Abstract

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Design of Supply Chain Networks under Risk and Disruptions

Supply Chain Network design involves strategic decisions on the location of production plants, distribution centres, capacities and transportation quantities. Supply chains are subjected to different types of disruptions. Supply chain disruptions are unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain and, as a consequence, expose firms within the supply chain to operational and financial risks. In this research, two types of disruptions are considered capacity disruptions and demand disruptions. Each of these disruptions is considered separately and then a simulation based model considered the two types simultaneously. The first proposed model considers the effect of capacity disruptions on supply chain design. This model is formulated as a Genetic Algorithm (GA). The GA generates different designs of the supply chain network from the potential plants and distribution centres. For each design, Integer Linear Programming (ILP) is used to find the optimum links and quantities of products flowing through them with the objective of minimizing the design cost. Each plant has a failure probability. This model suggests after disruption event recovery plan based on using regular capacities of other plants overtime to compensate as much as possible for the lost production. The second model is a developed Multi-objective Genetic Algorithm (MGA) which is developed to obtain a Robust SCND that considers total and partial failure of the production plants. The production plants are modulated and the failure probability of each module is considered. The MGA model is able to quantify the disruption cost and measure the robustness of the networks and the trade-off between the SC cost and the robustness of the network. In the Third proposed model the disruptions in the demand side are considered. A robust optimization approach is developed for the supply chain network design under demand uncertainty. The supply chain problem considered is a multi-product multi-period multi-echelon. The problem is formulated as a multi-objective model and solved using Goal programming (GP). The objectives are to maximize contribution, minimize the investment and disruptions costs. Instalment of production modules incrementally based on the demand at each planning period was considered. The Forth proposed model is a Monte Carlo simulation model. Through simulation, partial plant disruptions were considered. Each plant is subjected to disruptions in the availability of the machinery, performance and quality of produced units. Also the model considers the variability in demand. Several mitigation plans are tested which are, increasing regular capacity, using overtime, using inventory and combination between theses plans. Experiments are conducted to study the network performance when subjected to different kind of disruptions. From the computational results it was found that the failure cost represent a significant value of the total cost and should be considered from the design phase. Also in case of networks that are subjected to higher probabilities of disruptions the failure cost increases significantly and it might be better to design network which is not optimal in the basic case. Also the results of robust optimization showed that the design vary significantly with demand range of variability. The profit, contribution and total cost are highly sensitive to the ratio between disruption losses and selling price. The continuous instalment of production modules as the demand increases with time has reduced considerably the investment cost represented by the present worth. The ratio between the losses due to shortage/over-production and the selling price has a significant effect on the contribution and the total cost. The higher the value of this ratio is the higher the cost and the lower the contribution. However this ratio had no effect on the investment cost as the investment cost decrease with the increase in the demand variability. It was also proved that the higher the interest rate is high, the higher the saving in investment if the instalments are made on time of demand requirement. The results of the simulation showed that for the Multi-Period Supply Chain Performance under capacity and demand disruptions the plan considering overtime only had the best performance from the cost and profit point of view while the plan considering higher initial capacity and inventory had the best performance from the robustness point of view.