An Integrated Vendor-Buyer Model with Uncertain Lead Time, Life Time Under Inflation and Variable Holding Cost

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ABSTRACT

This study considers the problem of a vendor which supplies an item to the buyer with imprecise partial backlogging rate of unsatisfied demand and non instantaneous deterioration rate considering variable holding cost, the effect of inflation and time value of money. The supplier’s lead time is a stochastic function of his managing cost. The extra costs incurred by the retailer due to the uncertain lead time in terms of shortage costs or lost sales costs should be owed by the supplier. A numerical example is cited to illustrate the results and its significant features. Finally, to study the effect of changes of demand parameters, deterioration, inflation and managing cost on supplier and the retailer’s profit, a sensitivity analysis is presented numerically.

Keywords: Inflation, Life Time, Partial Backlogging, Supply Chain, Uncertain Lead Time, Variable Holding Cost

INTRODUCTION

Besides, in almost every business, supplier suffers from the problem of uncertain lead time at his end as well as the lead time is inversely proportional to the managing cost of the supplier. More the supplier is ready to spend as the managing expenses; smaller will be the lead time and vice-versa. However, there is a constraint upon the cost; the supplier can afford to spend. Due to his goodwill supplier is also willing to owe the extra cost incurred on retailer in terms of shortages cost and lost sales cost due to uncertain lead time. Due to the uncertainty of the arrival of replenishment unsatisfied demand is fulfilled at an imprecisely partially backlogging rate.

Liao and Shyu (1991) showed that lead time can be controlled through crashing. Later on, Ouyang et al. (1999) investigated uncertain lead time and studied the effect of cost reduction in a continuous review inventory model. Even then, this is a realm which has not been sufficiently explored by researchers.

Another area which is comparatively untouched is the concept of capital constraint for...
the supplier. However, as is very much evident from the face of facts, this constraint is very common. Khouja and Mehrzad (1996) explored a constrained multi product newsboy problem with progressive multi discount. Lau and Lau (1996) in the same year studied the newsstand problem for a capacitated multi product single period inventory system. Other researchers related to this area such as Khouja (1999) and Pasternack (2001).

The supply chain models in inventory are a comparatively new foray for researchers. There has been especially very limited research for a supply chain in inflationary environment. The idea of joint total cost of the supplier and the customer was first introduced by Goyal (1976). Later, Cohen and Lee (1988) determined material requirement for all materials at every stage in a supply chain. Subsequent contributions in this direction came from researchers like Pake and Cohen (1993), Gyana and Bhabha (1999), Sarker et al. (2000), Chein and Lin (2004) and Ahmed et al. (2007).

Singh et al. (2009) developed an Economic Order Quantity models for retail supply chain with time dependent demand. In recent years, inventory problems for deteriorating items have been widely studied after Ghare and Schrader (1963). They presented an EOQ (Economic Order Quantity) model for an exponentially decaying item with constant demand. Later, Covert and Philip (1973) used a variable deterioration rate of two-parameter Weibull distribution with constant demand rate and no shortages. Philip (1974) then developed the inventory model with a three-parameter Weibull distribution rate and no shortages. Shah (1977) extended Philip’s (1974) model and considered that shortage was allowed. Goyal and Giri (2001) provided an excellent and detailed review of deteriorating inventory literatures since the early 1990s. This work was extended by Goyal and Giri (2003), Ghosh and Chaudhari (2004) and Dye (2007). Singh et al. (2009) developed a supply chain model for ameliorating and deteriorating products.

The holding cost is explicitly assumed to be varying over time in only few inventory functions. This is particularly true in the storage of deteriorating and perishable items such as food products. Goh (1992) has taken holding cost variation over time as a continuous non-linear function. Shao et al. (2000) determined a manufacturing process with variable holding costs. Beltran and Krass (2002) considered deterministic time varying demands and concave holding costs. Singh et al. (2009) assumed an inventory model with power demand, partial backlogging and incremental holding cost under inflation.

Although a number of studies have been done on the supply chain system but still most of the researchers consider a constant holding cost, zero lead time and instantaneous deterioration rate. Hence, in our present study we undertake to study a supply chain network for more matching the problem to realistic situations taking into account the views of both the vendor and the buyer. Also we have considered the effect of inflation. This way the whole research caters to put forward some aspects of a supply chain with some real world considerations and market deliberations. Finally, a numerical example along with sensitivity analysis has been done to explore the model numerically.

**MATHEMATICAL MODELING**

Initially the retailer has placed an order at \( t = 0 \) that would have been sufficient for a length of \( T \) units of time. Let the fixed quantities be denoted by \( I_0 \). Then:

\[
I_0 = \int_0^T D(t)dt
\]

\[
I_0 = \frac{1 - e^{-\lambda T}}{\lambda}
\]

Due to the lead time problem at the supplier end, the order reaches the retailer at \( t = y \). During this time retailer backlogs the shortages arising due to absence of stock. These shortages are partially backlogged at a constant rate. After the arrival of stock, retailer first clears the backlog. As a result, after clearing of the
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