Continuous Review Inventory Model with Fuzzy Stochastic Demand and Variable Lead Time

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ABSTRACT

The present study considers a continuous review inventory system for the inventory model involving fuzzy random demand, variable lead-time with backorders and lost sales. The authors first use the triangular fuzzy number count upon lead-time to construct a lead-time demand. Using credibility criterion, the expected shortages are calculated. Without loss of generality, the authors have assumed that all the observed values of the fuzzy random variable, representing the demand are triangular fuzzy numbers. Consequently, the value of total expected cost in the fuzzy sense is derived using the expected value criterion or credibility criterion. For the proposed model, the authors provide a solution to find the optimal lead-time and the optimal order quantity along with the reorder point such that the total expected cost in the fuzzy sense has a minimum value. Numerical study is also provided to illustrate the results of proposed model.

Keywords: Continuous Review, Fuzzy Expected Value, Fuzzy Random Variable, Inventory, Lead-Time, Triangular Fuzzy Number Count

1. INTRODUCTION

In era of technology, every transaction in business can be reviewed on continuous basis for the purpose of monitoring and control. Being an important entity of business, inventory also requires continuous review for timely replenishment. In this context continuous review inventory system is an appropriate mathematical model to handle such problem. In traditional continuous review inventory systems, the lead-time demand deals with the probability theory and the annual average demand and the associated costs are presented by a crisp value (Hadley & Whitin, 1963; Singal et al., 1994). In addition, the issue of lead-time reduction has received a great deal of attention in the field of production/inventory management.

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We begin by reviewing recent studies on how to control lead-time. Liao and Shyu (1991) stated that lead-time is negotiable and can be decomposed into several components, each having a different piece-wise linear crash cost function for lead-time reduction. Ben-Daya and Raouf (1994) extended Liao and Shyu’s (1991) work to consider both lead-time and order quantity as decision variables. Moon and Gallego (1994) assumed unfavorable lead-time demand distribution and solved both the continuous review and periodic review models with a mixture of backorders and lost sales using the minmax distribution free approach. Ouyang et al. (1996) generalized Ben-Daya and Raouf’s (1994) assumption that shortages were allowed and constructed variable lead-time from a mixed inventory model with backorders and lost sales. Moon and Choi (1998), Hariga and Ben-Daya (1999) and Lan et al. (1999) pointed out three improvements for Ouyang et al. (1996). Moon and Choi (1998) considered the reorder point as a new decision variable. Lan et al. (1999) constructed a simplified solution procedure. Hariga and Ben-Daya (1999) developed five stochastic inventory models with complete and partial information about the lead-time demand distribution such that the reorder point is a decision variable. Chu et al. (1999) improved the solution procedure of Ben-Daya and Raouf (1994) by using the Newton–Raphson method with an appropriate starting point. Ouyang and Chuang (2000) considered a mixed periodic review inventory model in which the uncertainty of demand during lead-time is dealt with a probabilistic fuzzy set and annual average demand by a fuzzy number only. Chang et al. (2006) presented the same work considering lead-time demand as fuzzy random variable instead of probabilistic fuzzy set. Vijayan and Kumaran (2008) investigated the mixed \((Q, r)\) and \((R, T)\) inventory models including trapezoidal fuzzy costs. Thangam and Uthyakumar (2009) formulated a realistic supply chain model with imprecise demand, lead time and inventory costs. Recently, Shah and Soni (2011) developed continuous review inventory model for fuzzy price dependent inventory models with variable lead-time and present value.

There is no question that uncertainty plays a role in almost all scenarios dealing with inventory management. There are many reasons for variability and uncertainty in inventory systems. The conventional approaches for treating uncertainty in inventory management rely on probability theory. However, the probability based approaches may not be ample to reflect all uncertainties that may arise in a real world inventory system. On this view, several researchers used fuzzy set theory in modeling of inventory systems (cf. Chen et al., 1996; Chang & Yao, 1998; Yao & Lee, 1996, 1999; Yao & Chiang, 2003).

With the development of fuzzy set theory, the fuzzy/fuzzy stochastic approach has also been employed extensively for the characterizing the parameters of inventory problems. Along the direction of continuous review system several researchers have performed the investigation using different approaches in the fuzzy framework. For instance, Gen et al. (1997) proposed a new method for the continuous review inventory model where triangular fuzzy numbers represented input data. Kao and Hsu (2002) have considered a lotsize-reorder point inventory model with fuzzy demand. Chang et al. (2004) presented a lead-time reduction model based on continuous review inventory systems in which the uncertainty of demand during lead-time is dealt with a probabilistic fuzzy set and annual average demand by a fuzzy number only. Chang et al. (2006) presented the same work considering lead-time demand as fuzzy random variable instead of probabilistic fuzzy set. Vijayan and Kumaran (2008) investigated the mixed \((Q, r)\) and \((R, T)\) inventory models including trapezoidal fuzzy costs. Thangam and Uthyakumar (2009) formulated a realistic supply chain model with imprecise demand, lead time and inventory costs. Recently, Shah and Soni (2011) developed continuous review inventory model for fuzzy price dependent
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