Applied Soft Computing 28 (2015) 453–465

Contents lists available at ScienceDirect

Applied Soft Computing

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

An integrated production inventory model under interactive fuzzy credit period for deteriorating item with several markets

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ARTICLE INFO

Article history:
Received 21 March 2013
Received in revised form 18 May 2014
Accepted 30 November 2014
Available online 18 December 2014

Keywords:
Integrated production inventory
Multiple markets
Instantaneous replenishment
Part-payment
Fuzzy credit period

ABSTRACT

The presence of multiple markets create profitable opportunities to the supply chain system. In this regard, this paper consists of the joint relationship between a manufacturer and multiple markets in which manufacturer offers part-payment to the markets due to their collection of finished products during the production run time. Here it is also considered that manufacturer is facilitated with credit period by raw material supplier where credit period has been presented as an interactive fuzzy fashion. In this paper, two types of deterioration have been assumed such as one for finished products and the other for raw materials. A solution algorithm is presented to get fuzzy optimal profit for the proposed integrated production inventory system optimizing production run time. A numerical example is used to illustrate the proposed model. Finally, sensitivity analysis has been carried out with respect to the major parameters to demonstrate the feasibility of the proposed model.

1. Introduction

In real business world, sometimes a manufacturer, supplier and markets/retailer would like to make a long-term cooperative relationship as an integrated system to get a tensionless stable sources of supply and demand of items as well as reliability to gain optimum profit from each other. Globally, the industrial environment gradually becomes more and more competitive and much effort has been made towards the efficiency and effectiveness. So in this connection, the supply chain management plays an important role in the present situation. Pan and Yang [24] worked on integrated inventory system with controllable lead time. Chang et al. [2] addressed the optimal pricing and ordering policy for an integrated inventory model when trade credit is linked to order quantity. Then Chen and Kang [3] developed their integrated inventory model with permissible delay in payments. Ho et al. [13] enriched their integrated inventory model with price-and-credit-linked demand under two-level trade credit. There are many research works on integrated technique such as Goyal [10], Jaber and Osman [15], Huang [14] and Taleizadeh et al. [30].

In the inventory literature, there are many research works without consideration of production process. But sometimes, consideration of production process becomes necessary to describe a manufacturer's or supply chain model. Yang and Wee [36] developed an integrated production inventory model for deteriorating items. Law and Wee [18] enriched an integrated production-inventory model for ameliorating and deteriorating items taking account of time discounting. Ouyang et al. [22] took an optimal strategy for an integrated system with variable production rate and trade credit financing. Then Das et al. [8] improves a production policy for a deteriorating item under permissible delay in payments with stock-dependent demand rate. Soni and Patel [25] developed an integrated inventory system with variable production under partial trade credit. In an EPQ model, an optimal lot-sizing policy with production cost effects has been described by Teng et al. [33].

A manufacturer produces an item and it is sold at different markets. Again sometimes, it is seen that the markets have different selling seasons. So, manufacturer/supplier should have to adopt appropriate management policies/strategies in the business with the different markets. In a production inventory model with deteriorating items, He et al. [12] also considered multiple-market demands. Krichen et al. [17] described a single supplier and multiple cooperative retailers inventory model under permissible delay in payments. Then Pal et al. [23] researched on multi-echelon supply chain model in multiple markets with supply disruption.

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http://dx.doi.org/10.1016/j.asoc.2014.11.057
1568-4946/

Table 1
Comparison of articles.

Author(s) & published (year)	Integrated or not	Deterioration rate	Credit period	Market(s)	With production
Ghare and Schrader [9]	Not	Exponential	No	Single	No
Covert and Philip [6]	Not	Weibull distribution	No	Single	No
Goyal [10]	Integrated	No	No	Single	No
Goyal [11]	Integrated	No	Crisp	Single	No
Chu et al. [4]	Not	Constant	Crisp	Single	No
Pan and Yang [24]	Integrated	No	No	Single	Yes
Abad and Jaggi [1]	Integrated	No	Crisp	Single	No
Yang and Wee [36]	Integrated	Yes	No	Single	Yes
Teng et al. [32]	Not	No	Crisp	Single	No
Jaber and Osman [15]	Integrated	No	Crisp	Single	No
Law and Wee [18]	Integrated	Weibull distribution	No	Single	Yes
Ouyang et al. [22]	Integrated	No	Crisp	Single	Yes
Chang et al. [2]	Integrated	No	Crisp	Single	Yes
Chen and Kang [3]	Integrated	No	Crisp	Single	No
Das et al. [8]	Not	Constant	Crisp	Single	Yes
Huang [14]	Integrated	No	Crisp	Single	Yes
He et al. [12]	Not	Constant	No	Multiple	Yes
Chung and Liao [5]	Integrated	No	Crisp	Single	Yes
Ho [13]	Integrated	No	Crisp	Single	Yes
Krichen et al. [17]	Integrated	No	Crisp	Multiple	No
Liang and Zhou [19]	Not	Constant	Crisp	Single	No
Mishra and Mishra [21]	Not	Fuzzy	Crisp	Single	Yes
Yan et al. [35]	Integrated	Yes	No	Single	Yes
Mahata [20]	Not	Exponential distribution	Crisp	Single	Yes
Pal et al. [23]	Not	Constant	No	Multiple	Yes
Soni and Patel [25]	Integrated	Random	Crisp	Single	Yes
Su [26]	Integrated	Constant	Crisp	Single	No
Das et al. [7]	Integrated	Constant	Crisp	Single	Yes
Taleizadeh et al. [30]	Not	Constant	No	Single	Yes
Taleizadeh and Jolai [31]	Not	Constant	No	Single	No
Teng et al. [33]	Not	No	Crisp	Single	Yes
Wu et al. [34]	Not	Constant	Crisp	Single	No
Present paper	Integrated	Constant	Crisp and fuzzy	Multiple	Yes

In the business world, it is seen that a manufacturer produces the items which deteriorates as the time goes on. For example, some of the deteriorating items are - volatile liquids, medicine, fruit juice, cold-drinks etc. Ghare and Schrader [9] first derived an economic order quantity (EOQ) model by assuming exponential decay with constant demand. Next, Covert and Philip [6] extended Ghare and Schrader's constant deterioration rate to a two-parameter Weibull distribution. An EOQ model of deteriorating items was developed by Chu et al. [4]. Mishra and Mishra [21] worked on fuzzified deterioration under cobweb phenomenon and permissible delay in payments. After that, Taleizadeh et al. [28] enriched their inventory model for a deteriorating item with back-ordering and temporary price discount. A lot size model for deteriorating item with expiration dates under two-level trade credit financing was produced by Wu et al. [34].

Now-a-days in most of business, offering of a credit period to settle the account takes an important role. In the literature reviews, it is seen that raw materials supplier offers to manufacturer, manufacturer offers to wholesaler, wholesaler offers to retailers, manufacturer offers to markets a delay period which is crisp in nature to settle the account to entice the other. Goyal [11] derived a single item inventory model under the conditions of permissible delay in payments. Abad et al. [1] developed a seller–buyer model under permissible delay in payments by game theory to determine the optimal unit price with trade credit period, considering that the demand rate is a function of the retail price. Teng et al. [32] developed the optimal pricing and lot-sizing model under permissible delay in payments by considering the difference between selling price and purchase cost when demand rate is a function of the selling price. In supply chain system, Chung et al. [5] developed a simplified algorithm with two part trade credit. Liang and Zhou [19] described a two-warehouse inventory model for deteriorating items under conditionally permissible delay in payment. An EPQ-based inventory model for exponentially deteriorating items under retailer partial trade credit policy in supply chain was described by Mahata [20]. Su [26] worked on integrated inventory system with defective items allowing shortages under trade credit. Then Das et al. [7] woked on integrated supply chain model for a deteriorating item with procurement cost dependent credit period.

Real business world is full of uncertainties in non-stochastic sense, which leads to estimation of different inventory parameters as fuzzy numbers. Introduction to fuzzy set theory and basic ideas of fuzziness are described by Zimmermann [37]. Ko et al. [16] made a review on soft computing application in supply chain management system. Yan et al. [35] developed their integrated production distribution model with deteriorating item. Taleizadeh et al. [29] described a joint-replenishment inventory control problem using uncertain programming. For solving a fuzzy single-period problem, Taleizadeh et al. [27] developed meta-heuristic algorithms. Then Taleizadeh et al. [31] worked on fuzzy rough EOQ model considering quantity discount and repayment. From Table 1, it is seen that till now no researcher has worked on the integrated EPQ model for deteriorating item with fuzzy credit period in multiple sessional markets.

In this paper, a manufacturer receives the deteriorating raw materials from a supplier who offers a credit period (which is fuzzy in nature) to settle his/her account. We have also considered the fuzziness of the credit period in different ways. The manufacturer produces the item which deteriorates over time and supplies to the markets which have different selling seasons. The markets receive the required item as a lot at the beginning of its business. Those markets start their businesses before the production ends, they get an opportunity of part payment at the beginning and the remaining amount should be paid at the end of their own business. Here, the manufacturer and the markets maximize their profits as an integrated form to get rid of tension in the business.