



Supplier selection using consistent fuzzy preference relations

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ARTICLE INFO

Keywords:

Consistent fuzzy preference relations
Supplier selection
Decision making
Multi-criteria
Analytic hierarchy process

ABSTRACT

Supplier selection is usually involved a multi-criteria evaluation to assist decision-making. This study proposed a simple method for vendor selection. The proposed procedure utilizes the structure of criteria in analytic hierarchy process (AHP) model and employs consistent fuzzy preference relations (CFPR) to construct the decision matrices. The advantage of CFPR is computational simplicity and efficiency. The computation can be done by using an Excel spreadsheet or writing a simple computer program. Also, the CFPR method guarantees the consistency of decision matrices. In this paper, a step-by-step empirical example demonstrates the usage of this proposed method.

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1. Introduction

Supplier (or vendor) selection is an important issue in supply chain management (SCM) for many enterprises. Basically, there are two aspects in the issue of the supplier selection. One aspect is the criteria for evaluation of suppliers and the other aspect is the procedure or method of supplier selection.

How to evaluate a supplier depends on several different criteria (or factors). The criteria, such as price, quality, delivery, reputation, etc., are frequently selected for comparison and evaluation. These criteria can affect the outcome of the decision-making for vendor selection and they can also affect one another. For the past decades, the philosophy of just-in-time (JIT) and total quality management (TQM) in SCM has been employed in various commercial behaviors. The application of JIT and TQM is proved that it can reduce the cost of inventory and purchasing management. This philosophy may change some of the traditional criteria for supplier selection for different types of business. Besides, different companies may have different organization and cultural backgrounds which may also affect the operation in vendor selection. Therefore, which criteria are suitable and should be used for evaluation of suppliers in SCM for an enterprise is crucial.

On the other aspect, with so many criteria and different suppliers, how to choose a suitable and right supplier is important for many corporations in the today's competitive business. A suitable supplier may become and develop into a cooperative and long-term partnership in SCM, which can help the growth of a company and can be crucial to the success of the business. And hence, a

systematical and effective procedure or method to select the most appropriate supplier is imperative.

In this study authors utilize the structure of criteria in analytic hierarchy process (AHP) (Saaty, 1980, 1990a, 1990b) model and propose an effective and simple procedure using consistent fuzzy preference relations (CFPR) (Herrera-Viedma, Herrera, Chiclana, & Luque, 2004) to construct the decision matrices for rating suppliers. The rest of the paper is arranged as follows. Firstly, the multi-criteria for supplier selection will be reviewed. Secondly, the recent rating methods on supplier selection will be briefly discussed. The proposed method uses the hierarchy of AHP for criteria and CFPR for rating suppliers. Therefore, thirdly, the popular AHP will be briefly described. Then, the proposed rating method using CFPR is presented. Finally, a numerical example using AHP hierarchy with CFPR process for supplier rating is demonstrated.

2. Criteria for supplier selection

Dickson (1966) performed an investigation and presented twenty-three criteria for vendor selection, in which the quality, delivery, and performance history were the most important factors than others in 1960s.

Based on Dickson's 23 factors, Weber, Current, and Benton (1991) carried out a study and summarized 74 literatures on vendor-selection from 1967 to 1990. In JIT manufacturing strategies, the quality and delivery were rated as the most important factors by all 13 articles, especially the criterion of quality. The net price was also very important and discussed in eight of the 13 articles. Besides, production facilities and capability was another important factor. It is worthy to notice the factor of geographical location that was placed in the 20th position in Dickson's report, but it was addressed in seven of these 13 articles, which demonstrate that the

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factor of geographical location in a SCM system has played an important role and has got increasing attention in a modern business.

Swift (1995) summarized 5 factors for supplier selection from the view of preference for single sourcing or for multiple sourcing. These 5 factors are product, availability, dependability, experience, and price. By utilizing multivariate analysis of variance (MANOVA) and *F*-test, Swift indicated that purchasing managers who have a preference for single sourcing are more interested in the total life cost of the products, the technical support availability, and the reliability of product. If the customer prefers multiple sourcing, emphasis should be on the traditional attributes of price, quality, and delivery.

Choi and Hartley (1996) chose National Association of Purchasing Managers (NAPM) membership list (1994), Ohio Manufacturers List (1994), and Japanese Automotive Supplier Directory (1991) as objects of surveying to investigate the supplier selection-criteria. Based on the criteria of Dickson (1966), Weber et al. (1991), and some other important factors as suggested by earlier studies, Choi and Hartley (1996) summarized 26 criteria for supplier selection. After factor analysis, the 26 criteria were integrated into 8 factors: finances, consistency, relationship, flexibility, technological capability, customer service, reliability, and price.

Barbarosoglu and Yazgac (1997) presented a five-level AHP structure for supplier selection including the main mission in the top level and the alternative suppliers in the last level. In their AHP structure, the primary level contains three categories: performance assessment, business structure/manufacturing capability assessment, quality system assessment. A total of 16 evaluation criteria for the primary categories are grouped at the secondary level. The sub-criteria which are related to the second-level criteria are grouped in the third and fourth levels.

Goffin, Szwajczewski, and New (1997) summarized the main changes in purchasing between traditional and modern supplier management approaches. In reality, traditional factors can be seen as the factors in primary level within the AHP model; the factors in modern supply chain management approaches can be viewed as in the secondary level within the AHP model. The traditional approaches to purchasing were unit price (first), followed by quality and speed of delivery.

Muralidharan, Anantharaman, and Deshmukh (2002) proposed nine criteria for supplier selection. These nine criteria are quality, delivery, price, technical capability, financial position, past performance attitude, facility, flexibility, and service.

The previous literatures almost cover all the general criteria for supplier selection in SCM for various types of business. With so many criteria, which one should be used? As mention before, different companies may have different organizations and cultural backgrounds, the criteria should be carefully selected and modified according to the individual company need. Based on the criteria in the aforementioned papers, this study selected some criteria from these literatures and used them with some modification in accordance with the needs of the firms.

3. The analytic method for supplier selection

After determination of criteria, the experts or managers should choose an appropriate and systematic method to evaluate the alternative suppliers. De Boer, Labro, and Morlacchi (2001) performed a comprehensive review for all phases in supplier selection process, in which also cover various methods of supplier selection. Some of these methods used a single model, such as analytic hierarchy process (AHP), linear programming (LP), fuzzy set theory (FST) (Zadeh, 1965), etc. Some of these methods used combined model, such as AHP plus LP, AHP plus FST, etc.

Nevertheless, researchers still developed and improved methods using either a single model or combined models to propose rating methods for supplier selection. Some of these methods have different assumptions or constraints, and some of them are applied to different situations to assist decision-making in supplier selection. For example: Chen, Lin, and Huang (2006) proposed a fuzzy multiple criteria decision-making method to cope with supplier selection problems, and using TOPSIS (Hwang & Yoon, 1981) to determine the ranking order of all suppliers. Li, Yamaguchi, and Nagai (2007) proposed a gray-based approach to deal with the supplier selection problem. Araz and Ozkarahan (2007) introduced PROMETHEE (Brans & Vincke, 1985; Brans, Vincke, & Mareschal, 1986) methodology to evaluate suppliers for strategic sourcing, in which suppliers are assessed considering supplier's co-design capabilities and categorized based on overall performances. Also, potential reasons for differences in performance of supplier groups are identified, and performances of the suppliers are improved by applying supplier development programs. Gevriye and Gürpınar (2007) developed analytic network process (ANP) (Saaty, 1999, 2001) in supplier selection with the evaluation of the relations among supplier selection criteria in a feedback system. Demirtas and Üstün (2008) presented an integrated approach of analytic network process (ANP) and multi-objective mixed integer linear programming to consider both tangible and intangible factors in choosing the best suppliers and define the optimum quantities among selected supplier to maximize the total value of purchasing and minimize the budget and defect rate. Ng (2008) proposed a weighted linear program for the multi-criteria supplier selection problem, and studied a transformation technique which enabled the proposed model to be solved without an optimizer. Chou and Chang (2008) introduced a strategy-aligned fuzzy simple multiattribute rating technique (SMART) approach for solving the supplier/vendor selection problem from the perspective of strategic management of the supply chain. Ha and Krishnan (2008) outlined a hybrid method, incorporating multiple techniques into an evaluation process, in order to select competitive suppliers in a supply chain by performing a cluster analysis.

No matter what models or methods were employed or what situations were assumed, many models eventually come to the final stage and need a method to evaluate the suppliers. In this paper, the proposed method of supplier selection is very simple and easily implemented without any assumption or constraints. The method uses the structure of criteria in analytic hierarchy process (AHP) and employs the consistent fuzzy preference relations (CFPR) process to perform suppliers rating.

4. Analytic methods for building multi-criteria comparison matrices

Analytic hierarchy process (AHP) proposed by Saaty (1980, 1990a, 1990b) has become a general decision-making method for rating supplier and has been broadly applied to various domains (e.g. Al-Harbi, 2001; Chen & Huang, 2004; Lin & Hsu, 2003; Omasa, Kisshimoto, Kawase, & Yagi, 2004; Wei, Chien, & Wang, 2005; Yurdakul & Ic, 2004). The AHP method is primarily employed to solve problems involving many comparisons of criteria evaluation. In this paper, the proposed procedure utilized the hierarchy in AHP with consistent fuzzy preference relations (CFPR) process for rating the suppliers. The following will give the brief descriptions on AHP model and CFPR method, respectively.

4.1. Analytic hierarchy process (AHP) method

The computing procedure of AHP is as follows (Saaty, 1990a, 1990b, 1980; Saaty & Vargas, 1982):

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