Applied Soft Computing 21 (2014) 12–27

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

Multi-item partial backlogging inventory models over random planninghorizon in random fuzzy environment

Dipak Kumar Jana[a,*], Barun Das[b,1], Manoranjan Maiti[c,2]

[a] Department of Applied Sciences, Haldia Institute of Technology, Haldia, Purba Medinipur 721657, India
[b] Department of Mathematics, Jhargram Raj, College, Jhargram 721507, West Bengal, India
[c] Department of Applied Mathematics with Oceanology and Computer Programming, Vidyasagar University, Midnapore 721 102, West Bengal, India

ARTICLE INFO

Article history:
Received 22 February 2013
Received in revised form
29 December 2013
Accepted 14 February 2014
Available online 20 March 2014

Keywords:
Genetic algorithm
Inventory
Multi-item
Partial backlogging
Inflation and time value of money
Random planning horizon
Random-fuzzy variables

ABSTRACT

In this paper, some multi-item inventory models for deteriorating items are developed in a random planning horizon under inflation and time value money with space and budget constraints. The proposed models allow stock dependent consumption rate and partially backlogged shortages. Here the time horizon is a random variable with exponential distribution. The inventory parameters other than planning horizon are deterministic in one model and in the other, the deterioration and net value of the money are fuzzy, available budget and space are fuzzy and random fuzzy respectively. Fuzzy and random fuzzy constraints have been defuzzified using possibility and possibility–probability chance constraint techniques. The fuzzy objective function also has been defuzzified using possibility chance constraint against a goal. Both deterministic optimization problems are formulated for maximization of profit and solved using genetic algorithm (GA) and fuzzy simulation based genetic algorithm (FAGA). The models are illustrated with some numerical data. Results for different achievement levels are obtained and sensitivity analysis on expected profit function is also presented.

Scope and purpose: The traditional inventory model considers the ideal case in which depletion of inventory is caused by a constant demand rate. However for more sale, inventory should be maintained at a higher level. Of course, this would result in higher holding or procurement cost, etc. Also, in many real situations, during a shortage period, the longer the waiting time is, the smaller the backlogging rate would be. For instance, for fashionable commodities and high-tech products with short product life cycle, the willingness for a customer to wait for backlogging diminishes with the length of the waiting time. Most of the classical inventory models did not take into account the effects of inflation and time value of money. But at present, the economic situation of most of the countries has been much deteriorated due to large scale inflation and consequent sharp decline in the purchasing power of money. So, it has not been possible to ignore the effects of inflation and time value of money any further. The purpose of this article is to maximize the expected profit of two inventory control systems in the random planning horizon.

1. Introduction

In the past few decades, many researchers have studied inventory models with constant demand or dynamic demand (cf. Maity and Maiti [1]), Taleizadeh et al. [2–5], Maity [6], and others). More over, in a competitive market, attractive display of units in the showroom is an important factor. Levin et al. [7] noted that at times, the presence of inventory has a motivational effect on the people around it. It is a common belief that large piles of goods displayed in a super market will lead the customers to buy more". Thus many business people use the attractive display of units in the showroom to influence the customers. Maiti and Maiti [8] Roy et al. [9,27], Maity [10] and others have developed inventory models with stock dependent demand.

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* Corresponding author. Tel.: +91 9474056163; fax: +91 03224252800.
E-mail addresses: dipakjana@gmail.com (D.K. Jana), barundas2004@yahoo.co.in (B. Das), mmaiti2005@yahoo.co.in (M. Maiti).
[1] Tel.: +91 9434994401.
[2] Tel.: +91 9434944709.

http://dx.doi.org/10.1016/j.asoc.2014.02.021

Table 1
Summary of related literature for multi-item partial backlogging inventory models.

Author(s) and year	Partially backlogged	Demand rate	Delay in payment	Imprecise environment	Multi-item
Roy et al. (2007) [9]	No	Stock dependent	No	Only fuzzy	No
Yang et al. (2010) [34]	Yes	Stock dependent	No	No	No
Taleizadeh et al. (2011) [2]	Yes	Uniform	No	No	No
Taleizadeh et al. (2013) [28]	Yes	Uniform	Yes	No	No
Taleizadeh et al. (2013) [29]	Yes	Uniform	No	Yes	No
Taleizadeh et al. (2013) [30]	Yes	Uniform	Yes	No	No
Taleizadeh et al. (2013) [31]	No	Uniform	Yes	No	No
Taleizadeh et al. (2013) [32]	yes	Uniform	Yes	Only Fuzzy	No
Present paper	Yes	Stock-dependent	Yes	Both Fuzzy &random	Yes

In most of the earlier inventory models, life time of an item is assumed to be infinite while it is in storage. But, in reality, many physical goods deteriorate due to dryness, spoilage, vaporization, etc., and are damaged due to hoarding longer than their normal storage period. The deterioration also depends on preserving facilities and environmental conditions in warehouses/storage. So, due to deterioration effect, a certain fraction of the items either damaged or decayed and are not in perfect condition to satisfy the future demand of customers for good items. Deterioration for such items is continuous and constant or time-dependent and/or dependent on the on-hand inventory. A number of research papers have already been published on the above type of items by Maiti et al. [1], Roy et al. [11] and others.

Moreover, the effects of inflation and time value of money are vital in practical situation, especially in the developing countries with large scale inflation. Therefore, the effect of inflation and time value of money can not be ignored in real situations. To relax the assumption of no inflationary effects on costs, Buzacott [13] and Misra [15] simultaneously developed an EOQ model with a constant inflation rate for all associated costs. Bierman and Thomas [16] then proposed an EOQ model under inflation that also incorporated the discount rate. Misra [17] then extended the EOQ model with different inflation rates for various associated costs. Recently, Chern et al. [18] proposed partial backlogging inventory lot-size models for deteriorating items with fluctuating demand under inflation. Maity and Maiti [14] developed a multi-objective optimal inventory control problem for deteriorating multi-items under fuzzy inflation and discounting. Yang et al. [34] proposed an inventory model under inflation for deteriorating items with stock-dependent consumption rate and partial backlogging shortages.

Normally production inventory models are developed in infinite planning horizon because it is assumed that the production-inventory process including the various inventory parameters, demand, etc. remain unchanged over the future infinite time. In reality, it is not so due to several reasons such as variation in inventory costs, changes in product specifications and designs, technological changes due to environmental conditions, availably of product, etc. Moreover, for seasonal products like fruits, vegetables, warm garments, etc. business period is finite. Das et al. [20] and others supported this idea. Rather, for seasonal products, the planning horizon is not fixed, it varies over the years and may be considered as a random variable with some probability distribution. Recently, Taleizadeh et al. [28–32] developed and solved some inventory models in fuzzy, random, fuzzy-random, and fuzzy-rough environments using soft computing and others techniques. Table 1 represents the summary of related literature for multi-item partial backlogging inventory models.

Use of Genetic Algorithm (GA) in complex decision making problems is well established (Michalewicz [25], Jana et al. [36]. A simple GA starts with a set of potential solutions (called initial population) of the decision making problem under consideration. Individual solutions are called chromosome. Crossover and mutation operations are performed among the potential solutions with some probability p_c and p_m, respectively, to get a new set of solutions and it continues until terminating conditions are encountered. Behavior and performance of a GA is directly affected by the interaction between the parameters, i.e., selection process of chromosomes for mating pool, p_c, p_m, etc. Poor parameter settings usually leads to several problems such as premature convergence. Extensive research work has been made to improve the performance of GA for single/multi-objective continuous/ discrete optimization problems during last two decades. Michalewicz [25] proposed a genetic algorithm named Contractive Mapping Genetic Algorithm (CMGA) where movement from old population to new population takes place only when average fitness of new population is better than the old one and proved the asymptotic convergence of the algorithm by Banach fixed point theorem. Bessaou and Siarry [12] proposed a GA where initially more than one population of solutions are generated. Genetic operations are done on every population a finite number of times to find a promising zone of optimum solution. Finally a population of solutions is generated in this zone and genetic operations are done on this population a finite number of times to get a final solution. Last and Eyal [23] developed a GA with varying population size, where chromosomes are classified into young, middle-age and old according to their age and lifetime. Genotype diversity, Phenotype diversity of the final population are obtained to measure the performance of the GA. Pezzellaa et al. [26] developed a GA for the Flexible Job-shop Scheduling Problem, which integrates different strategies for generating the initial population, selecting the individuals for reproduction and reproducing new individuals. Recently many papers have been developed in GA (cf. Narmatha and Devaraj [22], Jana et al. [35]).

In spite of the above mentioned developments, following lacunas still exist in the formulation and solution of inventory models of seasonal products.

- In the literature, there are very few inventory models [20,28–32] under random planning horizon. Till now, none has formulated multi-item inventory models allowing shortages under random planning horizon. This vacuum has been removed by this investigation.
- In a real-life inventory system, limitations on available budget and storing space are very often faced by the retailers. These resources are sometimes fuzzy or random fuzzy. None has considered an inventory model with fuzzy and random fuzzy constraints.
- Till now, none has developed inventory models with random planning horizon taking, imprecise effect due to inflation and discounting, stock-dependent demand with uncertain resource constraint into account. Present investigation considers the above mentioned factors.
- Here random-fuzzy constraint has been successively introduced for the first time in a inventory model and transformed to a corresponding deterministic one using possibility-probability chance constraint techniques.