EOQ Model with Time Dependent Demand Rate and Time Dependent Holding Cost Function

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ABSTRACT
In this paper the authors consider the continuous deterministic, infinite horizon, single item inventory system within the setting of a retailer sector in which the demand rate for an item is time dependent. The parameter of the replenishment cost is kept constant, but the carrying cost per unit is allowed to vary. The optimal policies are found, and decision rules and classical EOQ model have been obtained by considering two different models. Numerical examples are given to illustrate the proposed models.

Keywords: Classical EOQ Model, Demand Rate, Holding Cost, Inventory Control, Retail

INTRODUCTION
Inventory models have been developed for which the demand rate is constant, a function of the length of time an item is held in inventory or a function of the on hand stock. Muhlemann and Valtis-Spanopoulos (1980), for example, investigated the EOQ model for constant demand rate with a variable holding cost, which is expressed as a percentage of the average value of capital investigated in stock.

An EOQ inventory system with the holding cost as a non-linear function of inventory has also been presented by Van der Veen and Weiss (1982) too, studied the traditional EOQ model but with the holding cost per unit modified as a non-linear function of the length of time an item is held in stock. Naddor (1966) gives a detailed derivation of the total inventory cost for a constant demand rate lot size system, when the holding on hand is cost as $q^m t^n$, where $q$ is the stock held and $t$ is the length of time it is kept, $m$ and $n$ being integers. Weiss and Van der Veen’s (1982) work is generalized by Naddor. In real life situations, the inventory loss is caused not only by a constant demand rate but also by deterioration. In the past few decades, many researchers have studied inventory models for deteriorating and non-deteriorating items. According to Baker and Urban, who asserted that “to keep sales higher, the inventory would need to remain higher, of course, this would also

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result in higher holding or carrying ……… costs”. Goh (1992) consider a model in which demand rate is deterministic and known function of level of inventory. We extend this paper and considered the demand rate is deterministic and is known function of time ‘t’. One of the important concepts for controlling inventory of the management is to decide when and how much to order or to manufacture, so that the total cost associated with the inventory system should be minimum. In some cases inventory undergo deterioration or decay. Deterioration means spoilage, obsolescence, damage, change, and loss of original values in a product or commodity that results in the decreasing usefulness from the original one. Some products like blood, vegetable, medicine, gasoline, volatile liquids and radioactive chemicals loss original form under deterioration during their normal storage period. Such types of items or commodities, while determining the optimal inventory policy of that type of product, the loss due to deterioration cannot be ignored.

Recently Baker, Urban, and Dutta (1988) and Pal (1990) have focused 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 time. Goh (1994) considered the model developed by Baker and Urban and relax the assumption of a constant holding cost. The holding cost, instead, treated as (a) a polynomial function of the length of time spent in holding (as in Weiss) and (b) a function form of the amount of on hand stock (as in Van der Veen).

Goh (1992) focused on inventory model having inventory level dependent demand rate. We are adopting the perspective by using a polynomial representation in time for holding cost that the value of keeping unsold inventory decreases with time. This type of inventory problem is often faced by retailer in the super market setting were products such as green vegetable have their setting price deceased markedly with each passing day, as a result of the loss in “freshness”. Holding on to such products will result in lost revenue. Viewed from this stand point, the temporal function from expression for holding cost is justified.

Singh et al. (2009) obtained an EOQ model for perishable items with power demand and partial backlogging in which he considered demand rate is time-dependent. Demand rate in this case is power pattern demand (PPD). Singh et al. (2008) obtained perishable inventory model in which it has been considered quadratic demand, backlogging and permissible delay in payments. Dye et al. (2007) obtained deterministic EOQ model for deteriorating items with capacity constraint and time proportional backlogging rate. A power demand pattern inventory model for deteriorating items was discussed by Dutta and Pal (1988). Roychowdhary and Chaudhuri (1983) were discussed an order level inventory model for deteriorating items with finite rate of replenishment.

In practice it can be observed that items having constant deterioration rate occurs rarely. Hollier and Mark (1983) were considered the constant partial backlogging rates during the shortage period in their inventory model. Goyal (1985) developed an EOQ model under the condition of permissible delay in payments. Goyal ignored the difference between the selling price and the purchase cost, and concluded that the economic replenishment interval and order quantity generally marginally increases under the condition of permissible delay in payments. Goyal’s (1985) model was corrected by Dave (1985) to allow for shortages and deterioration. Recently Jamal et al.’s model was extended by Chang and Dye (2001) by considering allowing for not only a varying deterioration rate of time but also the backlogging rate to be inversely proportional to the waiting time. Teng (2002) provided an alternative form from Goyal (1985), and proved mathematically that it makes economic sense for a well-established buyer to order less quantity and take the benefits of the permissible delay more frequently. Teng’s model was extended by Chang et al. (2003) and established an EOQ model for deteriorating items in which the supplier provides a permissible delay to the purchaser if order quantity is
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