Name of Scholar: Sanjay Kumar

Name of Supervisor: Professor Abid Haleem

Department: Mechanical Engineering

Title of the Thesis: SCM Issues Under Uncertainty

ABSTRACT

Supply Chain Management has become an important research area in the last few decades. Uncertainty in supply chain is one of the important areas where research has to be conducted in Indian context. Bullwhip effect is one of the major problems arising from uncertainty in supply chains. The area has been explored and researched for Indian industry in the present research.

This **literature review** attempts to classify the sources of bullwhip effect such as demand signal processing; rationing game, order batching and price variation. It further discusses identification and measuring the bullwhip effect in the supply chain. **Gaps** have been identified in the literature review. It has been identified that modeling of factors causing uncertainty, causes of bullwhip effect and problems associated with bullwhip effect have not been done in Indian context. Alternative solutions to reduce bullwhip effect have not been compared for Indian industry. Also quantification of bullwhip effect mitigation has not been done.

Factors responsible for uncertainty in supply chain have been identified from literature review and expert opinion and **structural modeling** has been done using Interpretive Structural Modeling (ISM) technique. The structural model so developed after identifying factors responsible for uncertainties provides us with various understandings. Uncertainty in the behavior of members is the top level key factor. Lack of IT enablement in supply chain, environmental disasters, government policies are the key bottom level factors responsible for uncertainty in supply chain decision making environment.

The various **causes responsible for bullwhip effect** needs to be identified and appropriate strategies developed to counter them. An **ISM** based **model** has been developed to understand the interactions of these factors. This model is based on the perception of experts and the available literature. Model so developed has provided us with extensive insight into the integrated behavior of these factors. From the model, it is being observed that supply uncertainty, demand forecasting and order batching are the top-level factors which are responsible for creating bullwhip effect, whereas government policies is the key bottom level factor.

Bullwhip effect is an important area of concern for Indian supply chain managers especially in retail supply chain. Different **problems cropping up due to bullwhip effect** have been identified. Lost revenue due to shortages, substandard productivity of capital invested and

capacity increase plans are the top-level problems associated with bullwhip effect. Excessive inventory investment required throughout the supply chain is the bottom level effect. **Application of AHP** indicates that vendor managed inventory is the best alternative solution to the problems caused by bullwhip effect but importance of every day low pricing and electronic data interchange can not be ignored to deal with variability in demand and information distortion respectively.

Analytical Network Process (ANP) approach has been applied in the research to suggest an **ANP based framework** An ANP framework seems logical in converting subjective assessment into the objective priorities of proposed alternative solutions. Calculation of Bullwhip Effect Reduction Weighted Index (BWERWI) depicting the effect of each alternative on all the three determinants of BWE indicates that for the illustrative problem the most significant alternative to reduce BWE is VMI followed by EDI and EDLP. The normalized values of BWERWI for different alternatives have also been provided in the research.

The bullwhip effect is undesirable and makes the supply chain less productive. This results in increased cost and losses to the organizations and sometime lost customers. Reduction of bullwhip effect is possible but complete removal of bullwhip effect in the supply chain seems to be impossible. **Modeling of bullwhip effect** has been done using **system dynamics**. Through modeling of a four members' supply chain, we have been able to identify the importance of information sharing, reduced order batch size and lead time to reduce bullwhip effect. Importance of information sharing, lead time and order batching has been identified and analyzed using statistical tools at appropriate places.

The four members' supply chain model run under different conditions have been compiled and their statistical significance has been tested using appropriate techniques. Quantification and analysis of the data collected has also been undertaken using correlation, t-test and F-test.

We have tried to model bullwhip effect mitigation environment for supply chain using graph theory and matrix method. It is an effective aid in improving the understanding of bullwhip effect from a supply chain perspective because of the quantification of bullwhip effect mitigation environment in a single numerical index termed as **Bullwhip Effect Mitigation Index (BWEMI)**. The suggested methodology would also help to benchmark and compare supply chains.