EOQ Model with Stock-Level Dependent Demand and Different Holding Cost Functions

H.S. Shukla, DDU Gorakhpur University, Department of Mathematics, Gorakhpur, India
R.P. Tripathi, Graphic Era University, Department of Mathematics, Dehradun, India
Neha Sang, DDU Gorakhpur University, Department of Mathematics, Gorakhpur, India

ABSTRACT

This paper presents EOQ (Economic Order Quantity) model with stock-level dependent demand and different types of holding cost function. We show that the total relevant inventory cost per unit time is convex with respect to cycle time. Mathematical models are established to determine optimal order quantity and total relevant inventory cost. Numerical examples are provided for two different models i.e. (i): Instantaneous replenishment with inventory dependent holding cost and (ii) Instantaneous replenishment with quadratic time dependent carrying cost. Numerical examples are provided to illustrate the proposed model. Sensitivity analysis of the optimal solution with respect to the parameters of the system is carried out. The second order approximation is used for finding closed form optimal solution. Mathematica 5.2 software is used to find numerical results.

KEYWORDS
Holding Cost, Inventory, Nonlinear Demand, Order Quantity, Stock-Dependent Demand, Total Cost and Cycle Time

INTRODUCTION

It is a real-life problem for many industries for deteriorating items how to prevent deterioration so that the items can be used for a long time. The crucial issues of the deteriorating inventory management that the supply chain’s societies are facing since last few decades. The main problems of deteriorating items are to keep fresher till these are handed over on last customer’s hands. All most all items in the universe deteriorate over time, while deteriorate rates for some items are very high and low for some items. Therefore, in the study of inventory problem, the presence of deterioration cannot ignore. In this paper, we analyze an inventory model for time varying deterioration under ramp type demand which is exponential time dependent this type of demand can be seen sudden produced commodities for sell in the market. This type of demand is applicable in real life such as seasonal commodities. The unit production is considered as inventory proportional to the demand. In this paper, we assume that the unit production cost is increasing function of demand. In case of disasters, storm and earth quake the production of and demand is proportional to each other. In rainy season the production of umbrella is increases, the demand of it is also increases.
Under the traditional inventory model the demand rate is considered as either constant or time-dependent but it is independent of stock-status. For certain types of item, specially consumed goods, the consumption rate may go up and down with the stock level. Goh (1994) considered the continuous, deterministic, infinite horizon, single item inventory system within on the existing inventory level. Alfares (2007) established inventory models for variable holding cost. Most of the models that consider demand variation in response to item availability assume that the holding cost is constant for the entire inventory cycle. In this paper, we present inventory model with stock-level dependent demand rate and different holding cost functions. Two types of holding cost are considered (i) stock-dependent (ii) quadratic time dependent. Baker and Urban (1998) and Dutta and Pal (1990) have concentrated their work on the deterministic inventory system with an inventory level dependent demand rate and with the holding cost held at a constant rate of \( h \) per unit per unit time. Soni and Shah (2008) developed a mathematical model to formulate optimal ordering policies for retailer when demand is partially constant and partially dependent on the stock and the supplier offers progressive credit periods to settle the account. Silver and Peterson (1982) observed that a sale at the retail level is directly proportional to the amount of inventory displayed. Gupta and Vrat (1986) established an EOQ model in which demand rate to be a function of initial stock-level. Mandal and Phanjdar (1989) developed productions inventory model for deteriorating items with uniform rate of production and linearly stock-dependent demand. Paul \textit{et al.} (1996) established a deterministic inventory system in which shortages are allowed and are fully backlogged. Pal \textit{et al.} (1993) developed a deterministic inventory model assuming that the demand rate is stock dependent and that the items deteriorate at a constant rate \( \theta \). Ray and Chaudhuri (1993) took the time value of money into account in analyzing an inventory system with stock-dependent demand rate and shortages. Padmanabhan and Vrat (1995) presented inventory models for permissible items with stock-dependent selling rate. Sarkar \textit{et al.} (1997) developed an order level lot size inventory model with inventory-level dependent demand and deterioration. Hou (2006) derived an inventory model for deteriorating items with stock dependent consumption rate and shortages under inflation and time discounting over a finite planning horizon. Balkhi and Benkherouf (2004) presented an inventory model for deteriorating items with stock-dependent and time-varying demand rate over a finite horizon. Other related research articles/papers on inventory systems with stock-dependent consumption rate have been developed by Lev (1994), Urban (1995), Mandal and Maiti (1999), Vrat and Padmanabhan (1990), Giri \textit{et al.} (1990).

Teng (2005) established an EOQ model to allow for shortages for deteriorating items and non-zero ending inventory. Goyal and Chang (2009) developed an ordering-transfer inventory model to determine the retailer’s optimal order quantity and the number of transfer per order from the warehouse to the display area. Yang \textit{et al.} (2010) developed a partial backlogging inventory model for deteriorating items with stock-dependent demand. Teng \textit{et al.} (2011) established an EOQ model for ending inventory to be zero and profit maximization. Soni and Shah (2008) presented a mathematical model to formulate optimal ordering policies for retailer when demand is partially constant and partially dependent on the stock and the supplier offers progressive credit periods to settle the account. Liao \textit{et al.} (2000) developed an inventory model for stock-dependent demand rate when delay in payment is permissible. Sarkar (2012) established an EOQ model for a firm to replenishment rate, stock-dependent demand, imperfect production and delay in payment with two progressive periods.

The demand functions increase with time in the growth stage of the product life cycle. We propose in this paper to extend the constant demand to be a quadratic non-decreasing demand function of time. Teng \textit{et al.} (2012) developed an EOQ model under trade credit financing with increasing demand. Sarkar (2012) established an EOQ model for firm to replenishment rate where demand and deterioration rate are both time-dependent. Skouri \textit{et al.} (2011) presented an order level inventory model for deteriorating items with general ramp type demand rate under condition of permissible delay in payments. Khanna \textit{et al.} (2011) established an EOQ model for deteriorating items having
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