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An experience-based system supporting inventory planning: A fuzzy approach

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ABSTRACT

The study aims to extend the Uncapacitated Fuzzy Single Item Lot Sizing Problem (known as F-USILSP) model and extend it for inventory planning. The F-USILSP model is a good choice when there is no statistical data collection, but where there is verbal or qualitative information from experts with experience. Previously, the mixed integer linear programming (MILP) relied on the crisp assumption which hinders the use of the F-USILSP. In this paper, a Possibility Approach is adapted to convert the F-USILSP to a mathematically solvable equivalent crisp USILSP (EC-USILSP). The EC-USILSP model is tested with a case. The organization under study is a petrochemical company power plant with trapezoidal fuzzy demand and triangular fuzzy unit price. The overall results show that the EC-USILSP is more practical and exhibits more flexibility when there is a need to add more realistic situations.

1. Introduction

Lot sizing problems are production planning problems of order quantity between purchasing or production lots (Brahimi, Dauzere-Peres, Najid, & Nordli, 2006). Small lot sizes lead to many orders and low inventory levels while large lot sizes lead to few orders and high inventory levels (Lee, Kramer, & Hwang, 1991). The consideration of lot sizes is, therefore, an economic problem in that the objective of inventory models is to minimize total inventory cost, which comprises unit price, ordering cost, and inventory holding cost, while satisfying demand (Brahimi et al., 2006; Hilmola & Lorentz, 2011; Lee et al., 1991). The first inventory planning model, namely Economic Order Quantity (EOQ), was proposed by Harris (1913). It was used to find an optimal order quantity in the case of an uncapacitated single stage and single item of inventory control with a well-defined demand pattern. Wagner and Whitin (1958) proposed an inventory model with time-vary demand, namely dynamic lot sizing, and used dynamic programming techniques to find an optimal order quantity. Other subsequent inventory models have been developed, based on the above models (Askin & Goldberg, 2002; Barancsi et al., 1990).

The USILSP is a type of inventory model with time-vary demand. Brahimi et al. (2006) stated that there are four basic formulations of the USILSP in the form of mixed integer linear programming or MILP; i.e., aggregate formulation (AGG), formulation without inventory variables (NIF), the shortest path formulation (SHP), and facility location-based formulation without inventory variables (FAL). In addition, Brahimi et al. (2006) added that USILSP modeling is popular for inventory planning for three reasons. Firstly, some industries can aggregate products to obtain a single product, for example, products that differ only in color can be treated as a single product. Secondly, the USILSP is a basic model but can be easily extended for more complex circumstances. Lastly, many complex lot sizing problems must employ USILSP as sub-problems (see Cattrysse, Maes, & Van Wassenhove, 1990; Merle, Goffin, Trouiller, & Vial, 1999).

Typically, when a classical inventory model is used, the Crisp Deterministic Assumption is required. However, often the information can be uncertain such as a situation in which only qualitative information from experienced operators or personnel. As a result, the fuzzy set theory is applied to resolve this information uncertainty (Dubois & Prade, 1980; Gumus & Guneri, 2009; Ketsarapong & Punyangarm, 2010; Zadeh, 1965; Zimmermann, 1996). In addition, Tütüncü, Akoz, Apaydin, and Petrovic (2008) suggested that some uncertainty within inventory systems should not considers the probability applications. Therefore, since 1980s, the fuzzy set theory has been widely used in modeling of inventory systems when dealing with vagueness and uncertainty (Cakir & Canbolat, 2008; Chang, Yao, & Ouyang, 2006; Chen & Chang, 2008; Dutta, Chakraborty, & Roy, 2007; Green, Inman, & Birou, 2011; Halim, Girl, & Chaudhuri, 2011; Hsieh, 2002; Mandal, Roy, & Maiti, 2005; Pai, 2003; Yao & Lee, 1999).

The rest of the paper is organized as follows: Section 2 presents the research premise; Section 3 presents the research objectives; Section 4 present the four steps of research methodology including,

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(1) the data collection process, (2) developing an inventory model, transforming the F-USILSP to an EC-USILSP model, developing the EC-USILSP model in the form of MILP, and an illustrative numerical example, (3) data analysis process, and (4) the decision making process. In Section 5, the case application of a petrochemical company is presented. Finally, the last Sections are the conclusions and recommendations for future studies.

2. Research problem

Generally, there are two types of uncertain parameter in a typical inventory model; i.e., fuzziness and randomness, which lead to the fuzzy inventory model and the stochastic inventory model respectively. Most stochastic inventory models are described by statistical or probabilistic information, which deals with the probability distributions of inventory parameters. Since statistical information is collected from a lot of sampling data, high cost and time lost for data collection must be considered. As a result, Small and Medium Enterprises (SMEs) are often faced with the situation which no reliable and quantitative data exist, despite abundant verbal information and experiences from key personnel or operators (Martz, Neil, & Biscaccianti, 2006). Moreover, extreme events such as natural disasters, resulting in rapid changes in demand, unit price, and/or ordering cost, prohibits the use of available data. When the above circumstance take place, an organization must be able to learn and adept itself (Melton, Chen, & Lin, 2006). Therefore, this study attempts to address the following research problem. How can an inventory planning model be developed to provide information for an inventory planner to make decisions effectively?

3. Research objectives

The objective of this research is to develop an inventory planning model to deal with a single item lot sizing problem with fuzzy parameters. This inventory planning model is designed in response to circumstances where there is lack of quantitative data but abundant experiences from operators or personnel.

4. Research methodology

The research methodology consists of four parts; (4.1) the data collection process (4.2) a developing inventory model (4.3) computing results and (4.4) a decision making process (see Fig. 1). The steps of each part are as follows.

4.1. Data collection process

The data collection process is a very important because the verbal information obtained from this process can be used as inputs in the F-USILSP model. Verbal information must be collected from experienced decision makers. Furthermore, a computer is an essential device for this process and is used for recording verbal or qualitative information. Therefore, with a lack of verbal information and without accurate computer records the F-USILSP model cannot be operated.

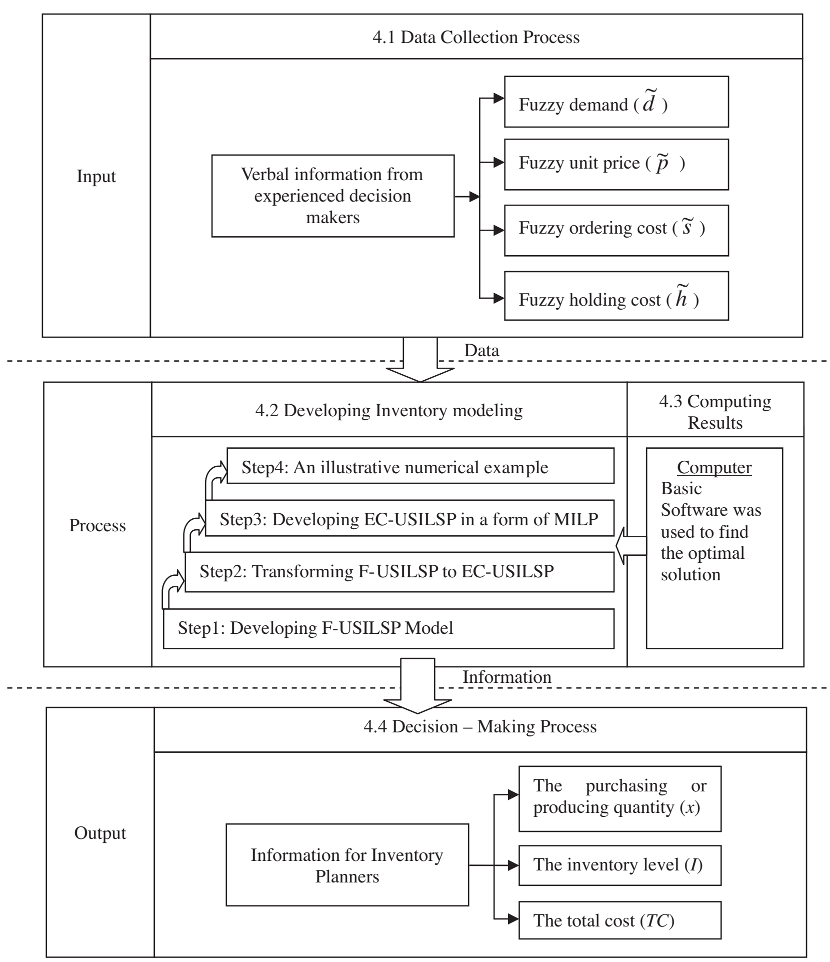

Fig. 1. Research methodology framework.