Chapter 14
A Three-Level Supply Chain Model with Necessity Measure

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ABSTRACT

In this chapter, a vertical information sharing in terms of inventory replenishment / requirement from the customer(s)→ retailer(s)→ producer→ supplier(s) has been done. The constant imprecise fuzzy demands of the goods are made to the retailers by the customers. These goods are produced (along with defectiveness, which decreases due to learning effects) from the raw materials in the producer's production center with a constant production rate (to be determined). Producer stores these raw materials in a warehouse by purchasing these from a supplier and the suppliers collect these raw materials from open markets at a constant collection rate (to be determined). The whole system is considered in a finite time horizon with fuzzy demand for finished products and fuzzy inventory costs. Here shortages are allowed and fully backlogged. The fuzzy chance constraints on the available space of the producer and transportation costs for both producer, retailers are defuzzified using necessity approach. Results indicate the efficiency of proposed approach in performance measurement. This paper attempts to provide the reader a complete picture of supply chain management through a systematic literature review.

INTRODUCTION

A supply chain model (SCM) is a network of supplier, producer, distributor and customer which synchronizes a series of inter-related business process in order to:

1. Optimal procurement of raw materials from nature;
2. Transportation of raw materials into warehouse;
3. Production of the goods in the production center;
4. Distribution of these finished goods to retailer for sale to the customers.

With a recent paradigm shift to the supply chain (SC), the ultimate success of a firm may depend on its ability to link supply chain members seamlessly. One of the earliest efforts to create an integrated

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supply chain model dates back to Cachon and Zipkin [1999], Cohen and Lee [1988], Nair et.al. [2006]. They developed a production, distribution and inventory (PDI) planning system that integrated three supply chain segments comprised of supply, storage / location and customer demand planning. The core of the PDI system was a network model and diagram that increased the decision maker's insights into supply chain connectivity. The model, however was confined to a single-period and single-objective problem. Viswanathan and Piplani [2001] concerned an integrated inventory model through common replenishment in the SC. Hill. et.al. [2007] discussed the SCM with lost sale. Recently Sarmah et.al. [2008] designed a coordination of a single-manufacturer/multi-buyer supply chain. All the above SCMs are considered with constant, known demand and production rates.

Gradually the fuzzy demand over a finite planning horizon has attracted the attention of researchers (cf. Xie et,al. [2006] and others). This type of demand is observed in the case of fashionable goods, daily emerging products, etc. Moreover, the most of the product goods are breakable. Here the decrease of breakability represents by the transmission of learning justified through the experience gain in planning, organization and the familarity of the workers with their tasks. Keachie and Fontana [1966] first introduced the learning effect for a decision making problem in inventory control system. Jaber and Bonney [8] showed the learning effect of lot sizes in an economic manufacturing quantity model.

After the development of fuzzy set theory by Zadeh [1965], it has been extensively used in different field of science and technology to model complex decision making problems. Since Zimmermann [1976, 1978] first introduced fuzzy set theory into the ordinary linear programming (LP) and multi-objective linear programming (MOLP) problems, several fuzzy mathematical programming and techniques have developed by researchers to solve fuzzy production and/or distribution planing problems (cf. Liang [2011], Maiti and Maiti [2005, 2007], Liu and Iwamura [1998], Santoso, Ahmed, Goetschalckx and Shapiro[2005]). Moreover, Petrovic [2001] developed a heuristic based on fuzzy sets theory to determine the order quantities for a supply chain in the presence of uncertainties associated in the presence of uncertainties associated with customer demand,

deliveries.Das et.al [2005, 2007] designed a supply chain scheduling model as a multi-products, multi-stages and multi-periods mixed integer nonlinear programming problem with uncertain market demand, to satisfy conflict objectives. Wang and Shu [2005] presented a fuzzy supply chain model by combining possibility theory and genetic algorithm approach to provide an alternative framework to handle supply chain uncertainties and to determine inventory strategies. Xie, Petrovic and Bumham [2006] designed a two-level hierarchical method to inventory management and control in serial supply chains, in which the supply chain operated under imprecise customer demand and was modelled by fuzzy sets.

PREREQUISITE MATHEMATICS

Any fuzzy subset $\tilde{A}$ of $\mathbb{R}$ (where $\mathbb{R}$ represents the set of real numbers) with membership function $\mu_{\tilde{A}}$:$\mathbb{R} \rightarrow [0,1]$ is called a fuzzy number. Let $\tilde{A}$ and $\tilde{B}$ be two fuzzy numbers with membership functions $\mu_{\tilde{A}}$ and $\mu_{\tilde{B}}$ respectively. Then taking degree of uncertainty as the semantics of fuzzy number, according to Liu and Iwamura:

$$Pos\left(\tilde{A} * \tilde{B}\right) = \sup\{\min\min\left(\mu_{\tilde{A}}\left(x\right),\ \mu_{\tilde{B}}\left(y\right)\right),\ x,\ y\epsilon\,\mathbb{R},\ x * y\} \tag{1}$$