Chapter 1
Supply Chain Risk Management

Abstract Recognizing various natural and man-made disasters have caused major supply chain disruptions over the last two decades, this chapter illustrates the vulnerability of many global supply chains and provides justifications for companies to develop a systemic approach to managing supply chain risks. Viewing supply chain risk management as comprising four steps—identifying risks, accessing risks, mitigating risks, and responding to risks—this chapter highlights the overall structure and key objectives of the book.

1.1 Introduction

The two decades straddling the turn of the millennium, 1990-2000 and 2000-2010, have witnessed many varied natural and man-made disasters causing havoc with the supply chains of many global companies. Likewise, the supply chains of companies have wrought disasters on society and the ecosystem. And, more often, problems in one link of the supply chain have caused unmitigated disaster to another link, resulting in large financial and non-financial damage. Indeed, as supply chains have grown globally with companies from the west as well as those from emerging economies seeking new markets and low-cost sources worldwide, natural, man-made or even self-inflicted disasters disrupt these far-flung supply chains of today much more so than they did in the distant past.

Natural and man-made disasters have disrupted supply chains of many companies. Such disasters include terrorist attacks, wars, earthquakes, economic crises in North America, Australia and Europe (2007–08), devaluation of currencies in Indonesia, South Korea, Thailand and other Asian countries (1997–98), SARS virus outbreak starting in China (November 2002 to mid-2004), the Indian Ocean tsunami affecting Indonesia but also India, Sri Lanka, and Thailand (2004), strikes in France by public sector workers and others against the proposed increase of retirement age (October 2010), and computer virus attacks like the Stuxnet attack on an Iranian nuclear plant by a foreign government (September 2010). Then there was the...
petroleum leak off the coast of Louisiana from a deep-sea drilling platform (summer of 2010) and the leakage of toxic waste in Hungary (October 2010).

Disruptions can come from within the supply chain itself. Supply problems caused the delay of the Sony PlayStation 3 (2006) resulting in Sony not only losing revenues but also long-term market share. Dell had to recall 4 million laptop computer batteries made by Sony owing to some problems with the batteries. In 2001, mobile-phone manufacturer Ericsson lost 400 million Euros after their supplier’s semiconductor plant caught on fire upon being hit by lightning; eventually, Ericsson ceded the mobile-phone business to a new entity, Sony Ericsson. A supplier’s insolvency resulted in UK auto-maker Land Rover having to lay off 1400 workers. The impact of major disruptions need not be financial alone: in 2007, over 100 brands of tainted pet food contaminated with the toxic chemical melamine killed thousands of dogs and cats in the United States.

Besides such newsworthy disruptions, there are many mostly small, but sometimes large, hiccups and bumps in the day-to-day challenge of matching supply and demand, although this challenge could persist for the long-term. There may be delayed supplier deliveries or delayed product launches. Losses could result from customer dissatisfaction caused by late delivery or otherwise less-than-perfect order fulfilment in an environment increasing supplier lead times. There could be quality problems, whether or not serious enough to require recalls, in the face of shortening product lifecycles and increasing customization. Thus, the supply chain’s ability to match supply to demand comes under threat with possibly disastrous consequences for the company as small losses accumulate over time despite the absence of any highly visible disaster.

How should companies make sense of these different kinds of risks stemming from different sources? While such risk incidents generally get categorized under the rather big umbrella of supply chain risk, neither the term nor its related terminology is well defined or scoped. Nor is there any consistent approach to managing these or indeed who should manage these risks: should it be the supply chain management people or should it be the enterprise risk management personnel or indeed cross-company with teams of people from the company and from its business partners? And where do we begin dealing with the kinds of risks above?

1.2 This Book

This book seeks to provide a starting point for companies seeking to develop an approach to managing supply chain risk and for young researchers wishing to start out in this field. There is already a body of literature building up. On one hand are the edited books targeting researchers with compilations of diverse views of different researchers: Brindley (2004); Kersten and Blecker (2006); Handfield and McCormack (2008); Zsidisin and Ritchie (2008); Wu and Blackhurst (2009); and Khan and Zsidisin (2010) along with special issues of operations management jour-
nals (cf. Seshadri and Subrahmanyam, 2005). On the other hand are books targeting practitioners: Sheffi (2005 a and b); Waters (2007); Kaye (2008) and Lynch (2009).

In contrast, we seek to bridge practice and research by providing a strong and common foundation for both by providing frameworks for supply chain risk management and research. This foundation is layered, each successive part of the book building upon the previous: we introduce the basics of the process of managing supply chain risk in Part I and develop and illustrate broad approaches to mitigating supply chain risk in Part II. The chapters in these two parts provide a common starting point for practitioners as well as for researchers. Next, we lay the foundations of mathematical modelling through broad reviews of the research literature in Part III and, finally, we provide researchers’ perspectives and topics for future research in Part IV. While the chapters in the third part are primarily for researchers and technically trained practitioners, those in the fourth part can benefit both practitioners and researchers in helping them understand the challenges and opportunities that lie ahead for supply chain risk management.

A more detailed view of the book is as follows: In Part I, successive chapters (Chapters 2–5) deal with different aspects of the process of risk management: identifying risks, assessing risks, mitigating risks, and responding to risk incidents. In addition, Chapter 6 discusses how global companies manage supply chain risk with an emphasis on the supply chain’s “connectedness” using the example of Samsung Electronics.

In Part II, the first two chapters (Chapters 7 and 8) deal with strategic and tactical approaches for mitigating supply chain risks. The remaining chapters in this part, Chapters 9–12, are applications of these broad strategic/tactical areas to specific domains: long-term demand uncertainty and consequent risk entailed in capacity decisions (Chapter 9), outsourcing (Chapter 10), supply management for new product development (Chapter 11) and product recall (Chapter 12).

Part III provides three detailed reviews of the research literature to get the researcher (or practitioner) started: Chapter 13 introduces risk models for supply chain Management, Chapter 14 provides different models to value flexibility in making the supply chain more robust, and finally Chapter 15 explores the application of stochastic programming for planning under demand uncertainty.

Finally, Part IV provides researchers’ perspectives on supply chain risk management and where the existing research literature is compared against the perceived need for research in Chapter 16. Practitioners will also find this chapter useful to understand how the researchers view supply chain risk management as a basis for engaging with them. The final Chapter 17 outlines topics for further research for researchers; practitioners can also see areas where they can cooperate with researchers to create a better understanding of supply chain risk management.
1.3 The Supply Chain Management Context

To discuss supply chain risk management, we should start with supply chain management and state the basics. A supply chain is a network of organizations possibly including suppliers, manufacturers, logistics providers, wholesalers/distributors, and retailers that aims to produce and deliver products or services for the end customer. Supply chain management is the management of material, information and financial flows through the supply chain. It includes the coordination and collaboration of processes and activities across different functions such as marketing, sales, production, product design, procurement, logistics, finance, and information technology within the supply chain.

Supply chain management includes tracking and seeking to improve operational performance metrics including:

- Time-related measures such as product development cycle time, time to market, production lead time, replenishment/delivery lead time, cash-to-cash cycle;
- Cost-related measures such as product development cost, material cost, production cost, labor cost, inventory cost, shipping and handling cost, sales and marketing cost, fixed and overhead cost; and
- Customer-satisfaction-related measures such as product availability, product and service quality, reliability, after sales support, and total cost of ownership.

In addition, there are strategic performance metrics such as profits, market share, revenue growth, return on assets (ROA), and share-price performance.

Throughout the 1990s and 2000s, many firms strived to improve their strategic performance measures by implementing various supply chain initiatives that led to supply chains becoming more global, and thus not only longer but also more complex. These initiatives were intended:

- To increase revenue (e.g., more product variety, more-frequent new product introductions, more sales channels/markets),
- To reduce cost (e.g., supply base reduction, online sourcing including e-markets and online auctions, offshore manufacturing, Just-in-Time inventory systems, vendor managed inventory), and
- To reduce assets (e.g., outsourced manufacturing, information technology and logistics).

These initiatives have led to complex supply chains. According to an industry study conducted by AMR Research in 2006, over 42% of the companies manage more than five different supply chains because of the need to produce multiple products for multiple markets.
1.4 The Need for Supply Chain Risk Management

Supply chains today are vulnerable to disruptions with large unanticipated consequences of seemingly contained events (c.f., Craighead et al., 2007). Three underlying reasons are: (1) these supply chains have more points of possible disruption than they did in the past; (2) being longer, these supply chains have less visibility, which causes slow decision-making and response in case of a disruption; and (3) local “fixes” create problems in other parts of the supply chain. In a 2004 study, Computer Sciences Corporation found 60% of the firms in their sample reporting that their supply chains are vulnerable to disruptions. At the same time, according to two independent studies, one by the Center for Research on the Epidemiology of Disasters (www.cred.be) and the other by the world’s largest re-insurer Munich Re (www.munichre.com), historical data indicates that the total number of natural and man-made disasters has risen dramatically in the new millennium. Moreover, Munich Re has reported that the average cost of disasters has increased by a factor of 10 since the 1960s.

Based on anecdotal observations, disruptions can also leave supply chains damaged for a long time. For example, out of the 350 businesses operating in the World Trade Center before the 1993 bombing of the World Trade Center, 150 were out of business a year later (Eskew, 2004). Indeed, these disruptions can have a negative impact in the long-term on a firm’s market value and strategic performance measures. Hendricks and Singhal (2005a) found that companies suffering from supply chain disruptions experienced 33-40% lower stock returns relative to their industry benchmarks over a 3-year time period that starts one year before and ends 2 years after the disruption announcement date, based on a sample of 827 disruption announcements made over a 10-year period.

1.5 Apprehension without Action

Despite the headline news of disasters and their known detrimental effects, most firms find it difficult to justify investment for mitigating supply chain disruptions that occur rarely or that have never occurred in the past. Indeed, Rice and Caniato (2003) and Zsidisin et al. (2000; 2004) comment that most companies invest little time or resources in managing supply chain risks even though they carry out supply chain risk assessments.

Two surveys capture this perplexing dichotomy. According to a study conducted by Computer Sciences Corporation in 2003, 43% of 142 companies, ranging from consumer goods to healthcare, reported that their supply chains are vulnerable to disruptions, but 55% of the companies had no documented contingency plans (c.f., Poirier and Quinn, 2003). According to another survey conducted by CFO Research Services, 38% of 247 companies acknowledged that they had too much unmanaged supply chain risk (c.f., Eskew, 2004).
To our knowledge, there is no specific study that examines the paradox of why firms perceive serious supply chain risk and yet do not take commensurable actions. Possible reasons could be:

- Firms underestimate the risk in the absence of accurate supply chain risk assessment;
- Firms are not familiar with ways to manage supply chain risks (Closs and McGarrell, 2004); and
- With inaccurate estimates of the likelihood of the occurrence of a major disruption, many firms find it difficult to perform cost/benefit or return-on-investment analysis to justify certain risk reduction programs or contingency plans (Rice and Caniato, 2003; Zsidisin et al., 2000)

The last reason appears the most compelling when we consider Total Quality Management (TQM) as an analogy. Anecdotal and empirical evidence confirmed that TQM can provide significant value to the firms and their customers (c.f., Hendricks and Singhal, 1996). However, fewer than 10% of the Fortune 1000 have well-developed TQM programs, according to a survey study conducted by Rigby (2001). This motivated Repenning and Sterman (2001) to conduct over a dozen in-depth case studies in industries including automobiles, chemicals, oil, and semiconductors. Their analysis suggested that most firms do not invest in improvement programs like TQM because “nobody gets credit for fixing problems that never happened.” We propose that the reason why so many firms do not invest in programs to reduce supply chain risk is the same as it was with TQM.

### 1.6 Robust Strategies for Supply Chain Management

Disasters and other dramatic incidents can take away the focus from the supply chain aspect of supply chain risk. Many executives and researchers started paying more attention to responding to severe disruptions after the September 11, 2001 attacks (c.f., Sheffi 2005 a and b, and Zsidisin and Ritchie 2008). However, it is important to manage risks in the larger context of coordinating supply and demand, the eventual goal of supply chain management.

As such, companies need to devise “robust” supply chain strategies that possess the following properties: On one hand, under normal circumstances such a strategy would enable the company to manage the supply and demand fluctuations efficiently in the typical supply chain management context (see section below). On the other hand, such a strategy would help the company sustain operations at some basic level during a disruption and restore operations soon after.

To help develop robust strategies, Lee (2004) proposed “Triple-A” principles: Alignment, Adaptability, and Agility referring to long-, medium-, and short-term perspectives, respectively. Let us discuss each of these three principles in turn.

1. **Aligning** interests among supply chain partners can reduce supply chain risks. For example, to mitigate its supply cost risk, Intercon Japan first developed a
second supplier Nagoya Steel in addition to Asahi Metal. Then Intercon Japan developed incentives and penalties for these two suppliers: a supplier would get a higher share of the business for offering a lower supply cost (Mishina and Flaherty, 1988). To align interests among multiple parties, trust and a long-term perspective are necessary. Lee (2004) provides other examples about how the Alignment principle can be used to reduce supply chain risk.

2. **Adaptiveness** means being able to respond to the changing demand and supply. Li & Fung (www.lifung.com), the largest trading company in Hong Kong for durable goods such as textiles and toys, has established a supply network of over 15,000 suppliers around the globe. This supply network enables Li & Fung to adapt to market conditions quickly. Consider the case when Indonesia Rupiah devalued by more than 50% in 1997. Many Indonesian suppliers were unable to deliver their orders to their U.S. customers because they were unable to pay for imported materials; however, Li & Fung adapted to the situation quickly by shifting some production to other suppliers in Asia and by providing financial assistance to those affected Indonesian suppliers to ensure business continuity. With an adaptive supply network, Li & Fung was able to serve their customers in a cost-effective and time-efficient manner. The reader is referred to St. George (1998) for details. According to Lee (2004), adaptability can be achieved by using intermediaries such as Li & Fung, by creating flexible product designs such as Xilinx’s programmable integrated circuits, or by monitoring new markets.

3. **Agility** enables a firm to reduce the impact of short-term changes in demand or supply. For example, to reduce the overstock and under-stock costs of different versions of DeskJet printers, HP redesigned its DeskJet printers by delaying the point of product differentiation. Specifically, HP first manufactures and ships generic printers to the distribution centers in different regions. These generic printers are then customized for different country-specific markets at each distribution center. The generic printers are produced according to a make-to-stock system, while the country-specific printers are customized in a make-to-order manner. This “postponement” strategy has enabled HP to respond to the demand changes quickly and effectively. The reader is referred to Lee and Tang (1997) for a detailed description of various mechanisms for delayed product differentiation such as modular design, standardization, commonality, etc., and to Feitzinger and Lee (1997) for a detailed description of successful implementations of various postponement strategies at HP.

Besides these three principles, firms can also build-in redundancies throughout the supply chain to reduce the impact of undesirable risk events associated with risks related to supply, process, and demand. For example, extra inventory, extra back-up production capacity, extra back-up suppliers, etc. are potential redundancies that would enable firms to make supply meet demand. However, redundancies are usually expensive because they are put to use only when certain unanticipated events occur (Sheffi, 2005 a and b). Also, redundancies disguise inefficiencies in the supply chain, which could inhibit the achievement of a lean supply chain.
1.7 Disciplinary Roots of Supply Chain Risk Management

While it is tempting to think of supply chain risk management as simply extending supply chain management to include risk, it is really a multi-disciplinary area with research and practice that draws on at least three fields: supply chain management, enterprise risk management, and crisis management. These domains in turn draw on a broad range of the academic literature in areas such as organizational behaviour, psychology, decision analysis, empirical analysis, stochastic modeling and mathematical programming.

Based on our analysis of the surveys of researchers presented in Part IV (Chapter 16), there is a general view that supply-chain risk management overlaps with both supply chain management and enterprise risk management. There are other viewpoints too, of course, for instance, that of supply-chain risk management as a subset of crisis management and business continuity. It may well be that identifying problems lies in enterprise risk management but solution approaches and their deployment lie in supply chain management and business continuity.

Each of these related areas has its own primary purpose that is different from that of supply-chain risk management. Enterprise risk management tends to focus on risk disclosure in financial reporting of a company so as to comply with such regulations as the Sarbanes-Oxley Act in the US or the KonTraG requirements in Germany. Likewise, supply chain management is primarily concerned with ways to improve the operational performance of a supply chain under “normal” circumstances. Crisis management focuses on the survival of the organization or even that of society and may seem distant from worries stemming from a delayed delivery of parts at a plant. Still, we need to draw on these related domains to structure supply-chain risk management research and practice as this book attempts to do.

While rooted in these disciplines, supply-chain risk management is not fully a part of any of these. It is not merely a part of supply chain management although good supply chain management needs to include principles of risk management. Likewise, it is not part of enterprise risk management, although to do effective enterprise risk management, a company needs to excel in supply-chain risk management. Finally, supply-chain risk management is not part of crisis management and business continuity, although if the supply chain experiences a crisis, then any solution to crisis management has to incorporate supply-chain risk management. Thus, supply-chain risk management is important not just to supply chain professionals, and given its growing importance to companies, it is beginning to be recognized as a discipline in its own right.

Next, we view supply-chain risk management as comprising the four steps in enterprise risk management:

1. Identifying risks (Chapter 2),
2. Assessing these risks (Chapter 3),
3. Mitigating these risks (Chapters 4), and
4. Responding to incidents through communication, coordination and other means (Chapter 5).
The first three entail activities that take place before the occurrence of an incident that generates negative (and mostly) unanticipated consequences (Chapters 2, 3, and 4). The fourth one applies to actions taken during and after the occurrence of an incident – the focus here is on time, which is also called time-based risk management (Chapter 5); of course, the planning of such actions can and should take place before risk events occur. In addition, we discuss how global companies mitigate risk (Chapter 6) with a focus on Samsung Electronics.