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Two storage inventory problem with dynamic demand and interval valued lead-time over finite time horizon under inflation and time-value of money

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Abstract

A finite time horizon inventory problem for a deteriorating item having two separate warehouses, one is a own warehouse (OW) of finite dimension and other a rented warehouse (RW), is developed with interval-valued lead-time under inflation and time value of money. Due to different preserving facilities and storage environment, inventory holding cost is considered to be different in different warehouses. The demand rate of item is increasing with time at a decreasing rate. Shortages are allowed in each cycle and backlogged them partially. Shortages may or may not be allowed in the last cycle and under this circumstance, there may be three different types of model. Here it is assumed that the replenishment cycle lengths are of equal length and the stocks of RW are transported to OW in continuous release pattern. For each model, different scenarios are depicted depending upon the re-order point for the next lot. Representing the lead-time by an interval number and using the interval arithmetic, the single objective function for profit is changed to corresponding multi-objective functions. These functions are maximized and solved by Fast and Elitist Multi-objective Genetic Algorithm (FEMGA). The models are illustrated numerically and the results are presented in tabular form.

Keywords: Interval valued Lead-time; Interval numbers; Multi-objective inventory model; Two warehouse; Inflation and time value of money; Finite time horizon; Multi-objective Genetic Algorithm

1. Introduction

Since the development of EOQ model by Harris [1], a lot of development/extension on the inventory control system with constant demand has been reported in the literature [2–4]. In reality, there are many situations where the demand rate depends on time. Silver and Meel [5], Doneldson [6], Wee and Wang [7], Change and

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Dye [8], Goyal et al. [9] and others developed their models with dynamic demand. Dey et al. [10] considered a demand function, which is increasing with time at decreasing rate.

In the busy markets like super market, corporation market, municipality market etc., the storage area of items is limited. When an attractive price discount for bulk purchase is available or the cost of procuring goods is higher than the other inventory related cost or demand of items is very high or there are some problems in frequent procurement, management decide to purchase a large amount of items at a time. These items cannot be accommodated in the existing store house (viz. the Own Warehouse, OW) located at busy market place. In this situation, for storing the excess items, one (sometimes more than one) additional warehouse (viz., rented warehouse, RW) is hired on rental basis, which may be located little away from it. We assume that the rent (holding cost for the item) of RW is greater than OW and hence the items are stored first in OW and only excess stock is stored in RW, which are emptied first by transporting the stocks from RW to OW in a continuous release pattern for reducing the holding cost. The demand of items is met up at OW only. In this connection several researcher have considered extensions of the basic two warehouse inventory model discussed by Hartely [11]. Sarma [12] developed a deterministic inventory model with infinite production rate and two level of storage. Murdeshwar and Sathe [13] made an extension to the case of finite production rate. Further, Goswami and Chaudhuri [14] considered two storage models with and without shortages, allowing time-dependent demand (linearly increasing). Bhunia and Maiti [15,16] modified and studied a two-warehouse inventory model for deteriorating items considering linearly time-dependent demand and shortages (for single period). Kar et al. [17] developed a two-storage inventory model with linearly time dependent demand over finite time horizon without lead-time and inflation.

Due to high inflation and consequent sharp decline in the purchasing power of money in the developing countries like Brazil, Argentina, India, Bangladesh etc., the financial situation has been completely changed and so it is not possible to ignore the effect of inflation and time value of money any further. Following Buzacott [18] and Misra [19], several researchers ([20,21] etc.) have extended their approaches to different inventory models by considering the time value of money, different inflation rates for the internal and external costs, finite replenishment, shortages, etc.

Lead-time is the time gap between the placement of order and receipt of it. In stochastic environment, stochastic lead-time is represented by a probability distribution which is derived from the earlier data obtained from the past observations. Till now, researchers considered the lead-time stochastically with a probabilistic distribution. A number of research papers have already been published in this direction by Das [22], Magson [23], Foote et al. [24] etc. But, now a days, with the advent of new companies due to globalization and also due to the development/presence of many new products in the market, it is not possible to have past data/earlier observations and hence the required probability distribution cannot be formulated to represent the lead-time stochastically. Rather, it may be possible to a time-interval for the lead-time i.e., the time gap between the placement of order and receipt of order may be said to be within a certain time period i.e., time interval from one/two observations. Hence, now-a-days, consideration of *interval lead-time* for inventory models is very relevant for the new products of new companies. In the present paper, upper and lower limits of lead-time have been considered as dependent variables i.e., for a decision maker; the optimum interval for the lead-time has been derived to have maximum profit (based on central value).

In this paper we have extended the idea of Kar et al. [17] for a deteriorating item with time dependent demand (which is increasing at decreasing rate) and interval valued lead-time over finite time horizon. Inflation rate and time value of money are taken into account. Deterioration rate of an item is assumed to be different indifferent warehouses (OW and RW). This type of demand is applicable for new type of products. Shortages are allowed in each cycle (except in the last cycle) and backlogged them partially. Decision Maker (DM) may or may not allow shortages in the last cycle and under this circumstance, there may be three models (model 1, 2, 3). In each model, we assume that the replenishment cycle lengths are of equal length and in each cycle the stocks of RW are transported to OW in continuous release pattern. Using the interval arithmetic, the objective function for profit is changed to corresponding multi-objective functions. These functions are maximized and solved by multi-objective genetic algorithm developed for this purpose. Moreover, a maximum possible profit interval has been presented due to different interval values of lead-time for each model. The models are illustrated numerically and the results are presented in tabular form.