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Fuzzy AHP approach for supplier selection in a washing machine company

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ABSTRACT

Supplier selection process has gained importance recently, since the cost of raw materials and component parts constitutes the main cost of a product and most of the firms have to spend considerable amount of their revenues on purchasing. Supplier selection is one of the most important decision making problems including both qualitative and quantitative factors to identify suppliers with the highest potential for meeting a firm's needs consistently and at an acceptable cost. In this study, supplier selection problem of a well-known washing machine company in Turkey is investigated and a fuzzy analytic hierarchy process based methodology is used to select the best supplier firm providing the most customer satisfaction for the criteria determined. After the main attributes and sub-attributes for supplier selection are defined to design the hierarchy structure, the weights of them and alternatives are calculated using fuzzy analytic hierarchy process approach. The supplier with the highest priority weight is selected as the best supplier. Macros in MS Excel are written to calculate the priority weights of the alternatives based on the questionnaire forms used to facilitate comparisons of main attributes, sub-attributes and alternatives.

1. Introduction

Increases and varieties of customer demands, advances of recent technologies in communication and information systems, competition in global environment, decreases in governmental regulations and increases in environmental consciousness have forced companies for focusing on supply chain management (Tracey & Tan, 2001). The "supply chain management" term defines the integration of activities to procure materials, transforms them into intermediate goods and final products, and delivers to customers. The supply chain consists of all links from suppliers to customers of a product. Goffin, Szwejczewski, and New (1997) have stated that supplier management is one of the key issues of supply chain management because the cost of raw materials and component parts constitutes the main cost of a product and most of the firms have to spend considerable amount of their sales revenues on purchasing. In most industries the cost of raw materials and component parts constitutes the main cost of a product, such that in some cases it can account for up to 70% (Ghobadian, Stainer, & Kiss, 1993). In high technology firms, purchased materials and services represent up to 80% of total product cost (Weber, Current, & Benton, 1991). Thus the purchasing department can play a key role in an organization's efficiency and effectiveness since the department has a direct effect on cost reduction, profitability and flexibility of a company by selecting the right suppliers significantly reduces the purchasing costs and improves corporate competitiveness (Ghodsypour & O'Brien, 2001).

Supplier selection is a multi-criteria problem which includes both qualitative and quantitative factors. In order to select the best suppliers it is necessary to make a trade off between these tangible and intangible factors some of which may conflict (Ghodsypour & O'Brien, 1998). The objective of supplier selection is to identify suppliers with the highest potential for meeting a firm's needs consistently and at an acceptable cost. Selection is a broad comparison of suppliers using a common set of criteria and measures. However, the level of detail used for examining potential suppliers may vary depending on a firm's needs.

Although analytical hierarchy process (AHP) is widely preferred for solving multi-criteria decision-making problems in real situations, it is insufficient to explain uncertain conditions in especially pair-wise comparison stage. Most of human's judgments are not represented as exact numbers. Since some of the evaluation criteria are subjective and qualitative in nature, it is very difficult for the decision-maker to express the preferences using exact numerical values and to provide exact pair-wise comparison judgments (Chan & Kumar, 2007). Fuzzy evaluations in decision making process are very useful to tackle this disadvantage of AHP.

To select the best supplier for a washing machine company, this study proposes a fuzzy extended AHP (FEAHP) approach using triangular fuzzy numbers to represent decision makers' comparison judgments and extent analysis method to decide the final priority of different decision criteria. The presented fuzzy AHP uses the linguistic variables and triangular fuzzy numbers as a pair-wise comparison scale for deriving the priorities of different selection

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attributes and sub-attributes. After pair-wise comparisons, the priority weights for main attributes, sub-attributes and alternatives are combined to determine the priority weights of the alternative suppliers. The supplier with the highest priority weight is selected as the best supplier. Macros in MS Excel are used to calculate the priority weights of the alternatives based on the questionnaire forms used to facilitate comparisons of main attributes, sub-attributes and alternatives. In particular, the approach presented can handle the inherent uncertainty and imprecision of the human decision making process and provide the flexibility needed for the decision maker to understand the decision problem.

The remainder of the paper is organized as follows: In Section 2, researches related with supplier selection problem in literature are given. In Section 3, we explain AHP, fuzzy AHP, fuzzy numbers, fuzzy sets and extent analysis method on fuzzy AHP. In Section 4, a FEAHP based approach to select the best supplier firm providing the most satisfaction for the criteria determined is developed and the steps of each stage of the procedure is explained in detail. The paper ends with concluding remarks in Section 5.

2. Literature survey

During recent years supply chain management and supplier selection process have received considerable attention in the literature. Supplier selection is a multi-criteria problem and there are not a lot of efficient techniques or algorithms that address this problem. However three major groups of methods in the literature are mathematical programming models, cost based models, and categorical models.

Since supplier selection problems usually have several objectives such as maximization of quality or maximization of profit or minimization of cost, the problem can be modeled using mathematical programming. Weber and Current (1993) proposed a multi-objective approach to supplier selection to aim at minimizing the price, maximizing the quality and on time delivery using systems' constraints and policy constraints in a mixed integer model. Ghodsypour and O'Brien (1998) proposed an integration of AHP and linear programming to consider both tangible and intangible factors in choosing the best suppliers and placing the optimum order quantities among them such that the total value of purchasing becomes maximum. Çebi and Bayraktar (2003) structure the supplier selection problem as an integrated lexicographic goal programming and AHP model including both quantitative and qualitative conflicting factors. Wang, Huang, and Dismukes (2004) use AHP and preemptive goal programming based multi-criteria decision-making methodology is then developed to take into account both qualitative and quantitative factors in supplier selection. Wang and Yang (2009) search supplier selection in a quantity discount environment using multi objective linear programming, AHP, and fuzzy compromise programming.

Since price has traditionally been a leading factor, selecting suppliers based on cost has been a common approach. A popular application of the cost approach has been calculating the total cost for each purchase. The total cost of working with each supplier is calculated and the cheapest one is selected. Timmerman (1986) proposes cost–ratio method which collects all costs related to quality, delivery, and services and shows them as a benefit or penalty percentage on unit price. Ellram (1990) explains that a formal total cost approach explicitly recognizes cost factors in addition to price and argues that any total cost approach should include transportation costs, receiving costs, quality costs, purchasing administrative expenses and the price of the item.

Categorical methods are similar to the cost based methods because where the categorical methods determines the best supplier using rating values on relevant supplier performance characteristics, the cost method does same process using dollar figures assigned to the characteristics. Verma and Pullman (1998) examined the difference between managers' rating of the perceived importance of different supplier attributes and their actual choice of suppliers in an experimental setting. Humphreys, Wong, and Chan (2003) presented a framework of environmental criteria which a company can consider during their supplier selection process.

AHP is widely used in studies related with categorical methods since it is one of the extensively used multi-criteria decision-making methods. It effectively keeps both qualitative and quantitative data in decision making problems and is easier to understand its process. Therefore it has been extensively applied to supplier selection problems. Muralidharan, Anantharaman, and Deshmukh (2001) proposed a methodology which makes estimation of the rating by a group on an individual basis the principle of anonymity. Handfield, Walton, Sroufe, and Melnyk (2002) illustrated the use of AHP as a decision support model to help managers understand the trade-offs between environmental dimensions. Pi and Low (2006) proposed a supplier evaluation and selection system via Taguchi loss function and AHP. Sevkli, Koh, Zaim, Demirbag, and Tatoglu (2007) used data envelopment AHP to select the best supplier for a TV company. Although Ounnar, Pujo, Mekaouche, and Giambiasi (2007) did not make a supplier selection in their research, best relationship between customer and supplier was examined using most of supplier selection criteria in the literature.

In order to deal with uncertainties of the decision problem and eliminate the disadvantages of AHP, fuzzy AHP is preferred in supplier selection studies. Altinoz (2001) examined supplier selection in general and specifically in the Textile sector. Feng, Chen, and Jiang (2005) proposed a comprehensive evaluation method based on fuzzy decision theory and characteristics of supply chain management for optimal combination and selection among candidate suppliers and outsourced parts. Haq and Kannan (2006) aims to demonstrate how fuzzy AHP model can help in solving supplier selection decisions in practice. Lu, Wu, and Kuo (2007) adds environmental principles into supplier selection process by applying fuzzy AHP. Chan, Kumar, Tiwari, Lau, and Choy (2008) propose a fuzzy AHP approach for global supplier selection. Chamodrakas, Batis, and Martakos (2009) uses fuzzy AHP to select supplier in electronic sector.

The most common method used in the solution of fuzzy AHP applications is the extent analysis method proposed by Chang (1992). Kahraman, Cebeci, and Ulukan (2003) used fuzzy AHP to select the best supplier firm providing the most satisfaction for the criteria determined in the white good sector. Same procedure is used to select the best catering firm providing the most customer satisfaction by Kahraman, Cebeci, and Ruan (2004). Chan and Kumar (2007) discussed a fuzzy extended AHP (FEAHP) approach using triangular fuzzy numbers to represent decision makers' comparison judgments and fuzzy synthetic extent analysis method to decide the final priority of different decision criteria.

3. AHP and fuzzy AHP

AHP is a systematic procedure to solve multi-criterion decision making problems. It includes both subjective and objective evaluation measures, offering a useful hierarchical procedure to control the consistency of the evaluation measures and alternatives preferred by decision makers to reduce bias in decision making process. The application of AHP to a decision problem involves four steps (Zahedi, 1986). In structuring of the decision problem into a hierarchical model, supplier selection problem is defined, objective is identified, criteria and attributes that must be satisfied to objective are recognized. Objective is at first level, criteria is at second level, attributes are at third level, and decision alternatives are