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Bayesian Belief Network Approach for Supply Risk Modelling

Anil Jindal, Giani Zail Singh Campus College of Engineering and Technology, Maharaja Ranjit Singh Punjab Technical University, Bathinda, India

Satyendra Sharma, Birla Institute of Technology and Science, Pilani, India

Srikanta Routroy, Birla Institute of Technology and Science, Pilani, India

ABSTRACT

Today's global and complex world increases the vulnerability to risks exponentially, and organizations are compelled to develop effective risk management strategies for mitigation. The prime focus of the research is to design a supply risk model using Bayesian belief network bearing in mind the tie-in of risk factors (i.e., objective and subjective) critical to a supply chain network. The proposed model can be re-engineered as per new information available at disclosure, so risk analysis will be current and relevant along the timeline as the situation is strained. The top three factors which influenced profitability were transportation risk and price risks. Netica is the platform used for designing and running simultaneous simulations on the Bayesian network. The proposed methodology is demonstrated through a case study conducted in an Indian manufacturing supply chain taking inputs from supply chain/risk management experts.

KEYWORDS

Bayesian Belief Network, Modelling, Supplier's Performance, Supply Chain Risk

1. INTRODUCTION

In today's competitive world running a commercial manufacturing organization smoothly and profitably is a daunting task due to presence of uncertainties at various locations of its supply chain network (SCN). Supply chain network of a manufacturing unit consists of activities such as procurement of raw material, transportation, converting into final product, packaging and supplying. It starts with procurement of raw material from a supplier anditcan have one or more than one suppliers. With the increase in competition and decrease in profit margins, organizations needs to implement policies such as globalized supply chain, higher capacity utilization, lower-inventories and just-in-time (Adhitya, Srinivasan, & Karimi, 2009). These policies favours single supplier, as a single supplier reduces complexity of supply network and therefore results in reduction of supply chain cost (Sadgrove, 2005). But a single supplier makesthe supply chain more vulnerable to disruptive risks.

Disruptions not only decrease the supply chain performance but without proper mitigation strategies, supply chain will take long time to recover (Sheffi & Rice Jr, 2005). To prevent supply

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chain networks from disruptions or halt, mitigation strategies have to be made by manager, that's why the use of supply chain risk management is inevitable. Supply-chain risk management (SCRM) in various literatures is defined as implementing the strategies to manage risk in the form of material, financial or information in supply chain with continuous risk assessment and rectification, with the aim of reducing vulnerability and ensuring proper working. Therefore supply chain risk management is a field of growing importance and is aimed at developing approaches for the identification, assessment, analysis and treatment of areas of vulnerability and risk in supply chains"(Neiger, Rotaru, & Churilov, 2009). Iwan et al. (2009) reviewed the Supply-chain risk management (SCRM) literature published from 2000 to 2007. There are four stages in SCRM, first is assessing the sources of risk for the supply chain, and then identifying the drivers of risk. After finding the drivers of risk, define the consequences of the risks on the supply chain and in the last stage development of mitigating strategies for supply chain risk so that it can operate smoothly and efficiently.

This paper has identified the possible sources of risks and their drivers coming from supplier side in automobile sector, and develops strategies to mitigate the consequences of risks. With these sources of risk and their drivers a model is developed using Bayesian belief network. The model is further tested with scenario analysis and sensitivity analysis to propose the risk mitigation strategies. The next section provides the literature on supply chain risk management, supplier selection and Bayesian belief network. The literature review is based on papers published on relevant topics from last 15 years. Section 3 provides the methodology of the present work, with the flowchart showing the steps required for solving the problem. After it, section 4 provides the results and discussion. The last section provides the conclusions and future scope of work.

2. LITERATURE REVIEW

The first step in supply chain risk management is to identify the risks associated with supply chain network from supplier end and to find their possible drivers. Therefore to identify the possible sources of risks in supply chain network a through literature review of the published papers is done and summarised in Table 1.

From the above literature review eight possible sources of risk were identified. But after discussion with the expert, these sources of risk are reduced to four which are very important and also include effect of other sources. After assessing possible source of risk the next step is to look for their possible drivers from the literature survey. Doing this risk model I came up with two possible drivers for each source of risk as explained below and shown in Table 2.

1. **Total Cost:** Total cost of a product includes all the expenses that have been incurred by an organization from ordering a product till it get consumed. It consists of price of a product, transportation cost, inventory cost and other indirect expenses. It is one of the main sources of risk that can enter into the supply chain of the organization, making the final product less competitive in market in term of cost. Total cost had been used by (Mulyati, 2015), (Khodakarami & Abdi, 2014), (Acebes, et al., 2014) in their risk model. Total cost of a product increases when cost of any one of its components increases as given below:
    a. **Price inflation:** It can increase when supplier increases its profit margin or there is shortage of supply with respect to demand or increase in raw material used by supplier or financial instability of supplier.
    b. **Transportation cost:** The main reason for variation in transportation cost is fluctuating fuel price but other reasons can also contribute in its increment such as non-availability of proper transportation mode, transportation union strike or change in government transportation policies etc.