

# **Dynamic Assessment of Supply Chain Disruption Mitigation Strategies**

## **Abstract of the Thesis submitted by**

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Disruptions in the global supply chains are continually increasing in the recent years. The disruptions are often dynamic in nature and they cause frequent as well as large fluctuations in the supply chain systems. More often than not, the causes of poor resilience of the supply chain systems to major disruptive events lie within the system under consideration. Dynamic effect of disruption, although initiated by external triggers, is primarily driven by the structure of the system and the control policies adopted by the managers. It is imperative that the supply chain managers need better methods to deal with such disruptions and their subsequent effects on supply chain resilience beyond conventional risk management techniques. This thesis is a study of how supply chains can cope better in the face of disruption by studying the interrelationship of resilience, robustness and bullwhip effect and with the help of strategies such as emergency sourcing, real-time information sharing, and decoupling point positioning.

The thesis employs dynamic modeling and simulation approach to capture the dynamic behavior of supply chain systems driven by inherent causal structure, delays, non-linearities and policies. For that purpose, control engineering techniques and Forrester's system dynamics methodology are adopted. The modeling of the supply chains to capture the problems under study is done in generic settings with the help benchmark models with additional considerations. It is assumed that the disruptions to the systems are caused exogenously.

Four problems are addressed in this thesis. In the first problem, the interrelationship between resilience, robustness and bullwhip effect is explored using a benchmark supply chain model which is being subjected to disruption in the customer demand process. Control engineering techniques and simulation are made use of for the supply chain dynamics study. The results show that resilience and robustness are two conflicting performance characteristics and therefore, a trade-off can be established between them. It is also observed that improvement in resilience and reduction of bullwhip effect can be achieved simultaneously through a proper selection of control parameters. Outcome of the study provides practitioners with insights into control design strategies

to improve supply chain disruption mitigation without negatively affecting both smooth dynamic performance of a supply chain and the issues of demand application.

The second problem addresses the scenario when, as a disruption mitigation strategy, the manufacturer adopts emergency sourcing as the primary supplier is disrupted. The simulation experiments and analysis are carried out for both short-but-frequent and long-but-rare disruption scenarios with long-term profit and backlog of the manufacturer as performance measures. For the short-but-frequent scenario, the results show that a trade-off between improvement in service level and long-term profitability of the firm exists which is affected by cost, response time and spare capacity of the backup supplier. For the long-but-rare scenario, a trade-off between preparedness and recovery actions exists to improve both profit and service level requirements. Results of the research problem provide implications for managers to make necessary disruption mitigation efforts in the event of operational as well as high impact, exterior disruptions.

The third problem is to investigate the effect of sharing real-time disruption and inventory information to mitigate supplier disruption through proper order allocation between the two upstream dual sourced suppliers. The study first evaluates the value of information sharing in disruption mitigation efforts and then examines the effect of various control system design configurations of the manufacturer for improved dynamic performance in the information shared supply chain settings. The findings of this study can provide the basis for managers to make informed decisions about using mitigation strategies with their supply chain partners.

The fourth problem is to examine the influence of the positioning of material and information decoupling points on supplier disruption mitigation efforts. Here, the study adopts system dynamics modeling and simulation approach and present a generic assemble-to-order (ATO) manufacturing system experiencing supplier disruption. The results showed that the decoupling point locations positively influences the disruption mitigation efforts. The finding of the study can provide basis for deploying disruption mitigation strategy for the manufacturing firms that follow a hybrid production strategy.

**Keywords:** supply chain, disruption, resilience, bullwhip effect, information sharing, emergency sourcing, dual sourcing, decoupling point, control engineering, system dynamics