

Supply Chain Coordination through a Revenue-Sharing Contract with Two Kinds of Fuzzy Demand

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ABSTRACT

This paper studies a supply chain coordinated by a revenue-sharing contract in fuzzy environment. Two kinds of fuzzy programming models are discussed: revenue-sharing contract with fuzzy linear demand model and fuzzy iso-price-elastic demand model. Supply chain coordination in both centralized decision setting and centralized decision setting are achieved by obtaining the optimal solutions in the discussed settings.

Keywords: Demand Model, Fuzzy Demand, Revenue-Sharing Contract, Supply Chain, Supply Chain Coordination

1. INTRODUCTION

Supply chain coordination has been an important research field in recent years. Lots of researchers focus on supply chain contract which includes the quantity flexibility contracts (Tsay, & Lovejoy, 1999), backup agreements (Eppen & Iyer, 1997), buy back or return policies (Emmons & Gilbert, 1998), quantity discount contract (Weng, 1995), and revenue-sharing contracts (Cachon & Lariviere, 2005).

Revenue-sharing contract plays an important role in the field of supply chain management and has become more prevalent in some industry such as movie and video rental industry over the years. Many researchers have attempted to provide the foundations for the role of revenue-sharing contracts in aligning supply chain incentives by characterizing the optimal use of revenue-sharing contract. For instance, Giannoccaro and Pontrandolfo (2004) propose a revenue-sharing model aiming at coordinating

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a three-stage supply chain, which increases the whole supply chain system efficiency as well as the profit of all the supply chain members by tuning the revenue-sharing contract parameters. Gupta and Weerawat (2006) design a revenue-sharing contract to maximize the centralized revenue by choosing an appropriate inventory level. Jaber and Osman (2006) studies a two-level supply chain model and relies on delaying in payments as a vehicle to coordinate the two players' orders and to minimize the supply chain wide costs. A simple profit sharing contract is proposed in such a way that the profit is distributed proportionally to each partner's investment amount. Zhang, Fu and Li (2012) study supply chain coordination without demand disruptions and give the feasible revenue-sharing contracts, which assures the desirability of the chain partners and the legality of selling. Next, they discuss how the supply chain is coordinated under one demand disruption and analyze the effects of demand disruptions on the centralized supply chain and derive the coordinating revenue-sharing contracts. Marcus (2012) discusses the problem of establishing efficiency in a manufacturer-retailer channel in the industrial economics and shows that channel coordination requires cost and revenue sharing via a revenue sharing rate and marketing effort participation rates on both manufacturer and retailer level.

Among literatures about supply chain coordination by revenue-sharing contracts above, market demand is characterized as a determinate or stochastic variable. However, in real world, not only demand changes from one period to another but also high degree of fuzziness is involved in data set. Therefore, it is difficult to estimate its probability distribution due to the lack of historic data. Fuzzy set theory which was originally introduced by Zadeh (1965) provides a framework for handling this type of problem in fuzzy environments. From then on, many researchers such as Zimmermann (1976) and Yager (1977) apply the theory successfully to optimization problems. Recently, Liu (2006) lays a foundation for optimization theory in uncertain environments, in which

numerous models are proposed to deal with the optimization problems. This paper characterizes market demand as a fuzzy variable and studies the optimal decision in supply chain coordinated by revenue-sharing in fuzzy environments based on credibility theory (Liu, 2006), and gives a new viewpoint in supply chain coordination by introducing the newly credibility theory.

This paper is organized as follows. In Section 2, we present a brief description of the preliminary knowledge about fuzzy variables. Section 3 models the revenues-sharing contract under two kinds of different fuzzy demand in centralized and decentralized settings and then obtains some conclusion about the contract.

2. PRELIMINARIES

Let Θ be a nonempty set, and $P(\Theta)$ the power set of Θ . For any $A \in P(\Theta)$, Liu and Liu (2002) presented a credibility measure $\text{Cr}\{A\}$ to express the chance that fuzzy event A occurs. Li and Liu (2006) proved that a set function $\text{Cr}\{\cdot\}$ is a credibility measure if and only if:

1. $\text{Cr}\{\Theta\} = 1$;
2. Cr is increasing. i.e., $\text{Cr}\{A\} \leq \text{Cr}\{B\}$ whenever $A \subset B$;
3. Cr is self-dual, i.e., $\text{Cr}\{A\} + \text{Cr}\{A^c\} = 1$ for any $A \in P(\Theta)$;
4. $\text{Cr}\{\cup_i A_i\} \wedge 0.5 = \sup_i \text{Cr}\{A_i\}$ for any A_i with $\text{Cr}\{A_i\} \leq 0.5$.

The triplet $(\Theta, P(\Theta), \text{Cr})$ is called a credibility space and a fuzzy variable is defined as a function from this space to the set of real numbers.

Definition 1: (Liu, 2006) The credibility distribution $\Phi : R \rightarrow [0, 1]$ of a fuzzy variable ξ is defined by:

$$\Phi(x) = \text{Cr}\{\theta \in \Theta \mid \xi(\theta) \leq x\}$$

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