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A Review on Supply Chain Disruption: Managing Risk

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Abstract:

Design of a flexible supply chain is a complex and challenging task. This complexity arises due to sudden and unexpected changes (natural disaster, terrorist attack, labor strike, political instability etc.) in the market structure. Therefore, supply chains designed during more stable time need to be reshaped to deal with market volatility. However, modern supply chains are longer and very complex, and recent lean practices have resulted in supply chains becoming more vulnerable. Many researchers focus on the creation of an efficient supply chain to reduce cost and provide high incentive for all supply chain members but leveraging supply chain disruption risk management as a competitive advantage is ignored. This paper presents a literature review to highlight the importance of supply chain disruptions and its consequences. The objective of this paper is to discuss various strategies proposed by various researchers to manage supply chain disruptions. This paper also suggests a general framework, based on the literature survey, to help managers to manage supply chain disruptions and create a safer supply chain.

Keywords: Supply Chain Management, Supply Chain Disruption, Supply Chain Uncertainty

1. Introduction

The need for managing dependency among supply chain members has become very important with the changing trends towards globalization, outsourcing, contract manufacturing and information technology. Though these options bring some benefits but also increase complexity, risk and vulnerability for supply chain members. Due to globalization, supply chain became longer and now requires more time to ship the products to the consumers. Contract manufacturing and outsourcing creates dependency on external suppliers. With these changing trends, cost of supply chain is increased but predictability and reliability of supply chain is decreased (Oke & Gopalakrishnan 2009).

In supply chain, product passes through numerous supply chain members with some value addition and reaches to the end consumer. Supply chain tends to become inefficient because of the lack of coordination among various supply chain members (suppliers, service providers, consumers etc.). The continuous growing dynamic structure of the supply chain creates many challenges for an effective supply chain system. To achieve an effective and efficient supply chain, supply chain members have to perform as a part of unified system and coordinate with each other.

This paper presents a systematic literature review to throw light on the importance of supply chain disruptions. The objective of this paper is to report possible solutions to manage supply chain disruptions proposed by various researchers and also define a general framework to help managers to think about and manage supply chain disruptions.

2. Literature Review

Though, there are efforts in the literature regarding the management of supply chain disruptions, it appears that the study of supply chain disruption is still in its infancy. It is evident from the literature survey that the need for managing disruption is realized but little effort has been reported in the literature to develop a holistic view of supply chain disruption.

It is interesting to note the following perspectives on supply chain disruption as reported in the literature:

In general, there is lack of managerial ability to integrate and coordinate the business relationships among supply chain members (Lambert & Cooper 2000). Stank, Crum, and Arango (1999) highlighted inter-firm coordination processes characterized by effective communication and information exchange.

Lee (2000) proposed supply chain coordination as a mechanism to redesign rights to take decision, workflow, and resources between chain members to improve the performance in terms of high profits, improved customer service performance, and faster response time.

In case of a global supply chain, disruption may come in many forms varying from natural disasters, terrorist attacks, accidents in a manufacturing plant and operational challenges such as strikes, faults, frauds, equipment failures etc. As firms adopt just-in-time inventory, leaner operating models and leverage global sourcing models, supply chain complexity is increasing along with

uncertainty in both supply and demand. Exposure of supply chain disruptions has also increased because of these modern models. These supply chain disruptions creates greater pressure on companies to keep supply chains flexible and integrate disruption risk management in supply chain operations. Companies are trying to get their piece of the global advantage, as the operational risks and possibilities of disruption are very high. But continuous evolution in the global supply chain is one of the major challenges in managing these disruption risks. Like Murphy's Law, supply chains disruptions seem expected and should get the attention of senior management and shareholders. With longer supply chain and shorter clock speeds, there are more possibilities for disruptions. These disruptions may have an adverse effect on the financial position of the company.

Hendricks and Singhal (2003) reported that on the occurrence of a disruption, firms on an average experience 107% decrease in operating income, 7% lower sales growth, and 11% higher costs. The firms also suffered 33-40% lower stock returns over a three year period after the disruption.

Hendricks and Singhal (2005a, 2009) also highlighted the impact of supply chain disruptions on market performance of companies.

Hendricks and Singhal (2005b) reported on another evidences of financial performance of different companies on the occurrence of supply chain disruptions.

Many other researchers (Murphy 1999; Latour 2001; Christopher, Juttner & Peck 2002; Ross 2003; THE AGE 2003; Chopra & Sodhi 2004; Cavinato 2004; Skidmore 2002; Sullivan 2006) have also reported costly consequences of disruptions.

Many firms lack contingency plans and well-defined roles concerning disruptions (Rebmann, Strawn, Swick & Reddick 2013; Hillman & Keltz 2007).

Mitroff and Alpaslan (2003) analyzed crisis readiness of Fortune 500 companies over the past two decades. They found 95% of them not prepared for an unfamiliar disruptive event. In order to achieve competitive advantage, companies need to identify, understand and manage supply chain risks.

MIT research group on "Supply Chain Response to Global Terrorism" (2003) highlighted that firms usually focus on the type of disruption and ignore its source in order to know how to prepare against risks. For instance, a disruption can be caused by a strike, an earthquake or a terrorism action and each will have the same impact. But this is not the case always. Therefore, it is important to identify various types of failure modes of supply chain. The team identified various failure modes as listed in Table 1.

Failure Mode	Description	Impact
Disruption in supply	Delay or unavailability of supply	Shortage of inputs
Disruption in Transportation	Delay or unavailability of the transportation infrastructure	Delay of inbound and outbound movement of goods
Disruption at Facilities	Delay or unavailability of plants/warehouses	Bottleneck in operations
Freight breaches	Violation of the integrity of cargoes and products	Loss or adulteration of goods due to theft
Disruption in communications	Delay or unavailability of the information and communication infrastructure	Inability to coordinate operations and execute transactions.
Disruption in Demand	Delay or disruption downstream	Loss of demand, temporarily or permanently

Table 1: Different types of failures modes

Source: MIT research group on "Supply Chain Response to Global Terrorism", Sheffi, Rice, Fleck and Caniato (2003)

3. Supply Chain Disruption Management : Literature Solutions

Several disruption management strategies have been developed to align supply chain operations and activities to ensure better supply chain performance. Some researchers focus precisely on disruptions and discuss the solutions that companies should adopt to have safer supply-chains. Some of these strategies are given as follows:

3.1. Building the 'Triple-A' Supply Chain

Lee (2004) suggests that the key to survive in such context is through building "The Triple-A Supply Chain"- agile, adaptable and aligned supply chain.

Great companies create supply chains that respond to sudden and unexpected changes by fostering agility, adaptability and alignment in the supply chain.

3.1.1. Agility

Agile supply chain handles external disruptions smoothly and responds fast to the sudden and unexpected fluctuations in supply or demand. Most supply chains respond quickly to these sudden changes at the high cost. But agile supply chains respond both

quickly and cost-efficiently.

In the 1990's, Compaq took more time than Intel to launch its new microprocessor because of its long design cycle. Since Compaq's products stayed in the pipeline for a long time, it could not cut the price of its product when component's prices fell as Intel was able to. And when there was a change in engineering specifications, Compaq incurred more reworking costs than other manufacturers because of its long design cycle. Therefore, Compaq did not reap much benefit because of the lack of an agile supply chain (Lee 2004).

It is very critical to achieve agile supply chain due to sudden changes in the supply chain. For instance, terrorist attack in New York in 2001 and SARS epidemic in Asia in 2003 and 9/11 attacks in U.S disrupted many companies supply chains. Many firms have seen their supply-chain weakened after these disruptions. For instance, Ford had to shut down its few plants, as it couldn't get enough parts from its suppliers in Canada due to the reinforced security at the borders in the few days that followed 9/11 (Pochard 2003).

But now supply chains traverse globe, natural disasters, epidemics and terrorism has intensified the supply chain partly.

Agile supply chain requires:

- Constant monitoring of data on changes in supply and demand and sharing the same continuously with supply chain members in order to respond quickly.
- Collaboration with suppliers and customers to redesign processes/products and develop backup plans.
- Maintaining small inventory of inexpensive and key components to prevent manufacturing delays.
- Developing contingency plan and crisis management team.

having a dependable logistics partner to respond to unexpected needs.

In 1999, an earthquake in Taiwan delayed shipments of computer components to the United States. Most PC vendors such as Compaq, Apple and Gateway couldn't deliver the products on time but Dell adopted agility and collected the data on the earthquake damage early, understood the vendors' problem quickly and changed the prices of PC configurations overnight and gained market share in such crisis (Pochard 2003).

3.1.2. Adaptability

Adaptable supply chain adjusts supply networks to meet changes in the market structure and modify supply network to organization's strategies, products and technologies. These structural changes can be economic, political, social, demographic or technological. Best supply chains identify these changes by collecting latest data, removing noise and following key patterns. For instance, in 1980s, Hewlett-Packard set up its R&D and manufacturing division both for Ink-jet printers in United States. HP wanted its production and product development team to work together because of new technology and demand of Ink-jet printers in United States. When demand grew in other parts, HP set up its manufacturing division in Europe and Asia also. But by the mid-1990s, HP realized that printer-manufacturing technologies had matured and adopted outsourcing production. This adaptation of supply networks resulted HP as the market leader (Lee 2004).

Building an adaptable supply chain requires:

- Monitoring of economic changes
- Evaluating the needs of end consumers
- Creating flexible product designs and evaluation of supply chain implications of product designs
- Identification of suppliers that compliments existing ones
- Identification of intermediaries to find reliable vendors in unfamiliar parts of the world
- Creation of different supply chains for different product lines, to optimize capabilities for each.

3.1.3. Alignment

Supply chains are one of the major risks facing many companies today because all supply chain partners are striving to maximize their own interest by overlooking the interest of the chain. Best companies take care to align the interest of all supply chain partners with their own interest. If any supply chain member's interests differ from others' interests, its actions will not maximize the supply chain's performance. It is very critical to achieve the alignment because every member tries to maximize only its own interests.

For instance, all through 1990's, Cisco's supply chain was graded as reliable supply chain. Cisco outsourced the production of most of its products and worked closely with its contract manufacturers to cater the needs of consumers of different parts of the world. Contractors maintained a large inventory for month without evaluating the demand for Cisco's products. That was the misalignment of interests of Cisco and its contractors. When U.S economy slowed down, contractors continued to produce and store stock at the same price. Company had to sell \$2.25 billion of inventory as scrap. This misalignment caused Cisco to suffer huge loss (Lee 2004).

The process of alignment requires:

- Redefining the terms of relationship among supply chain members so that members share risks, costs, rewards fairly
- Providing all members with equal access to forecasts, sales data and plans.
- Defining members' roles and responsibilities to avoid conflict
- Alignment of incentives to maximize overall chain performance by maximizing each members' returns from the partnership.

3.2. Dual Sourcing

Pochard (2003) focused on how companies can use real options to value dual sourcing strategies- single sourcing and multiple sourcing. Both can be performed in many different ways and it seems that there is no single best solution.

3.2.1. Single Sourcing

Single sourcing is cost effective and improves relationships with suppliers. But it introduces risk if supplier goes out of business, acquired by another company, or provides lower quality services. This will lead to shortage for key components that could be dangerous for the firm that may have to close some plants and loose business. Therefore, managers must consider the possibility of relying on multiple suppliers to cope with disruptions in supply.

3.2.2. Multiple Sourcing

Managers can consider more flexible strategies and contract with back-up suppliers. This can be done in various ways:

- Can establish different contracts (long-term contracts, option contract and supply contract) with various suppliers.
- Can create a local supply source with the appropriate manufacturing capacities
- Can develop multiple supply sources with the appropriate manufacturing facilities.

In order to make a choice between those two approaches, it may be useful to quantify their values. In that respect, real options are very useful. Pochard (2003) developed an analytic model to analyze and value the benefits of relying on dual sourcing. This model takes into account various parameters such as the frequency of disruption and the loss of market share. Using MATLAB, it defined the particular circumstances that justify a second supplier. Sensitivity analysis is used to determine the impact of each parameter. The model also demonstrated the value of the option of delaying decision and showed that a time-varying dynamic strategy works the best. This tool allows to evaluate the decisions that are made in an uncertain environment, and to take into account flexibility.

4. Suggested Framework

This paper attempts to identify certain key points, based on the literature survey, which need to be taken care of to understand the economic implications of supply chain disruption risks. In order to understand and manage supply chain disruptions, companies must identify supply chain disruptions risk, evaluate the consequence of supply chain disruption risks and create a flexible supply chain to sustain and absorb disruption without negative impact. Proposed framework is presented in Figure1.

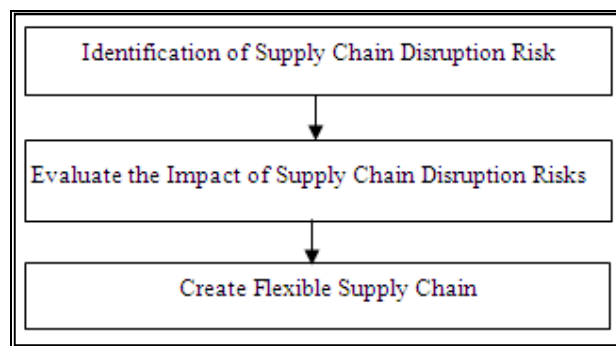


Figure 1: Suggested Framework

4.1. Identification of Supply Chain Disruption Risk

As risks of supply chain disruptions are not equal, similarly its consequences are not equal. Therefore it is necessary to identify the various sources of supply chain

disruption risk. These sources are as follows:

Operational Challenges: There may be discontinuity in the supply chain because of various operational problems such as supplier discontinuity, equipment breakdown, and accidents in manufacturing plant (fire, explosions, hazardous spills, structural failures etc.), financial crisis, bankruptcy, strikes, high cost labor etc.

Natural disasters: earthquakes, hurricanes, tornados, epidemics, extreme weather conditions

Terrorist attack or war or Political instability

Top management generally does not consider unforeseen challenges such as political instability, terrorism or natural disaster.

When it comes to developing a strategy to reduce the risks of future terrorist activities, we cannot predict the nature of attacks and terrorist's motive. Hence it is extraordinarily difficult to plan protective actions. Similarly, Individuals and companies are not very concerned about the natural disasters prior to their occurrence. Only after the event, they plan protective action. Uttarakhand (India) flood and landslides in June 2013 is the evidence of lack of disaster planning. After this disaster, Indian Govt. established a state rehabilitation and reconstruction authority to redevelop the areas destroyed by the flash floods. But, in general, with the passage of time, this concern also dissipates. People tend to cancel their flood or earthquake insurance policies if they have not experienced losses from one of these events in several years.

4.2. Evaluate the Impact of Supply Chain Disruption Risks

Supply chain experts suggest that the best way to manage disruption risks is to understand a company's vulnerabilities towards disruption risks. These vulnerabilities need to be analyzed in every aspect of supply operations such as manufacturing processes, equipments, technology, transportation and distribution. Typically, a supply chain participant with "special vulnerabilities" may hide these from other supply chain participants. But current cross-functional communication system such as ERP (Enterprise Resource Planning) systems improved information dissemination among all supply chain members and provided supply chain visibility (Kaur, Kanda and Deshmukh, 2011)

Following steps will help companies to evaluate the impact of supply chain disruption risks:

Define roles and responsibilities design disruption risk management process.

Identify all processes such as manufacturing, new product development and supply chain operations that are likely to be affected by disruptions. Also identify what will be the effect of disruptions on assets, inventory, brand image and goodwill of the company. Formulate risk management policies for each key process to identify vulnerabilities, cause for these vulnerabilities, probability of occurrence, and mitigation of risk transfer activities.

Provide feedback to management and supply chain participants on the performance of their plans and their compliance with agreed, supply chain wide standards by auditing and review of implementation plans.

4.3. Create Flexible Supply Chain

Many companies have centralized manufacturing and distribution facilities to achieve economy of scale but these companies are not able to cope with demand fluctuations. In order to meet increase in demand, manufacturer delivers additional merchandise but distributors may not need excess inventory to meet this demand fluctuation. This will result in excess inventory and as a result, to get rid of this excess stock, companies mark down these products and earn less profit than they had planned to. Therefore, it is very important for companies to have flexible supply chain to adapt the supply-chain according to the availability of resources. It will help to quickly take corrective actions to minimize the impact of sudden and unexpected disruptions. In this case, firms can add redundancies or redesign its products or manufacturing processes to facilitate a rapid changeover when needed.

Lucent's Electronic Switching Systems Division which set up a fast and cost effective supply chain in the United States. The supply chain worked efficiently as long as the demand was from the United States itself. But when Asia became the fastest growing market, Lucent's supply chain could not work brilliantly as it was doing earlier. Its response time increased because of the manufacturing plant in the United States. It affected both the amount of time and the money; company takes the supply chain to deliver the product across continents. Lucent's problems became more severe when its vendors shifted their manufacturing plants in Asia to take the advantage of lower labor costs (Lee 2004).

Thus efficient supply chain will not ensure the company to win its rivals. In order to get ahead of competition, companies need to create flexible supply chain to accommodate structural shifts in the market.

5. Conclusion

Though global sourcing brings many benefits, there are indeed potentially negative consequences such a longer supply chain, dependency on external suppliers etc. These negative consequences will become more severe due supply-chain disruptions. Therefore, it has become important how to avoid and manage supply-chain disruptions in its infancy. The intent of this paper was not only to highlight the supply chain disruptions areas that need more attention, but to provide a list of certain measures to assist with the complexities and vulnerabilities of global supply chains.

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