Abstract

The risks in the modern supply chain are abundant and are growing due to the following reasons, outsourcing, globalization, reducing the supplier base, eliminating the non-value-added activities from the process, and reducing the safety stock. The growing SC risk results in negative consequences like the devastation of social and financial values, customer dissatisfaction, loss of firm reputation, which altogether affect the actual SC performance to deviate from the expected SC performance. The cycle starts with the identification of potential SC risk drivers, followed by the assessment (prioritization/ranking) of the most critical risk drivers. The next phase is to develop effective strategies to mitigate the unwanted effect of the identified risk and implement the necessary course of action. The risk control step can be referred to as the treatment of the residual risk as per the tolerance level or risk appetite (risk-seeking, risk-neutral, or risk-averse nature) of the SC stakeholders. Finally, risk has to be continuously monitored to keep track of the emerging risks. In this regard, this thesis aims to develop an integrated SC risk management framework.

The first phase of the SCRM process is the identification and assessment of the various drivers and sub-drivers of SC risk. Models and approaches to quantify the SC risk in terms of operational measures are limited in the literature. In this regard, a hybrid DEMATEL-ANP framework is proposed to quantify and prioritize various risk and sub-risk drivers of the SC, which is capable of capturing of the interrelationship between the risk and sub-risk drivers. The proposed framework is employed in the case of Indian petroleum SC. The results indicate that transportation/logistics (delivery system), quality of the petroleum products, continuous flow of the crude supply, customer's order, and legal/political regulations are the most significant risk drivers. The Indian petroleum SC managers are well concerned about the criticality of each SC risk driver, and based upon their opinion the petroleum SC possesses a risk score of 34% in the considered region of the country. The results obtained from the proposed (DEMATEL-ANP framework) study are compared against AHP (Analytical Hierarchy Process), and the importance of considering the mutual interrelationship between risk and sub-risk drivers are highlighted.

The second most vital step of the SCRM process is Risk mitigation (RM), which involves the selection of a suitable RM strategy to reduce the (future) adverse impact of risk. The selection of an RM strategy at a given level of SC risk is a formidable task because it depends on many exogenous factors like resource availability of a firm and planning horizon for implementation. In this regard, a Decision Support System (DSS) is proposed to expedite the process of selecting an

effective RM strategy. A three-level keyword based systematic review approach is employed to explore both proactive and reactive RM enablers (practices), and they are further mapped to their respective RM strategies by using correspondence analysis. A focus group discussion is conducted to conceptualize a 3-D matrix, considering the risk score, resource availability, and time period of implementation as independent variables and RM strategies as dependent variables. A rule-based fuzzy inference system is utilized to counteract the uncertainty (subjectivity) involved in the considered problem. Finally, various decision making under uncertainty theories have been considered to capture the rational behavior of SC managers towards risk. Additionally, the efficacy of the proposed DSS is demonstrated by considering two conjectural scenarios in the case of Indian petroleum SC. The unique contributions of this study are presented as theoretical implications and managerial propositions in the context of the developing country.

This last phase of the SCRM process deals with the risk control and risk monitor phases of the SCRM process. Today's modern world business scenario is volatile, and most of the decision parameters are dynamic in nature. In this research work, a multi-echelon, multi-product, and multi-modal SC design problem is addressed by considering various sources of aleatory uncertainties viz. demand, supply, production, etc. A real-world case of petroleum SC in the Indian context is selected to demonstrate the efficacy of the proposed model considering the requisite constraints. The results show that total SC cost and the risk demonstrate conflicting behavior with each other. Total SC cost increases with an increase in risk aversion level. Around 98 percent of operational risk can be reduced at the expense of a 2 percent increase in total SC cost. Penalty cost contributes the maximum to the increase in total SC cost along with risk aversion level. Responsiveness (service level) of the SC remains unaltered under various risk aversion levels. Additionally, the relationship between rational behaviors (optimistic, pessimistic, realistic, random, and equiprobable) and risk aversion behavior (risk-seeking, risk-neutral, and risk-averse) is derived. The results show that in the risk-seeking phase, the lines of realistic and equiprobable believers converge with each other, but in the risk-averse phase, the decision-maker(s) has to be realistic than equiprobable and random to minimize the expected SC cost. Further, in the risk-seeking and risk-averse zones, the lines of risk for random and equiprobable behavior converge with each other, which means they demonstrate almost the same risk. In the risk-neutral phase, random and pessimistic behavior curves are close to each other, which signifies if a decision-maker is risk-neutral, being random or pessimistic will incur him/her the same risk.