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Multi-objective fuzzy inventory model with three constraints: a geometric programming approach

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Abstract

A multi-item multi-objective inventory model with shortages and demand dependent unit cost has been formulated along with storage space, number of orders and production cost restrictions. In most of the real world situations, the cost parameters, the objective functions and constraints of the decision makers are imprecise in nature. Hence the cost parameters, the objective functions and constraints are imposed here in fuzzy environment. This model has been solved by geometric programming method. The results for the model without shortages are obtained as a particular case. The sensitivity analysis has been discussed for the change of the cost parameters. The models are illustrated with numerical examples.

Keywords: Inventory; Geometric programming; Multi-criteria evaluation; Fuzzy number; Fuzzy goal programming

1. Introduction

In general the classical inventory problems are designed by considering that the demand rate of an item is constant and deterministic and that the unit price of an item is considered to be constant

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and independent in nature [11,18,21]. But in practical situation, unit price and demand rate of an item may be related to each other. When the demand of an item is high, an item is produced in large numbers and fixed costs of production are spread over a large number of items. Hence the unit cost of the item decreases, i.e., the unit price of an item inversely relates to the demand of that item. So, demand rate of an item may be considered as a decision variable. Cheng [6], Jung and Klein [13] formulated the economic order quantity (EOQ) problem with this idea and solved using geometric programming (GP) method.

GP method [10] is an effective method to solve a non-linear programming problem. It has certain advantages over the other optimization methods. The advantage here is that is usually much simpler to work with the dual than the primal. To solve a non-linear programming problem by GP method degree of difficulty (DD) plays a significant role. (It is defined as DD $=$ total number of terms in objective function and constraints-total number of decision variables-1). It will be difficult to solve the problem for higher values of DD. If DD $= 0$, the dual variables can be determined from the normality and orthogonality conditions. If DD > 0, there are infinite number of solutions of the system of constraint equations in the dual problem. So, one always tries to reduce the DD to avoid the numerical complexity. This method is now widely used to solve the optimization problem in inventories. Recently, Ata et al. [1] and Chen [5] developed some inventory problems and solved by GP method. Worral and Hall [27] analysed the inventory models with some constraints and solved by GP technique. Hariri and Abou-el-ata [12] and Abou-el-ata and Kotb [2] gave a new idea on GP to solve multi-item inventory problems. (Here, after, this new GP has called modified geometric programming (MGP).)

It is often difficult to determine the actual inventory costs of the inventory problem. They fluctuate depending upon different aspects. So the inventory cost parameters such as holding cost, set up cost, shortage cost are assumed to be flexible, i.e., fuzzy in nature. The inventory problem is controlled by some constraints. Restrictions on storage space, number of orders and production cost affect the optimal inventory cost. But, in real life problems, it is almost impossible to predict the total cost and resources precisely. These may be imprecise in nature. Decision maker may change these quantities within some limits as per the demand of the situation. Hence these quantities may be assumed uncertain in non-stochastic sense but fuzzy in nature. In this situation, the inventory problem along with constraints can be developed with the fuzzy set theory.

Zadeh [29] first gave the concept of fuzzy set theory. Later on, Bellman and Zadeh [3] used the fuzzy set theory to the decision-making problem. Tanaka [23] introduced the objectives as fuzzy goals over the α-cut of a fuzzy constraint set and Zimmermann [30] gave the concept to solve multi-objective linear-programming problem. Fuzzy set theory now has made an entry into the inventory control systems. Sommer [22] applied the fuzzy concept to an inventory and production-scheduling problem. Park [17] examined the EOQ formula in the fuzzy set theoretic perspective associating the fuzziness with the cost data. Das et al. [7], Roy and Maiti [19] solved a single objective fuzzy EOQ model using GP technique. De and Goswami [8] derived a replenishment policy for items with finite production rate and fuzzy deterioration rate represented by a triangular fuzzy number using extension principle.

In this paper we have formulated a multi-item, multi-objective inventory problem along with three constraints such as limited storage space, number of orders and production cost. Shortages are permitted but fully backlogged. The cost parameters and constraints are considered here in fuzzy environment. The problem has been solved by MGP technique. As a particular case, we also investigate the case when shortages are not allowed. The sensitivity analysis has been discussed for the change of cost parameters. The models are illustrated by numerical examples.