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Comparing supply chain risks for multiple product categories with cognitive mapping and Analytic Hierarchy Process[☆]

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ABSTRACT

The risk management framework includes the practice of keeping safety stocks and safety lead time buffers. However, in today's high-tech and highly globalized world where competition is so fierce and paramount that managing and mitigating the risk by creating a more resilient supply chain has become indispensable for any organization. Assessing and managing the supply chain risks become very important in this context and one such risk assessing tool is Analytic Hierarchy Process (AHP). AHP supports managers in identifying the risk indicators, assessing the impact of undesired events and the varied cause and effect relationships along the chain, and thus prioritizing the objectives of the supply chain, hence arriving at the selection of the best supplier from various alternatives. Thus, the objective of this paper is to identify and assess supply chain risk across multiple product categories using cognitive maps and Analytic Hierarchy Process (AHP) methodology.

1. Introduction

Today's world is dynamic and marked by uncertainties. Unplanned and unnatural events are encountered frequently. The business organizations and their operations are probably the most vulnerable ones to these uncertain, unplanned and unnatural events. These unwanted and unpredictable events when coupled with the supply chain of an organization underlie Supply Chain Disruptions. These disruptions can be categorized into internal to the firm, external to the firm but internal to the supply chain network, and external to the environment are regarded as Supply Chain Risks. Supply chain risks can lead to a variety of problems such as long lead-times, stock outs, inability to meet customer demand, and increase in the cost of production which ultimately may lead to losses to the firms.

Since older times there has been a risk management framework; this framework includes the practice of keeping safety stocks and safety lead time buffers. However, in today's high-tech and highly globalized world where competition is so fierce and paramount that managing and mitigating the risk by creating a more resilient supply chain has become indispensable for any organization. Hence, for managers assessing the risks has become the need of the hour. One such risk assessing tool is Analytic Hierarchy Process (AHP). AHP supports managers in identifying the risk indicators, assessing the impact of undesired events and

the varied cause and effect relationships along the chain, and thus prioritizing the objectives of the supply chain, hence arriving at the selection of the best supplier from various alternatives.

Thus, the objective of this paper is to identify and assess supply chain risk across multiple product categories using cognitive maps and Analytic Hierarchy Process (AHP) methodology. The knowledge of the decision makers is tacit knowledge and they generally use certain mental models for evaluation while making a decision. Cognitive maps were used to elicit the decision maker's mental models and the criteria for evaluation of supply chain risk. The cognitive maps resulted in a set of criteria and levels 2 and 3 subcriteria on which we further applied the Analytic Hierarchy Process technique to quantify the relative importance of the criteria. This research mainly focused on the retail industry in which the vendors from four categories of products were assessed. The four categories of products were perishable, non-perishable, durable and non-durable.

The main contribution of the study is that although we have only considered four products from different categories of the market, our study can be further extended to numerous categories that are present in the market. This kind of research can be done for other categories and sub-categories of different market. This will not only lead to identification of various supply chain risks which a retailer can identify in their vendors but also give the marketers various attributes which

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could be further included in their products and help them to penetrate the market further.

2. Literature review

2.1. Supply chain performance

Supply chain performance can be defined as a supply chain's ability to appropriate quality of products and services in specific quantities at the desired time, and also, to minimize the cost of products and services in the supply chain. Performance can be evaluated on the criteria of efficacy, efficiency, effectiveness (Beamon 1999). According to Beamon (1999), inclusiveness (measurement of all pertinent aspects), universality (allow for comparison under various operating conditions), measurability (data required are measurable), and consistency (measures consistent with organization goals) are some of the important supply chain characteristics. There should be a constant improvement in functioning of the supply chains. This, makes measuring of Supply Chain Performance important. The process of measuring efficiency and effectiveness of the undertaken actions is referred as Performance measurement. Performance measurement system is expected to understand the set of indicators which are used to quantify the efficiency and effectiveness of operations (Leończuk, 2016). According to Min (1994), as the market becomes more and more globalized, an increasing number of firms are now seeking their supply bases around the world rather than sticking to one supplier for the delivery of the raw materials required. This means that the firm needs to deal with a lot of uncertainty and risks while going for supplier selection. This involves a lot of quantitative and qualitative factors, which are in conflict with each other. It also states that multinational firms are requiring an analytical approach for international supplier selection. In the field of analytics, a lot of prior studies have taken place for supplier selection. The list of these methods includes weighted-point method, matrix approach, Vendor Profile Analysis (VPA), Analytic Hierarchy Process (AHP), Multiple Objective Programming (MOP), etc. To elaborate, a categorical method rates potential suppliers on a number of equally-weighted factors and then allows the decision maker to choose its supplier with the highest total score. The paper also states the pros and cons of each method as well as stating how they evolved from one another (Min, 1994).

The effective management of supply chain is measured by the supply chain performance. In today's world where the competition between the industries is cut-throat, the overall productivity and the profitability of a company in a particular industry depends on the performance of the supply chain. For effective supply chain performance there is a necessity of an integrated supply chain structure. This structure tries to minimize the investment cost, operating cost and the time out of the supply chain process thus reducing the non-value added activities and their associated structure. An integrated supply chain structure helps to create a greater responsiveness from the customers and add flexibility into the supply chain; these owe to the reduction in cost, thus, it enhances the bottom-line performance and cost competitiveness. Stewart (1995), has further mentioned in his paper that four categories of operational change needs to be considered while considering the integration of the supply chain, and these are policies, practices and procedures; organization; structure and systems.

Supply chain management is one of the most important parts of any business thriving on the foundation of a robust supply chain. The concept of supply chain management represents the most advanced state in the development of purchasing, procurement and other activities of supply chain. At a strategic level, supply chain management is a dynamic discipline that is playing a significant role in meeting the needs of the customers in manufacturing and non-manufacturing sectors (Gunasekaran et al., 2004).

Companies and managers have now realized the potential benefits of the supply chain performance in building a greater understanding of

the supply chain and in providing the important feedback on the improvement progress. Companies have realized that now there has been an increasing competition between different supply chains rather than the two companies. Measuring of supply chain performance is also important in testing and revealing the viability of a firm's strategies (Ramaa et al., 2009). Measuring supply chain performance provides important feedback information, helps to reveal progress, increase employers' motivation and communication, and helps to diagnose problems.

Change in demand becomes more complicated when production capacity is constrained. When there is a peak rise, the demand exceeds the maximum output capacity. On the other hand, when there is a fall, there is a surplus capacity available. In order to deal with these two situations, production can be done in advance for the peak periods, thus, improving the ability to meet demand but it, also, creates inventory build-up with a high amount of uncertainty. Sourcing strategy, also, reflects the performance capabilities of supply bases. There are a large number of vendors available in the market which differs in lead times and flexibility of production. A vendor with the lowest costs, generally, offers no flexibility with respect to capacity commitments. They tend to have larger lead times and shipment times. More responsive vendors may have shorter lead times and provide greater flexibility with respect to production commitments (Agrawal et al., 2002).

2.2. Supply chain risks

Supply-chain risks can create supply-chain problems which in turn causes unanticipated changes in flow due to disruptions or delays (Christopher and Lee, 2004). These disruptions can be short-term or long-term and pose a threat to the organization, ranging from minor to major. Delays in material flows often occur when a supplier is not able to respond to demand changes. These delays can be dealt by economically placing and sizing. Disruptions in the supply chain are unpredictable but are often quite damaging. Building inventory is one way of dealing with these disruptions. Whenever the company relies on information system, then, the risk imposed by these information systems is referred to as System Risk. The greater the dependence on information risk, the greater is the threat from such risk. Robust backup systems coupled with a recovery process, is one way of dealing with such system risks. Forecast risk occurs when there is a difference between a company's projected demand and actual demand in market. These are increased further with longer lead times, seasonal demand, high product variety and smaller product life cycles. These can be dealt with building responsive production and delivery capacity. Due to fluctuating exchange rates or supplier price hikes, risk arising from unanticipated increases in acquisition costs is referred to as Procurement risk. Receivables risk, the possibility of being unable to collect on receivables, can torpedo the performance of any company. These types of risks bust the financial performance of an organization. In order to deal with these above mentioned risks, two things need to be considered when formulating constructing supply-chain risk management strategy. First, an organization wide understanding of supply-chain risk needs to be created. This should be followed by determining the methodology to adapt approaches to mitigate risk to the circumstances of their particular company (Chopra and Sodhi, 2004).

Our paper categorized potential supply chain risks as delays, disruptions, forecast inaccuracies, systems breakdowns, intellectual property breaches, procurement failures, inventory problems and capacity issues.

The possibility of mismatch between supply and demand is referred to as Supply Chain Risks. These risks can be arising from multiple sources like environmental, organizational or supply chain-related variables. These cannot be predicted with certainty along with the impact on the supply chain. Supply chain vulnerability is the "the propensity of risk sources and risk drivers to outweigh risk mitigating

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