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ORIGINAL ARTICLE

A Periodic Review Inventory Model with Controllable Lead Time and Backorder Rate in Fuzzy-stochastic Environment

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Abstract In this paper, an attempt has been made to develop a periodic review inventory model by considering lead-time and the backorder rate as control variables in fuzzy stochastic environment. Without loss of generality, we have assumed that all the observed values of the fuzzy random variable, representing the demand as triangular fuzzy numbers. The variance of fuzzy random demand is taken into consideration to give due attention to every fuzzy observations. The protection interval demand has also been assumed to be fuzzy stochastic. The expected shortages are calculated by using credibility criterion. For the proposed model, we provide a solution procedure incorporating numerical technique viz. Scan and zoom method to determine an optimal policy. A numerical example is taken up to illustrate the solution procedure and sensitivity analysis of the optimal solution with respect to the key parameters of the system is carried out.

Keywords Periodic review system · Fuzzy random variable · Expected value · Variance

1. Introduction

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The acquisition, production and distribution of inventory are subject of concern to all organizations. Large costs are incurred as a result of replenishment, shortages and utilization of managerial time in making and implementing inventory management decisions. Thus, properly designed decision rules, based on mathematical modeling, can lead to substantial benefits. In this context, periodic review inventory control system is the most appropriate mathematical model to deal with such type of problems. In the real world, the most applied operating doctrine for the periodic review system is the order up to R doctrine. In this policy, the inventory level is examined at constant intervals and at the time of review an order is placed so as to bring the inventory level up to a target level R. In this regard, there are several possible operating policies discussed by Hadly and Whitin [1]. Later on, the numerous works have been published related to the periodic review inventory model to get closer to real situations. For instance, Montgomery et al. [2] studied both deterministic and stochastic demand inventory models with a mixture of backorder and lost sales. Donaldson [3] presented a periodic review inventory model with normal demand and derived the optimality conditions for the order-up-to level and the review period. Eynan and Kropp [4] developed a simple near optimal approach to determine the cycle time which minimizes ordering and holding costs when the service level is specified in advance. In the context of periodic review inventory model, researchers like, Chiang [5-8], Chan and Song [9], Chen and Chen [10] and Lee and Schwarz [11] have presented the model under different conditions.

In most of the earlier literature dealing with inventory problems in deterministic, probabilistic or fuzzy environment, researchers have considered lead-time as constant, stochastic or fuzzy. Therefore, it is not subject to control. According to Tersine [12] lead-time usually consists of the following components: Order preparation, order transit, supplier lead time, delivery time and setup time; in other words it is controllable. In many practical situations, lead time can be reduced by an added crashing cost; in other words it is controllable. By shortening the lead time, we can lower the safety stock (SS), reduce the loss caused by stock-out, improve the service level to the customer, and increase the competitive ability in business. Liao and Shyu [13] first formulated an inventory model in which lead-time is a unique decision variable and the order quantity is predetermined. Subsequently, many scholars have developed several inventory models considering the lead time as a decision variable (see [14-17]). Joshi and Soni [18] developed a (Q, R) inventory model with service level constraint and variable lead time in fuzzy-stochastic environment.

According to the opinion of Ouyang and Chuang [19] (also see [20]), under most market behaviors, they think that many products of famous brands or fashionable commodities may lead to a situation in which customers prefer their demands to be backordered while shortages occur. Certainly, if the quantity of shortages is accumulated to a degree that exceeds the waiting patience of customers, some may refuse the backorder case. This phenomenon reveals that, as shortages occur, the longer the length of lead time is, the larger the amount of shortages is, the smaller the proportion of customers can wait, and hence the smaller the backorder rate would be. Hence, they assumed that the backorder rate is dependent on the length of lead time through the amount of shortages. So, this paper considers a periodic review inventory model