Chapter 2
Managing Supply Chain Risks: Understanding the Impact of Network Characteristics

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ABSTRACT
This chapter takes an exploratory look at the use of formal network measures to further understanding of the sources of extended enterprise or supply chain risk. It attempts to show that network measures can provide additional insight to ‘uncover’ sources of risk that could remain hidden using ‘traditional’ measures alone. More specifically, network measures of criticality, centrality, redundancy, distance and topology are combined with traditional measures of criticality, organisational slack, global sourcing and outsourcing to develop a more complete understanding on the determinants of the impact and/or probability of supply chain disruption. The measures identified provide researchers and managers with a wide-ranging framework for risk identification.

INTRODUCTION
Virtual Enterprises (VEs) can be defined as networks of suppliers, customers, engineers and other specialised service functions linked through advanced inter-organisational information technology in dynamic environments. This chapter is specifically focussed on the supply chain component of VEs and less on other aspects such information technology or their temporary nature.

In recent years the management of supply chain risks has risen to prominence within both academic and practitioner communities. A recent survey found that 80% of supply management executives had experienced disruptions in their supply chain within the past 24 months and that 75% predicted risks would increase over the next three years (Aberdeen Group, 2005). The increased probability of disruption can be ascribed to several factors, including the rise of global supply chains (Juttner et al, 2003), lean operations and supply (Sheffi, 2005), supply base complexity (Choi and Krause, 2006) and an excessive focus on outsourcing. Ironically, factors originally championed for driving better supply chain efficiency now appear to be creating greater vulnerabilities.
Supply chain disruptions have been shown to have major implications for the profitability, survival and future growth of organisations. Previous research has estimated that supply disruptions cost an average of $50 – 100 million per day (Rice and Caniato, 2003) and that prolonged disruptions, such as the 18 day labour strike at a brake supplier factory for GM, can reduce earnings by as much as $900 million per quarter. Furthermore, recovery from disruption can often be prolonged. Event studies have shown that operating performance reduced can remain diminished by as much as two years (Hendricks and Singhal, 2005). These severe effects are often amplified by a lack of preparation within organisations. It has been estimated that a mere 5 – 25% of Fortune 500 companies have sufficient supply chain risk strategies in place and that approximately 50% of organisations lack formal metrics and procedures for assessing and managing supply risks (Mitroff & Alpasan, 2003; Aberdeen Group, 2005).

Critical to reducing vulnerability to disruptions is supply chain design. The same disruption can have very different implications depending on how organizations have designed their supply chain and planned for such an event. For example, take the responses of Apple and Dell to the earthquake that hit Taiwan in 1999. Dell was able to direct sales to products with available components through its direct order supply chain while Apple faced product backlogs due to its lack of supply chain flexibility and inability to change product configurations (Sheffi, 2005). This, and many similar examples, clearly demonstrates that supply chain design can have important implications to both the response and impacts of disruptions.

In an effort to help managers reduce disruptions, research has focused on actionable supply chain design variables that may help reduce firm level vulnerability. Studies have identified a range of pertinent variables but the most common include organizational slack, global supply chains, the level of outsourcing and sole sourcing arrangements (e.g. Chopra and Sodhi, 2004; Kleindorfer and Saad, 2005). Whilst the literature has yielded significant insights into the phenomena of supply chain disruptions, existing models are somewhat limited in their explanatory power. For example, Wagner and Bode (2006) find that their predictor variables explain between 3 – 13% of the variance in various measures of supply chain vulnerability. Anecdotally, this is supported by evidence that suggests that although we now better understand the causes of disruptions, their frequency and impact still appear to be on the rise (Finch et al, 2009).

There is, therefore, a need to understand more fully what drives vulnerability within supply chains. It is the contention of this chapter that additional understanding may be obtained by combining extant predictors (such as those identified above) with network measures. By introducing formal network measures to the study of supply chain vulnerability, we can identify different causes of disruption that remain hidden when we follow what we could term as ‘traditional’ analysis. A similar argument is made by Choi and Kim (2008) who demonstrate how looking at the embeddedness of an organisation within its own network is important to explaining performance. An individual supplier should not be solely evaluated in isolation but also based on how that supplier is connected into the wider network. It also helps to formalise the work of Craighead et al. (2007) who recognised the importance of the network but without using formal network measures.

This exploratory chapter uncovers some of the network measures that may benefit risk identification and analysis within supply networks. In doing so, it follows a tradition within other fields that have used formal network measures to understand the robustness of their networks of interest. For example, Albert et al (2000) show that properties of a network have quite clear and distinct effects on the robustness of the Internet and the World Wide Web. Similar results have been found for many other forms of networks including organisational networks (Stanley et al, 1996), metabolic
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