

Assessment of Disruption Risks in Supply Chains

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INTRODUCTION

A supply chain is a series of stages (e.g., suppliers, manufacturers, distributors, retailers, and customers) at which inventory is either stored or converted in form or value or both. Supply chain disruption has become a pressing concern for businesses. As companies expand their operations globally through outsourcing and offshoring for competitive efficiency, they become more vulnerable to disruptions. Disruption in one country can seriously impact global supply chains. The devastating 9.0-magnitude earthquake and tsunami in Japan and the massive floods in Thailand in 2011 are examples of disruption risks that have caused profound damages to global supply chains as these countries are the locations of key suppliers for electronic and automotive industries. In addition, the number of risk events worldwide, including natural and man-made disasters, has continuously increased. Thus, global supply chains are exposed to various disruptions in the volatile business environment. They may disrupt facilities or transportation links in a supply chain network, which may lead to the disruption of the entire supply chain. Both practitioners and researchers are motivated to understand the influences of supply chain disruptions and to develop strategies that enhance organizational resiliency in order to ensure business continuity when disruptions occur.

In this chapter, we discuss supply chain risk management through the processes of risk identification, risk assessment, and risk mitigation. Our main focus is to present a framework for as-

sessing disruption risks for supply chain network components. We quantify the disruption risk score of facilities and transportation links based on three factors: *hazard*, *vulnerability*, and *risk management practice*. The assessment can serve as a guideline for practitioners to quantify disruption risks in their supply chains and facilitate the development of risk mitigation strategies.

BACKGROUND

The 2008 airport closure in Thailand is an example of disruption risk in transportation links. Air shipments of electronic products from Thailand were re-routed to airports in nearby countries. This resulted in increased lead-time and transportation cost. The earthquake and tsunami in northeastern Japan and the massive floods in Thailand in 2011 are examples of disruption risks that disrupted both facilities and transportation links. They impacted organizations worldwide and forced industries to re-evaluate their global supply chain practices in order to manage disruption risks (Ravindran & Warsing, 2013).

Managing supply chains under disruption risks has become a challenge for both practitioners and researchers. In a report by Harvard Business Review Analytic Services (2011), 89% of companies indicated that natural disasters have been among the top risks over the last three years. From a research perspective, many scholars have attempted to improve supply chain decision-making through risk identification, risk assessment, and risk miti-

gation. Interested readers are referred to Chapters 7 and 8 in *Supply Chain Engineering: Models and Applications* by Ravindran and Warsing (2013) for a comprehensive discussion of managing risks in global supply chains.

The airport closure, earthquake, and floods discussed earlier are well-known examples of external risk to supply chain networks. However, these risks are not the only factors influencing supply chain disruptions. Thailand's massive floods in 2011 have shown that supply chain disruptions are provoked by a country's conditions and a lack of effective risk management practices. Geographically, Thailand's industrial zones are flood-prone, and the country has experienced brief and minor floods from time to time. However, the 2011 monsoon season caused unusual heavy rains in many areas. Poor urban planning, political instability, deforestation, and poor floods mitigation led to an ineffective response to the crisis (Ye & Abe, 2012). Seven industrial estates built on low-lying lands were severely inundated with water, creating profound losses at several companies. Even companies whose facilities were not damaged had to suspend production due to difficulties in obtaining parts from suppliers that had been directly impacted by the floods. The suspensions then spread to other production sites worldwide; Toyota and Honda were forced to halt production in several countries (Fuller, 2011; Ye & Abe, 2012).

Risk management practices, including risk monitoring and risk mitigation, are also important. Although many disruptive risks, such as earthquakes, tsunamis, and floods, are difficult to predict, establishing risk management practices may help to alleviate impacts or fasten recovery. During the Thailand floods, many companies underestimated the situation and relied on the government. Water was rising overnight before many plants could move their equipment; the floods damaged infrastructure and equipment and forced the plants to shut down all operations (Fuller, 2011). Another example to illustrate the benefits of risk management practices is the reac-

tions from Ericsson and Nokia to the fire at their supplier, Phillips electronics semi-conductor plant, in New Mexico in March 2000. Nokia responded to the potential disruption quickly by shifting to a backup supplier, and production returned to normal in three weeks (Ravindran & Warsing, 2013). Nokia's extraordinary efforts and collaborations with its suppliers enabled the company to avoid disrupting its customers (Sheffi, 2005). Ericsson, however, underestimated the situation and had no backup plan. By the time Ericsson realized the magnitude of the problem, it was too late; the company endured part shortages and lost \$640 million in business in the North American mobile phone market (Ravindran & Warsing, 2013; Sheffi, 2005).

For global supply chain networks in which entities are located in different geographical regions and goods are moved through various transportation links, each entity and transportation link has its own disruption risk and vulnerability conditions that may lead to the disruption of the entire supply chain network. Firms must understand both the risks and the vulnerability of their supply chain components when designing the supply chain networks to balance business efficiency and risk (Asbjørnslett, 2009; Craighead et al., 2007; Kungwalsong & Ravindran, 2013; Steckel & Kumar, 2009). In this study, we present an assessment of supply chain risks due to man-made and natural disasters based on *hazard*, *vulnerability*, and *risk management practice* factors.

CURRENT STUDIES IN SUPPLY CHAIN RISK MANAGEMENT

A general framework of supply chain risk management has to include risk identification, risk assessment, and risk mitigation. In this paper, we use the risk management process described in Ravindran & Warsing (2013). Interested readers are referred to other studies in Chopra and Sodhi (2004), Handfield and McCormack (2008), and Manuj and Mentzer (2008).

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