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A supply chain application of fuzzy set theory to inventory control models – DRP system analysis

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A R T I C L E   I N F O

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A B S T R A C T

As competition abounds, the efficient solution on inventory control of a DRP's (Distribution Requirement Planning) supply chain management is a vital success factor for companies in today's business world. A stochastic program of market distribution and its deterministic equivalent control program is approximated by a multi-echelon lot-sizing model based on "risk inflated effective demands". The DRP-decomposition of this approximate model, which can be used with allocation application of Fuzzy Set Theory, is then introduced.

The aim of this paper is to find methods to address traditional DRP's weaknesses and to improve the performances of DRP systems. In this paper, the field of continuous review model will be focused in, and a new method on the model with triangular fuzzy numbers (input data) will be presented. By using the method, the maximum of order quantity under a minimum of total cost can be obtained.

In many previous research, authors take a precise number approximately as the representative of a fuzzy number. But the precise number can not reflect the property of fuzzy inventory control number fully. Therefore, in a numerical example of this paper, in addition to providing a transformation for reducing a fuzzy number into a closed interval by introducing the interval mean value concept proposed by Dubios and Prude, this fuzzy system can be transformed into a more precise diagnosis system for channel members in the supply chain distribution organization.

1. Introduction

1.1. Research motivation

DRP (Distribution Requirement Planning) is one of the important subsystems which a modernization meat supply manufacturer adopts to respond to the chain store retail environment to achieve its supply chain management objective (Vollmann, Berry, Whybark, & Jacobs, 2004). In many sectors, the network through which a given item flows takes the form of a tree and, as illustrated in Fig. 1, this tree often has more than two echelons. Typically, the intermediate nodes in the tree are warehouses, the leaves are sales points or consumption points responding to an external demand, and the time required to ship items from node to node is not negligible.

Almost research works on inventory control problem from this multi-echelon distribution network are solved by converting vagunese or imprecise input data to crisp one. But, many variables in inventory control process from this supply chain distribution network may truly be fuzzy. Some components of the setup, holding and shortage costs may be unknown with uncertainty problem (Gen, Tsujimura, & Zheng, 1996).

In many previous research, authors take a precise number approximately as the representative of a fuzzy number. But the precise number can not reflect the property of fuzzy inventory control number fully. Therefore, in this paper, a transformation for reducing a fuzzy number into a closed interval by introducing the interval mean value concept proposed by Dubios and Prude will be presented. The fuzzy number can be transformed into a closed interval, and possibility theory is used here to obtain a more precise result for above interval.

Overall in this paper, the field of continuous review model will be focused in, and a new method on the model with fuzzy input data will be presented. By using the method, the maximum of order quantity under a minimum of total cost can be obtained. For the reason that result should be a fuzzy number because of fuzzy input data, and the certain number about order quantity is preferred in real-world, it is necessary to transform the fuzzy result to crisp one.

The application of strategic diagnosis system to supply chain management could be found in the papers of Supply Chain Management (Dahel, 2003; Huang, Uppal, & Shi, 2002; McAdam & Brown, 2001; Sadler & Hines, 2002). Sadler and Hines (2002)

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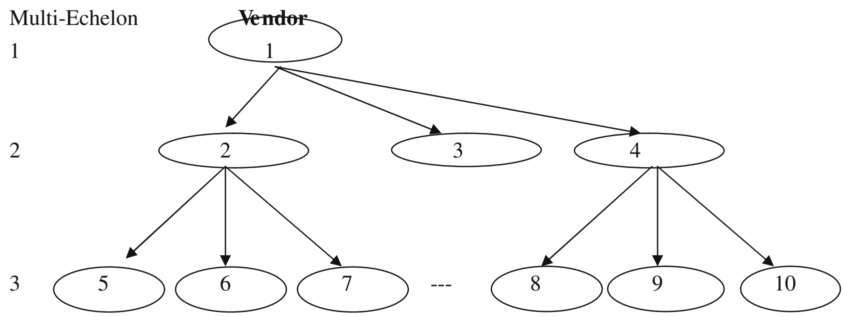

Fig. 1. Conceptual framework of Fuzzy CRIM model method.

proposed a conceptual model for strategic operations diagnosis without empirical results for meat business to retail business system (Sadler & Hines, 2002). However, Bhutta and Huq (2002) evaluates the problems of the strategic diagnosis system by evaluating the consistency between the result and the decisions of the strategic channel management. In other words, if the forecasting results for the manufacturing business to retail business strategic diagnosis system are highly consistent with the decisions made by the strategic experts experience, then the channel strategic diagnosis system method are considered helpful for channel strategy decision-makings.

Except there must have a lot of transformation technique method talking about the fuzzy set method basis to reflect the property of fuzzy number fully, however, the research also providing a concrete bilateral channel diagnosis about whether a channel strategy is appropriate or not is in paucity. This research, based on the point of view, this fuzzy system can be transformed into a more precise diagnosis system for channel members in the supply chain distribution organization. We are trying to construct a channel strategic diagnosis system analysis by using more precious transformation technique of fuzzy set method.

1.2. Research purpose and procedure

This study attempts to start filling the void of how channel strategic diagnosis system to construct a distribution requirement planning system analysis by using more precious inventory control transformation technique of fuzzy set method in the Asia-Pacific Orient supply chain distribution. Thus, the purpose of this study is to use the transformation technique method of fuzzy set method to reflect the inventory control property of fuzzy number fully, and to give the supply chain manager a concrete bilateral suggestion about whether a critical channel inventory control strategy is appropriate or not.

This paper is constructed in the following way. The literature review of the DRP (Distribution Requirement Planning), the mean value of a fuzzy number for inventory control and strategic Continuous Review Inventory Model (CRIM) are analyzed in Sections 2 and 3. More specifically, Sections 4 and 5 gives the model construction process and its empirical Numerical example for the meat business to retail business data in Taiwan supply chain distribution. Finally, the Sections 6 and 7, their conclusions and future directions are discussed.

2. Distribution Requirement Planning (DRP) theory

Since Whybark proposed the DRP logic under uncertainty in 1975, researchers have developed numerous models to help to solve the inventory control problems, each with their own pros and cons (Whybark & Vastag, 1993). In the same spirit as MRP logic, DRP (Distribution Requirements Planning) framework is a rolling horizon echelon-by-echelon approach that bases procurement decisions on time-phased projected future node requirements. The approach has several advantages (Martin, 1994). It can deal with any number of echelons, it takes the dependent nature of the demand into account, it manages lead times effectively, it can take economies of scale in transportation into account through the choice of appropriate lot-sizing algorithms, it can take any resource constraints into account indirectly through the intervention of a "master scheduler", notwithstanding the fact that it has been implemented in several commercial software packages also supporting other needs of distribution/supply organisations (demand and order management, warehousing, transportation, personnel productivity, accounting, ...).

The main drawback of the DRP approach is that it was fundamentally designed to support deterministic time-varying demands. Several mechanisms, such as safety stocks, safety times and freeze periods were introduced to "manage" demand uncertainty, but they are often used arbitrarily. For example, fixed safety stocks are often used even if the demand follows a non-stationary stochastic process. Good approaches to compute safety buffers in DRP systems are not available currently (Bookbinder & Ng, 1986). Also when the master scheduler has to intervene to solve a resource problem, such as a warehouse inventory shortage, his or her decisions are not necessarily "optimal" (Bookbinder & Heath, 1988). Then, good DRP systems usually provide some help in the form of simulation and "pegging" facilities, for example, and they are usually flexible enough to permit the solution of such problems through "expediting" actions. In other words, if the weaknesses listed above could be corrected, DRP systems would provide an flexible and efficient environment to manage the flow of items in the complex supply/distribution trees discussed above (Bookbinder & Tan, 1988). The aim of this paper is to find methods to address these weaknesses and to improve the performances of DRP systems.

In this present study, it focus that a stochastic program of market distribution and its deterministic equivalent control program is approximated by a multi-echelon lot-sizing model based on "risk inflated effective demands." The DRP (Distribution Requirement Planning)-decomposition of this approximate model, which can be used with allocation application of fuzzy set method, is then introduced (Martel, Diaby, & Boctor, 1995).

3. Model development

3.1. Problem description, assumptions and notation

The multi-echelon solid distribution problem can be described as follows. Assume that a retail market separates N multi-echelon types of chain store supermarkets to satisfy the market demand for the unique modernizational meat supply manufacturer over a