IDENTIFYING MAJOR FACTORS FOR SUPPLY CHAIN RISK FROM NATURAL DISASTERS: A CASE STUDY

Kun Liao, Central Washington University, 20000 68th Ave W, Lynnwood WA 98036, liaok@cwu.edu, (425)-640-1574 x 3891
Ozden Bayazit, Central Washington University, 20000 68th Ave W, Lynnwood WA 98036, bayazito@cwu.edu, (425)-640-1574 x 3754

ABSTRACT

As firms establish their global supply chains, the risk increases dramatically due to increased complexity of their supply chains, which could lower market and financial performances. Natural disasters become a major threat when firms develop suppliers in other countries to take economic advantages. In this paper, major factors for supply chain disruptions caused by natural disasters are identified through a case study. In-depth interviews revealed that single sourcing is a significant weak part of a supply chain structure in terms of the disruption risk when the supplier is located in a place vulnerable to natural disasters. Actions are suggested for supply chain managers to lower this type of disruption risk.

Keywords: Risk management, supply chain risk, single sourcing, location, case study

1. INTRODUCTION

Risk from uncertainty has been extensively researched in various business fields such as finance, operations, and marketing. Supply chain risk has recently been given increased attention by firms and researchers since it has a negative impact on market and financial performances (Fortune, 2011; Tang, 2006). The estimated costs of natural disasters for Japan are $210 billion in 2011 (Fortune, 2011). Supply chain risks include operational risks and disruption risks; operational risks are caused by normal uncertainties from supply, demand, and cost, while disruption risks are caused by natural or man-made disasters (Tang, 2006). This study identified major supply chain risk factors through one case of disruption caused by several major natural disasters in the world. Through in-depth interviews, the weak part of the supply chain, such as the single supply issue, is identified. Actions are suggested for supply chain managers to lower disruption risks caused by natural disasters.

The paper is organized as follows: Section 2 is a literature review followed by research methodology in Section 3. Findings from the case study and suggestions for improvement are explained in Section 4. Lastly, conclusions to include limitations and future research directions re highlighted.

2. LITERATURE REVIEW

As a result of organizations becoming more engaged in offshore manufacturing and global outsourcing practices, as well as a recent series of natural disasters (hurricanes, powerful earthquakes, floods), supply chain risk management has started taking center stage as a vital priority for many organizations. Those events triggered enormous disruptions to many supply chains. Organizations have come to realize that a resilient supply chain will secure organization's competiveness whereas fragile supply chains will threaten organization's position in the market. Researchers have also reacted by focusing on this rapidly-developing field of supply chain risk management. As a result, a large number of researchers have become interested in the area as identified in a recent literature review by Rao and Goldsby (2009). The study revealed that "the recent past has seen a surge in interest of researchers and practitioners in the area of supply chain risk". Tang and Musa (2011) have also investigated the research tendency of the supply chain risk management area through a comprehensive literature review and concluded that there is an increasing interest in the field. Additionally, their study focused on major risk issues and risk mitigation techniques based on material flow, information flow and financial flow. As a result of their study identifying a gap in the literature, authors attempted to propose several quantitative techniques that could be used for risk management: (i) Robust planning, (ii) revenue management, (iii) agency theory, (iv) option theory, (v) reverse logistics and (vi) system dynamics.

Literature on supply chain risk management has been growing as evidenced by the increased number of research studies that came out over the past few years. Some studies focused on defining the supply chain risk (Harland *et al.*, 2003; Zsidisin, 2003) whereas some others focused on identifying the sources of supply chain risks (Chopra and Sodhi, 2004; Juttner, 2005; Christopher *et al.*, 2011; Wagner and Bode, 2008). Some looked into the relationship between supply chain risks and supply chain performance (Ritchie and Brindley, 2007; Hendricks and Singhal, 2005); some other studies suggested some effective strategies to mitigate the supply chain risk as well as developed some models to manage the supply chain management risk (Christopher and Lee, 2004; Juttner, 2005; Tummala and Schoenherr, 2011).

Chopra and Sodhi (2004) have identified nine sources of supply chain risk including disruptions, delays, systems, forecast, intellectual property, procurement, receivables, inventory, and capacity. They suggested that managers must create a shared, organization wide understanding of supply-chain risk and then they must determine how to adapt general risk-mitigation approaches to the circumstances of their particular company.

Kleindorfer and Sadd (2005) proposed a SAM (i.e., specifying, assessing, and mitigating) model to manage supply chain risk, including specifying the sources of risk, assessing the risk, and mitigating the risk. In another study by Thun *et al.* (2011), a survey is conducted in the German auto industry to analyze the differences between small companies and large size companies in terms of management of uncertainty. As a result of the survey study they conducted, authors concluded that regardless of the size of the company, supply chains are vulnerable due to the lack of the effective supply chain risk management strategies. Further the results also showed that no significant differences existed concerning the evaluation of the key drivers of the supply

chain risks. However based on the results, small companies used different instruments to manage uncertainty such as safety stock, or overcapacities whereas large size companies used more preventive instruments such as reliable suppliers. Wakolbinger and Cruz (2011) developed a framework that highlighted the importance of considering risk-sharing contracts as a tool to mitigate supply chain disruption risk. The study also showed the positive impact of information acquisition and sharing in supply chain networks. In an attempt to explore the relationship between supply chain resilience, supply chain vulnerability and supply chain risk management in a global disruption event, Juttner and Maklan (2011) examined three supply chains. Their study highlighted the relationship between supply chain resilience and supply chain vulnerability in a risk event. Four resilience capabilities including flexibility, velocity, visibility and collaboration seemed to decrease or limit the negative consequences of the risk events. A study by Christopher *et al.* (2011) focused on understanding how managers assess global sourcing risk and what they do to mitigate it. Conducting through multiple case studies and in-depth interviews, they found out that more than half of the companies they investigated did not have a structured supply chain risk management system while some companies were in the process of developing one. The study also presented major global sourcing risk groups including supply risks, environmental and sustainability risk, process and control risks, and demand risks. Global sourcing and network re-engineering as well as creating a global sourcing risk management culture were the two most common global risk mitigation and management strategies used by the companies. Yu *et al.* (2009) looked into the decision of choosing single sourcing versus dual sourcing in the presence of the supply chain disruptions. They concluded that depending on the magnitude of the disruption probability either single sourcing or dual sourcing might be effective.

3. RESEARCH METHODOLOGY

A senior director of supply chain of a major Japanese auto manufacturer was interviewed to collect first-hand information to identify major factors of supply chain disruptions. In the study, the name of the company will be kept confidential. This senior director has worked with the company in the supply chain management division for more than 10 years and is qualified as a major information source on supply chain management and supply chain risk management of the company. In addition, Internet search is conducted for relevant information.

4. FINDINGS AND SUGGESTIONS

This study adopts Kleindorfer and Sadd's SAM model (i.e., specifying, assessing, and mitigating) to first identify sources of supply chain risk under natural disasters through an interview and Internet information search (Kleindorfer and Sadd, 2005). Then, mitigating actions are proposed to supply chain managers.

4.1 Findings

The director of the Japanese auto manufacturer provided information regarding the current status of the firm's supply chain. The company considered risks associated with its supply chain, including operational risks and disruption risks, when the system was designed.

For operational risks, the firm has used a backup system for auto part suppliers. First, different suppliers are used for the same part of different models, for example, the Part X. Supplier A produces Part X for Model Alpha vehicle, Supplier B for Model Beta, and Supplier C for Model Gamma. When the company introduces a new model, Model Delta, each supplier is asked to bid for the Part X contract for the new model. This system does not only enjoy the economies of scale by offering the Part X contract for one model to one single supplier, but also encourages competition among the other Part X suppliers as well considering the fact that each single contract supplier has pressure from peer suppliers making the same part for different models. In addition, each supplier could become a strategic backup for other suppliers, if there is a quality problem or price issue with one supplier. If there is only a single supplier for all models of vehicles for some reason, the buyer company will encourage the supplier to have backup lines for some key manufacturing processes. By using the self-backup system, the operational risk is largely decreased.

For disruption risks, the firm identified the supply network as a major weak part of the supply chain under natural disasters. For example, the company already diversified its first-tier suppliers by using two different suppliers for some key components; these two suppliers can back up each other. Also, the firm considered requiring the same suppliers to operate at different locations to lower the risks caused by natural disasters. However, since the probability of disruption risk is very low, the buyer company did not systematically set up a system to cover all first tier suppliers. Recent disruption of supply chain operations from the Japanese Tsunami in March 2011 shows the weak part of supply network design in terms of supplier diversification.

Moreover, the above methods are not enough for mitigating the risk under natural disasters. The Thailand flood impacted another weak part of its supplier network; the problem is the single source for a third-tier supplier, although the company has already diversified the first tier or even the second tier suppliers. This new finding calls for attention from industry, and challenges academicians to design a new model of supply networks to decrease supply chain risks under natural disasters. In the new model, all tiers of suppliers should be considered.

4.2 Suggestions

This study therefore proposes the following model of risk chain which includes major business risks:

Natural Disasters—Supplier Destroy Risks—Supply Chain Disruption Risks—Market Risks— Financial Risks

In this model, natural disasters destroy suppliers, in turn, disrupting the supply chain. The disrupted supply chain cannot meet the market demand, resulting in lower than normal financial performance.

In order to lower disruption risks of a supply chain, two major factors should be considered: facility locations and a robust supply network. Facility location is a preventive method from a quality management perspective while a robust supply network is a reactive method. These two methods can be used together or separately. Due to the complexity of a supply chain of a major automotive manufacturer, some suppliers can establish facilities in low risk regions in terms of natural disasters while others cannot when certain resources such as human resources are only available in the high risk regions. Therefore, supply network analysis should combine both and evaluate the overall risks of the whole supply chain as well as the individual risk with any single component since a major supply delay of any single component might cause a delay for the whole supply chain system.

This new thinking could help industries to create new clusters in new regions and also provide local governments a marketing tool to attract major manufacturing businesses to their regions. In this paper, a portfolio of supply networks is introduced including flood-resist supply network (FRSN), earthquake-resist supply network (ERSN), hurricane-resist supply network (HRSN), and snowstorm-resist supply network (SRSN). Geographic and weather information are included to identify the possible locations for a supply network. Portfolio theory has been widely used in managing financial assets. Those assets with less correlated rates of return can be combined into one portfolio to have a relatively stable total return of the portfolio due to the diversification of risks (Markowitz, 1952). By choosing multiple suppliers subject to less correlated risks, disruption risks caused by natural disasters could be largely reduced through diversification.

Understanding the relationship between supply risks and natural disasters is the first step of managing supply chain disruption risks. Moreover, redesigning a supply chain with a robust supply network is more critical for industrial managers as well as researchers to minimize the impact of natural disasters. In industries, lean thinking is very popular for designing a supply chain. Although many lean supply networks enjoy savings from eliminated wastes, each network itself is fragile in terms of operational and disruption risks (Wong *et al.*, 2002). This paper proposes a portfolio of supplier networks which are robust under uncertainty and, at the same time, still keep the major benefits from each individual lean supplier network. From a risk perspective, each component cannot be produced by one single supplier at one location or several locations which might be affected by one possible large-scale natural disaster, for example, a hurricane. Therefore, this study suggests a location selection decision model for the manufacturing facility of each single component. This decision model includes two factors, the region of natural disasters and the single supplier issue for all suppliers of the component.

In addition, a database of the whole supply chain should be established including information of every tier of suppliers. Periodical supply network analyses should be conducted to identify the weak parts of the whole supply chain, especially those hidden weakness such as sharing one single third tier or fourth tier supplier, which is located in a high risk region with natural disasters.

5. CONCLUSIONS

This study adopted Kleindorfer and Sadd's SAM (i.e., specifying, assessing, and mitigating) model to systematically analyze the supply chain disruption risk under natural disasters (Kleindorfer and Sadd, 2005).

One senior supply chain director of a major Japanese automotive manufacturer was interviewed. In addition, Internet research is conducted to collect information about supply chain risks caused by natural disasters. Two major factors for the supply chain risks are identified: Location based on the possibility of natural disasters and single versus multiple suppliers. This study would help managers to realize negative impacts of natural disasters on supply chain. Moreover, supply chain managers could benefit from taking actions by using the suggestions for changes.

The limitations of this study include the limited information from one single case in one industry. Our future studies will focus on collecting more information about the supply chain risk caused by different types of natural disasters from several different industries in different countries.

REFERENCES

References available upon request from Kun Liao at liaok@cwu.edu