Upcoming Operations Research Ph.D. Final Exam

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(Q, r) Inventory Policies under Uncertain Supply Chain Environment

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Abstract
In the classic inventory (Q, r) systems, demand and leadtime data are assumed to be available and follow normal distributions, and supplier is assumed to be reliable. However, in the new global Supply Chain (SC) environment, SCs are dynamic and full of uncertainties. How to adapt (Q, r) policies to new uncertain supply chain environment is an interesting topic to explore. This work provides new methods to decide continuous inventory policies under risky SC environment.

In the first part, we develop a (Q, r) model based on fuzzy-set representations of various sources of uncertainty in the SC. Sources of risk and uncertainty in our model include demand, lead time, supplier yield, and penalty cost. The naturally imprecise nature of these risk factors in managing inventories is represented using triangular fuzzy numbers.

In addition, we introduce a human risk attitude factor to quantify the decision maker’s attitude toward the risk of stocking out during the replenishment period. The total cost of the inventory system is computed using defuzzification methods built from techniques identified in the literature on fuzzy sets. A numerical example is provided to compare our fuzzy-set computations with those generated by more traditional models that assume full knowledge of the distributions of the stochastic parameters in the system. Our analysis supports that fuzzy set theory provides a means of actually quantifying the cost of not knowing the underlying demand distribution and parameters.

In the second part, we construct a serial multiple-level SC coordination model by (Q, r) policies in the same fuzzy risk environment presented in the first part. Heuristics analogous to classical (Q, r) policies are presented to determine local optimal policies for multiple installation instances on the basis of techniques identified in the literature on fuzzy sets. An external coordinator with three roles is introduced and a coordination process is implemented to improve SC performance to meet a target. Numerical examples and simulation results are given to illustrate heuristics and validate coordination processes.

In the third part, we study the impact of continuous review inventory policy by a supplier with partial and random yield. We first examine revised EOQ model with a two-stage partial yield supplier, then we discuss (Q, r) policy under a supplier with one additional stage of supply stoppage. We assume that demand arrival follows Poisson process, and each supply stage duration is exponentially distributed. Two situations in (Q, r) policy: instant replenishment and non zeros lead time, are studied by Renewal Reward Processes, and in each case total logistics cost function with a fill rate constraint is derived. An efficient heuristics based on pattern search is put forward to search for the optimal policy. Numerical examples and Monte-Carlo simulation results are presented to evaluate our approaches.