether or not components or products are critical is often easier said than done. Many organisations seem to use a value-added calculation as the basic criteria. Yet a brewery was hit in the fuel crisis because it ran out of cheap but bulky packaging cardboard trays, where maintaining more than 24 hours emergency stock was deemed unnecessary. Similarly, implementing a dual sourcing strategy, where typically local suppliers are given only a fraction of the business, can be difficult. One company reported an incident where their local supplier, who only accounted for 5% of the organisation's business, ceased to supply when he was swamped with orders from its main, prioritised customer.

To summarise, we suggest that further research should investigate these trade-offs and develop tools supporting managers in their supply chain and situation-specific decision-making processes.

CONCLUSION AND IMPLICATIONS FOR FUTURE RESEARCH

Based upon a synthesis between our conceptualisation of supply chain risk management and the views of practitioners, four critical aspects of the management concept were identified: (1) Assessing the risks sources for the supply chain; (2) defining the supply chain risk concept and adverse consequences; (3) identifying the risk drivers in the supply chain strategy and (4) mitigating risks for the supply chain. There now follows a summary of our findings on each of

these aspects by distinguishing between positive as well as normative future research issues.

The following table summarises the future research issues under each of the critical aspects.

Table 3: An agenda for future research in supply chain risk management

<i>Positive Research Issues</i>	<i>Normative Research Issues</i>
<i>(1) Assessing the risks sources for the supply chain</i>	
Understanding risk assessment processes within supply networks and the risk implications of different network structures.	Developing more practical approaches to guide the risk assessment process in supply networks.
<i>(2) Defining the risk concept and adverse consequences</i>	
Investigating risk concepts in different supply chains and/or industries from a contingency perspective.	Developing risk management approaches for specific supply chains and/or industries.
<i>(3) Identifying the risk drivers of the supply chain strategy</i>	
Furthering our understanding on the role of risk in supply chain strategy development and implementation processes.	Developing approaches helping managers to track the vulnerabilities of their supply chain strategies.
<i>(4) Mitigating risks for the supply chain</i>	
Investigating how risk performance trade-offs are managed in the supply chain.	Developing processes guiding supply chain trade-off decision making.

Positive research adopts the perspective of attempting to describe, explain, predict and understand the supply chain risk management activities that are currently practiced and hence,

actually exist. Suitable methodologies comprise qualitative methods like in-depth interviews and case studies, but also quantitative surveys. In contrast, normative research attempts to prescribe what organisations and individuals ought to do with regard to supply chain risk management (Hunt, 1991). Our analysis showed that more positive research is needed in order to fully understand the complexity of supply chain risk management before practicable managerial guidelines and frameworks can be developed. Hence, what is needed is more empirically grounded research on supply chain risk management.

Current awareness of supply chain risk management has been raised over recent years by a succession of disruptive events affecting the international and UK business environment. Whereas these incidents have highlighted the importance of robust supply networks for individual organisations and whole industry sectors, they prompt us to suggest 'quick fix' solutions in a firefighting mode. Individuals and organisations might have a strong temptation to return to normality after major crises, but we believe that it is an academic responsibility to establish supply chain risk management as an important, if so far neglected, area of applied research.

References

- BETTIS, T. & THOMAS, H. (Ed.) (1990) *Risk, strategy and management* (Greenwich Connecticut, JAI Press Inc.).
- BAIRD, I. & THOMAS, H. (1990) What is risk anyway?, in: BETTIS, T. & THOMAS, H. (Eds) *Risk, strategy and management*, (Greenwich Connecticut, JAI Press Inc.).

- BRAITHWAITE, A. & HALL, D. (1999) Risky business? Critical decisions in supply chain management (Parts 1 & 2), *Supply Chain Practice* (1), Part 1: (2), pp. 40-57; Part 2: (3), pp. 44-58.
- CHRISTOPHER, M. & LEE, H. (2001) Supply chain confidence, Working Paper, Cranfield School of Management, England.
- DAS, T.K. & TENG, B. (1998) Resource and risk management in the strategic alliance-making process, *Journal of Management*, 24, (1), pp. 21-42.
- ENGARDIO, P. (2001) Why the supply chain broke down, *Business Week*, March 19, 2001. Issue: 3724, p. 41.
- ERICSON, J. (2001) Addressing supply chain disruptions, *Line5 – The E-Business Executive Daily*, October 4, www.line56.com.
- GILBERT, G. & GIPS M. (2000) Supply-side contingency planning, *Security Management*, 44, (3), pp. 70-74.
- GLASER, B. & STRAUSS, A. (1967) *The discovery of grounded theory: Strategies for qualitative research* (London, Wiedenfeld and Nicholson).
- GOLDBERG, S., DAVIS, S. & PEGALIS, A. (1999) *Y2K risk management* (New York, Wiley).
- HALL, R. (1999) Rearranging risks and rewards in a supply chain, *Journal of General Management*, 24(3), pp. 22-32.
- HARLAND, C. & BRANCHLEY, R. (2001) Risk in supply networks, *Proceedings of the European Operations Management Association 8th Annual Conference*, Bath, UK, June 3-5, pp. 306-318.
- HELLWEB, E. (2002) Supply chain hero, www.business2.com, January.

- HOFFMAN, K. (1998) Helping the supply chain cope with the whims of nature, the will of man, www.supplychainbrain.com, February.
- HUNT, S. (1991) *Modern marketing theory*, (Cincinnati Ohio, South-West Publishing Co.).
- JOHNSON, E. (2001) Learning from toys: lessons in managing supply chain risk from the toy industry, *California Management Review*, 43, (3), pp. 106-124.
- KAHNMANN, D. & TVERSKY, A. (1979) Prospect theory: An analysis of decision under risk, *Econometrica*, 47, pp. 263-291.
- LAMMING, R., JOHNSEN, T., ZHENG, J. & HARLAND, C. (2000) An initial classification of supply networks, *International Journal of Operations and Production Management*, 20, (6), pp. 675 – 691.
- LA LONDE, B. (1997) Supply chain management: myth or reality? *Supply Chain Management Review*, 1, (Spring), pp. 6-7.
- LEE, H., PADMANABHAN, P. & WHANG, S. (1997) The paralyzing curse of the bullwhip effect in a supply chain, *Sloan Management Review*, Spring, pp. 93-102.
- MARCH, J. & SHAPIRA, Z. (1987) Managerial perspectives on risk and risk taking, *Management Science*, 33, (11), pp. 1404-1418.
- McGILLIVRAY, G. (2000) Commercial risk under JIT, *Canadian Underwriter*, 67, (1), pp. 26-30.
- MILES, M. & HUBERMAN, A. (1994) *Qualitative data analysis: an expanded sourcebook* (London, Sage).
- MILLER, K. (1992) A framework for integrated risk management in international business, *Journal of International Business Studies*, Second Quarter, pp. 311-331.

- NELSON, D., MAYO, R. & MOODY, P. (1998) *Powered by Honda: developing excellence in the global enterprise* (New York, Wiley).
- NORRMAN, A. & LINDROTH, R. (2002) Supply chain risk management: purchasers' vs. planners view on sharing capacity investment risks in the telecom industry, *Proceedings of the IPSERA 11th International Conference*, Enschede Holland March, 25-27, pp. 577-595.
- PABLO, A. (1999) Managerial risk interpretations: does industry make a difference? *Journal of Managerial Psychology*, 14, (2), pp. 92-107.
- SCOTT, C. & WESTBROOK, R. (1991) New strategic tools for supply chain management, *International Journal of Physical Distribution & Logistics Management*, 21, (1), pp. 23-33.
- SHEFFI, Y. (2002) Supply chain management under the threat of international terrorism, *International Journal of Logistics Management*, 12, (2), pp.1-12.
- SIMONS, R. (1999) How risky is your company? *Harvard Business Review*, 77, (3), pp. 85-94.
- SMITH, C., SMITHSON, C. & WILFORD, S. (1990) *Managing financial risk* (New York, Harper & Row).
- SMITH, M. & ZSIDISIN, G. (2002) Early Supplier Involvement at MRD, *Practix, Best Practices in Purchasing & Supply Chain Management*, June, Issue four, pp. 9-12.
- SOUTER, G. (2000) Risks from supply chain also demand attention, *Business Insurance*, 34, (20), pp. 26-28.

- SVENSSON, G., (2000) A conceptual framework for the analysis of vulnerability in supply chains, *International Journal of Physical Distribution & Logistics Management*, 30, (9-10), starting page 731.
- SVENSSON, G., (2002) A conceptual framework of vulnerability in firms' inbound and outbound logistics flows, *International Journal of Physical Distribution & Logistics Management*, 32(2), pp. 110-134.
- TING, W. (1988) *Multinational risk assessment and management* (Westport Connecticut, Greenwood Press).
- TVERSKY, A. & KAHNEMANN, D. (1992) Advances in prospect theory: Cumulative representation of uncertainty, *Journal of Risk and Uncertainty*, 5, pp. 297-323.
- YIN, R. (1994) *Case study research: design and methods* (Thousand Oaks, CA, Sage).
- ZALTMAN, G., LEMASTERS, K. & HEFFRING, K. (1982) *Theory construction in marketing: some thoughts on thinking* (New York, Wiley).
- ZSIDISIN, G., PANELLI, A., & UPTON, R. (2000) Purchasing organization involvement in risk assessments, contingency plans, and risk management: an exploratory study, *Supply Chain Management*, 5, (4), starting page 171.
- ZSIDISIN, G. (forthcoming) A grounded definition of supply risk, under review at *European Journal of Purchasing & Supply Management*.