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A QFD-based fuzzy MCDM approach for supplier selection

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ABSTRACT

Supplier selection is a highly important multi-criteria group decision making problem, which requires a trade-off between multiple criteria exhibiting vagueness and imprecision with the involvement of a group of experts. In this paper, a fuzzy multi-criteria group decision making approach that makes use of the quality function deployment (QFD) concept is developed for supplier selection process. The proposed methodology initially identifies the features that the purchased product should possess in order to satisfy the company's needs, and then it seeks to establish the relevant supplier assessment criteria. Moreover, the proposed algorithm enables to consider the impacts of inner dependence among supplier assessment criteria. The upper and the lower bounds of the weights of supplier assessment criteria and ratings of suppliers are computed by using the fuzzy weighted average (FWA) method. The FWA method allows for the fusion of imprecise and subjective information expressed as linguistic variables or fuzzy numbers. The method produces less imprecise and more realistic overall desirability levels, and thus it rectifies the problem of loss of information. A fuzzy number ranking method that is based on area measurement is used to obtain the final ranking of suppliers. The computational procedure of the proposed framework is illustrated through a supplier selection problem reported in an earlier study.

1. Introduction

Supply chain management has become a key aspect that has implications for effective and efficient management of industrial relations. It has also become an important focus for firms and organizations to obtain a competitive advantage [1]. In facing an ever-increasingly competitive and rapidly changing environment, firms need to reorganize their supply chain management strategy to harmonize with external environments by integrating the organizational resources, information, and activities so as to maintain competitive advantages [2].

Supplier's performance has a key role on cost, quality, delivery and service in achieving the objectives of a supply chain. Gencer and Gürpinar [3] pointed out that the cost of purchased goods and services accounts for more than 60% of the cost of goods sold, and over 50% of all quality defects can be traced back to purchase material. Hence, supplier selection is considered as one of the most critical activities of purchasing management in a supply chain. Selecting the right suppliers significantly reduces the purchasing cost and improves corporate competitiveness [4]. With the increased emphasis on manufacturing and organizational philosophies such as total quality management and just in time, all companies are faced with quality assurance issues in design, manufacturing, purchasing, and delivery. The performance of suppliers has become a crucial element in a company's quality success or failure, and clearly influences the responsiveness of the company [5]. The overall objective of the supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and build the closeness and long-term relationships between buyers and suppliers [6].

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At the beginning of the 1980s, Evans [7] found price to be the most important attribute in the purchase of routine products. However, recent studies have discovered a shift away from price as a primary determinant of supplier selection [8]. Organizations, which practice the latest innovations in supply chain management, no longer accept commodity partnerships that are exclusively based on price. Other important factors such as quality, delivery time and flexibility are included in managing these inter-organizational relationships.

There is a continuing need for robust evaluation models that effectively incorporate several supplier criteria. With its need to trade-off multiple criteria exhibiting vagueness and imprecision, supplier selection is a highly important multi-criteria decision making problem. The classical multi-criteria decision making (MCDM) methods that consider deterministic or random processes cannot effectively address decision problems including imprecise and linguistic information. In practice, decision making in supplier selection includes a high degree of vagueness and imprecision. Fuzzy set theory is one of the effective tools to deal with uncertainty and vagueness.

Group decision making is an important concern in MCDM methods. Multiple decision-makers are often preferred to prevent the bias and minimize the partiality in the decision process. For group decision making problems, consensus is an important indication of group agreement or reliability. In order to fully reflect the real behavior of the group, a final decision should be made on significant level of consensus. Therefore, aggregation of expert opinions is crucial to properly conduct the evaluation process.

The objective of this study is to propose a fuzzy multi-criteria group decision making approach based on the quality function deployment (QFD) concept for supplier selection. In supplier selection process, the company's ultimate aim is to have access to suppliers that ensure a certain quality standard in terms of the characteristics of the purchased products or services [9]. Achieving these objectives depends largely on considering the relationships between purchased product features and supplier assessment criteria, and also the relationships between supplier assessment criteria disregarding the unrealistic independence assumption. Thus, constructing a house of quality (HOQ), which enables the relationships among the purchased product features and supplier assessment criteria as well as inner dependence of supplier assessment criteria to be considered, is key to identify how well each supplier characteristic succeeds in meeting the requirements established for the product being purchased.

The decision framework developed in this paper considers QFD planning as a fuzzy multi-criteria group decision making tool and utilizes two interrelated HOQ matrices to evaluate alternative suppliers. When relative weight of purchased product feature, relationship measure between purchased product feature and supplier assessment criteria and ratings of suppliers with respect to each supplier assessment criteria are represented as fuzzy numbers, computation of the weights of supplier assessment criteria and the ratings of suppliers fall into the category of fuzzy weighted average [10]. The proposed approach calculates both the weights of supplier selection criteria and the ratings of suppliers by using a fuzzy weighted average method, which develops a pair of fractional programs to calculate the upper and lower bounds of the criteria weights and the supplier ratings. The FWA method enables the fusion of imprecise and subjective information expressed as linguistic variables or fuzzy numbers, and alleviates the concern for loss of information. The proposed algorithm allows for considering the impacts of inner dependence among supplier assessment criteria, thus it disregards the unrealistic mutual independence assumption of attributes. A ranking method based on area measurement that attempts to alleviate the drawbacks of the existing fuzzy number ranking methods is employed to rank the potential suppliers. Most ranking methods observe the order of fuzzy numbers and do not measure the degree of difference between them. Furthermore, some of the ranking methods can only be applied when membership functions are known. This issue can be problematic when one considers that fuzzy numbers to be ranked are generally the output of fuzzy number aggregation operations and their exact membership functions are unknown. Moreover, the inclusion or omission of fuzzy numbers to or from the comparison may alter the original ranking [11].

The rest of the paper is organized as follows: The following section presents the literature review on supplier selection. Section 3 outlines the developed methodology and provides a stepwise representation of the proposed fuzzy decision making approach. In Section 4, the application of the proposed framework to a previously reported case study concerning an enterprise that manufactures complete clutch coupling is illustrated. Finally, conclusions are provided in Section 5.

2. Literature review

Recently, buyer and supplier relationships in manufacturing enterprises have received considerable attention in the business–management literature. The purchasing function is increasingly seen as a strategic issue in supply chain hierarchy. Weber and Current [12] stated that in high-technology industries, material purchased externally can represent up to 80% of total product cost. It is vital for the competitiveness of most firms to reduce such purchasing costs to a minimum. In order to accomplish this, the firm must determine its business partners. This decision was referred as supplier selection problem by Weber and Current [12]. The complexity of the supplier evaluation and selection problem has motivated the researchers to develop models for helping decision-makers.

Earlier studies on supplier selection focused on identifying the criteria used to select suppliers. Dickson [13] conducted one of the earliest works on supplier selection and identified 23 supplier attributes that managers consider when choosing a supplier. The study concluded that quality, on-time delivery, and performance history were the three most important criteria in supplier evaluation.