A Simulation-Based Optimization Approach to a Lost Sale Stochastic Inventory Model

Rafael Diaz, Old Dominion University, USA
Barry Charles Ezell, Old Dominion University, USA

ABSTRACT

This paper describes a stochastic inventory model where the control review system is periodic; demand contains auto-correlated components; and categorized as a lost sale case. The authors propose a simulation-based optimization based on using a combination of simulated annealing, pattern search, and ranking and selection methods to search and approximate solutions to this problem. Simulated annealing is employed to stochastically nominate and pre-select solutions in a decision space. Pattern search is used to systematically define a grid of competitive neighbors around pre-selected solutions. Ranking and selection is used to evaluate the performance of such competing pre-selected alternatives. On one hand, results show that service level in terms of filling rates deteriorate as the autocorrelation grows and is ignored. In contrast, service levels were kept almost invariable to the effects of the serially correlated components for solutions suggested using the proposed algorithm.

Keywords: Autocorrelated Demands, Control Review System, Simulated Annealing, Simulation-Based Optimization, Stochastic Inventory Model

INTRODUCTION

There is a long-standing attention to the effects of uncertain demand on supply chains with regard to both practical and theoretical issues. The effects of demand uncertainties are often observed over supply chain performance, and these uncertainties evidently affect the ability to control costs and generate revenues. These uncertainties are frequently so variable that they force operational and strategic managers to constantly review their forecast and modify the planning and control processes. This in turn may affect decisions pertaining to sales and operating planning.

Properly recognizing these uncertainties make a difference between successful supply chain and others. To achieve a strategic fit is essential to understand both relevant sources of variability as well as their effects. To meaningfully consider these complexities it is necessary to employ a framework that would allow managers to capture information in relation to demand uncertainty and transform it into usable knowledge. This information may be used to design policies that enable the firm to minimize...
risk exposure and maximize its opportunity to better match supply with demand.

Matching the supply with demand is a constant challenge in supply chains. The configuration of supply chain assets is generally rigid while demands continuously fluctuate. Mechanisms that address issues related to matching the demand and the supply are quite diverse. Inventories and capacities are effective levers for balancing the supply and demand from the supply perspective. On the other hand, managers can use advertising and marketing tools to spur increases in the demand from the demand viewpoint. Other levers include information, sourcing, and pricing.

Pricing is an essential lever in increasing revenue resultant from supply chain assets utilization. Pricing decisions shape the amount of product demanded, and therefore, revenue generated. Revenue management advocates use pricing decisions as a critical element to improve the matching of the supply and the demand. As a result, the opportunity to maximize profits derived from supply chain assets increases.

Pricing decisions play a key role in promoting sales and are one of the instruments for maximizing the revenues generated by the supply chain. Common pricing strategies include everyday low pricing (EDLP) and Promotion policy (Hi Lo). Lee, Padmanabhan, and Whang (1997), have identified and mathematically proved that promotion policy is one of the contributors of the ‘bullwhip effect’. Lee, Padmanabhan, and Whang (1997), characterize the ‘bullwhip effect’ as the increased variance in demand that is observed as we move upstream in a supply chain. This basically means that the demand variance in supplier orders would be much greater than that observed in retailer orders or sales. This amplification of variance can mislead supply chain members in making inventory decisions that can cause significant losses. This leads Lee, Padmanabhan, and Whang (1997) to propose the use of EDLP as against Hi Lo pricing strategy. Lummus, Duclos, and Vokurka (2003), note that major retailer Wal-Mart has been using the EDLP strategy successfully. However, there are reasons that would lead a supply chain member to launch promotion and offer pricing discounts to another member downstream. For example, Blattberg, Eppen, and Lieberman (1981) point out that retailer may use price promotions to attract customers from other retailers and gain market share. They also introduce the idea that an upstream member may offer a price discount to a downstream member with the intention of relieving himself of the inventory holding cost. O’Donnell, Maguire, McIvor, and Humphreys (2006), suggest that in an ideal world all the firms would use EDLP, however practically companies do use price promotions to increase their market share and profits.

The above discussion points to the fact that many organizations tend to use price promotions to gain certain benefits although it has been pointed out as a major cause for the well-known bullwhip effect. This situation urges the need for proper analysis of the effects of promotion mechanisms over other levers such as inventories. The key factors in this analysis are deciding the depth and frequency of the discount as well as the inventory and capacity policies that support the implementation of such mechanisms.

The price promotion policies are commonly practiced in retail environment. One of the important concerns in analyzing these systems is the proper modelling of the uncertain demand pattern. Lee, So, and Tang (2000) have reported that a positive autocorrelation is commonly found among a large number of retail products in varying proportions. Many studies including (Kahn, 1987; Miller, 1986; Lee, So, & Tang, 2000) have used this method to model serially correlated demand patterns. Kurata and Liu (2007) used a modified version of the autoregressive AR (1) method called as the Markov switching time series to model a demand pattern under promotion.

Different inventory models that consider auto-correlated demands have been studied before. Positive auto-correlated demands were considered in the work of Hausman and Erkip (1994), who examined the inventory /warehouse of a major national supplier of consumer
Selection of Concrete Production Facility Location Integrating Fuzzy AHP with TOPSIS Method
www.igi-global.com/article/selection-concrete-production-facility-location/69513?camid=4v1a