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An interpolating by pass to Pareto optimality in intuitionistic fuzzy technique for a EOQ model with time sensitive backlogging

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ABSTRACT

This article fuzzyfies EOQ crisp model with backlogged while demand of the customers varies with selling price and promotional effort. The demand rate in stock out situation decreases with duration of the shortage period and it comes back to its initial rate since promotional effort continues. The cost function consists of set up cost, inventory cost, shortage cost and cost for promotional effort. The coefficient vectors of the concerned minimization cost function are considered as fuzzy numbers which are transformed into interval numbers. Then, the interval objective function has been transformed into a classical multi-objective EOQ model using intuitionistic fuzzy technique. A comparative study on Pareto optimality and optimality under Lagrange's interpolating polynomial function has been made illustrating numerical example.

1. Introduction

The basic characteristics of an inventory control problem consider two vital factors: (i) correct formulation of objective function based on versatile nature of the associated cost and demand functions, (ii) proper choice of optimization technique by a decision maker (DM) who can choose his/her best policy to overcome the bottlenecks of the problem associated with in the model. Like other factors, demand plays a pivotal role to characterize inventory management problems. According to Lau and Lau [27], a small change in demand pattern may result in a large change in optimal strategies of an inventory system. Several researchers [see Table 1A] formulated various types of objective function for an EOQ model considering the demand rate of the customers as a suitable function of time, selling price, on-hand inventory (stock) level and promotional effort, etc. [7,30,42,5,9,47,23,46,49,44,39,37,38]. Through its continuation we have defined the demand rate as an exponential function of the promotional effort which has a great implication in the competitive marketing system. Recently, research works on production and supply chain are extensively developed by (Cárdenas-Barrón with others, [21,32,33,34,35,36]).

Now, the operational part of the management of an inventory system is an another important factor of a business organization. In real situations, the nature of several cost components along with other parameters associated in an inventory model are non-randomly uncertain (fuzziness) rather than randomly uncertain (probability theory). Zadeh [48] first developed the concept of fuzzy set theory and later on Bellman and Zadeh [8] made an application of fuzzy set theory in several decision making problems of operations research. Thereafter, several research works (Table 1B) enlightened this noble

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Table 1A
Literature review in crisp environment.

Author	Assumptions on demand rate	Other assumptions/solution procedure
Barbosa and Friedman [7]	$D(t) = \alpha t^{\gamma-1}$ $\gamma >$ for increasing$\gamma <$ for decreasing $\gamma = 1$ for constant	EOQ model, no backlog, (r + 2) root law
Baker and Urban [5]	$D(q) = \alpha q^{1-\beta}$	EOQ model, disposal cost, profit function/slope of the curve method
Bhunia and Maiti [9]	$R(t) = \alpha - \beta Q(t) + \gamma D(t)$ $\alpha > 0, \gamma \geqslant 0, 0 \leqslant \beta < 1$ $D(t) = a + bt, a > 0, b \geqslant 0$ $R(t)$ is replenishment rate	Deterioration, discount, no backlog, Warehouse, multi-item, multi-stage EOQ
Cárdenas-Barrón [10]	EOQ model with fixed demand	Multi-stage, multi-customer supply chain
Cárdenas-Barrón et al. [11]	EOQ model with fixed demand	Two-stage supply chain with arithmetic–geometric approach
Cárdenas-Barrón et al. [12]	Fixed demand	Integrated production-inventory model in three-stage supply chain
Cárdenas-Barrón et al. [13]	EOQ model with fixed demand	VMI control system, multi-product with multi-constraint
Cárdenas-Barrón et al. [14]	Fixed demand with partial backlogging	Replenishment lot size, rework, multi-delivery policy
Ghosh et al. [21]	Price dependent demand, deterioration and partial backlogging and lost sale	Profit maximization
Ho et al. [23]	$D(p) = \alpha p^{-\beta}$ $\beta > 1$ is a price elasticity coefficients	Vendor–buyer trade credit, cash discount, delay in payments, joint profit
Kabiran & Olafsson (2011)	–	Optimization via simulation using golden region search
Lau and Lau [27]	Variable demand	Multi-echelon inventory and pricing model
Sachan [30]	$D(t) = kt$ k = Constant	EOQ model, shortage deterioration, up-down order quantity
Sana [32]	Demand influenced by sales teams' initiatives, deteriorating and ameliorating items	Profit maximization, multi-item EOQ model
Sana [33–35]	Sales teams' initiatives, stock and price sensitive demand	Profit maximization problem in a dynamical system
Sana [36]	EOQ model for stochastic demand under limited capacity of Own warehouse	Cost minimization problem
Sarkar et al. [37]	Time varying increasing demand	Cost function under inflation
Sarkar et al. [38]	Stock dependent demand	Profit function, imperfect production system
Sarkar and Sarkar [39]	Stock dependent demand with time varying deterioration	Profit function, EOQ model with partial backlogging
Urban and Baker [42]	$D(p,t,Q) = \alpha p^{-\varepsilon} t^{\gamma-1} Q^{1-\beta}$ $\alpha > 0, \varepsilon > 0, \gamma > 0, 0 < \beta < 1$	EOQ, pricing markdown
Yao et al. [46]	$D(p,\varepsilon) = \alpha - \beta p + \varepsilon$ ε is a random variable	Stochastic and price dependent demand, EPQ model, Return policy, Numerical and Stackelberg game method
You and Hsieh [47]	$D(p,t) = \alpha - \beta p + \gamma Q(t)$ p = unit selling price	EOQ profit model, changing price strategies
Wang et al. [44]	$D(p) = \alpha - \beta p$ p is selling price, α is primary demand, β is price sensitivity	Return EOQ, time-lag, profit model, reusable items
Zhang et al. [49]	$D_1(p_1,p_2) = a_1 - b_1 p_1 - \gamma(p_1 - p_2)$ $D_{12}(p_1,p_2) = a_2 - b_2 p_2 + \gamma(p_1 - p_2)$ γ = demand leakage rate	Profit function, Lost sales, imperfect fences, joint price
De et al Present article	$R = De^{\rho-\tau p}$ (normal demand) $D' = Re^{-(\sigma-\rho)t_2}$ (shortage time demand) p = unit selling price, ρ = promotional effort, t_2 = shortage period, $\sigma > \rho$	Cost minimization problem, then study with intuitionistic fuzzy set

concept in inventory as well as supply chain literature. Kaufmann and Gupta [25] developed a fuzzy mathematical model in engineering and management science. Zimmermann [50] studied in fuzzy linear programming problems with various types of objective functions. Vojosevic et al. [43] fuzzified the order cost into trapezoidal fuzzy number in the backorder model. Using this proposition, Wu and Yao [45] studied a fuzzy inventory with backorder for fuzzy order quantity and fuzzy shortage quantity. With the help of fuzzy extension principle, an economic order quantity in fuzzy sense for inventory without backorder model was developed by Lee and Yao [28]. Kao and Hsu [24] investigated a lot size reorder point inventory model with fuzzy demands applying the α-cut of the fuzzy numbers and ranking index method. Kumar et al. [26] formulated a fuzzy model with ramp type demand rate and partial backlogging. Recently, De and Sana [19,20], developed a fuzzy and