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Group decision making process for supplier selection with VIKOR under fuzzy environment

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ABSTRACT

During recent years, how to determine suitable suppliers in the supply chain has become a key strategic consideration. However, the nature of supplier selection is a complex multi-criteria problem including both quantitative and qualitative factors which may be in conflict and may also be uncertain. The VIKOR method was developed to solve multiple criteria decision making (MCDM) problems with conflicting and non-commensurable (different units) criteria, assuming that compromising is acceptable for conflict resolution, the decision maker wants a solution that is the closest to the ideal, and the alternatives are evaluated according to all established criteria. In this paper, linguistic values are used to assess the ratings and weights for these factors. These linguistic ratings can be expressed in trapezoidal or triangular fuzzy numbers. Then, a hierarchy MCDM model based on fuzzy sets theory and VIKOR method is proposed to deal with the supplier selection problems in the supply chain system. A numerical example is proposed to illustrate an application of the proposed model.

1. Introduction

In today's fierce competitive environment characterized by thin profit margins, high consumer expectations for quality products and short lead-times, companies are forced to take the advantage of any opportunity to optimize their business processes. To reach this aim, academics and practitioners have come to the same conclusion: for a company to remain competitive, it has to work with its supply chain partners to improve the chain's total performance. Thus, being the main process in the upstream chain and affecting all areas of an organization, the purchasing function is taking an increasing importance. Thus supply chain management and the supplier (vendor) selection process is an issue that received relatively large amount of attention in both academia and industry.

Supplier selection is a fundamental issue of supply chain area which heavily contributes to the overall supply chain performance. Particularly for companies who spend a high percentage of their sales revenue on parts and material supplies, and whose material costs represent a larger portion of total costs, savings from supplies are of particular importance. These, strongly urge for a more systematic and transparent approach to purchasing decision making, especially regarding the area of supplier selection. Selecting the suppliers significantly reduces the purchasing cost and improves corporate competitiveness, and that is why many experts believe that the supplier selection is the most important activity of a purchasing department. Supplier selection is the process by which suppliers are reviewed, evaluated, and chosen to become part of the company's supply chain. The overall objective of 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 (Chena, Lin, & Huangb, 2006).

Several factors affect a supplier's performance. Dickson (1966), Ellram (1990), Roa and Kiser (1980), Stamm and Golhar (1993) identified, respectively 60, 18, 13 and 23 criteria for supplier selection.

The supplier selection process is often in influenced by uncertainty in practice (de Boer, van der Wegen, & Telgen, 1998; Min, 1994). Due to strategic importance and involvement of various uncertainties and risks associated with the supplier selection process, several decision makers from departments other than purchasing such as production, finance, and marketing are very often involved in the decision making process for supplier selection process. Therefore, some scholars emphasized the need for a rational and systematic group decision making process for supplier selection (de Boer et al., 1998). In essential; the supplier selection problem in supply chain system is a group decision making combination of several and different criteria with different forms of uncertainty (Chena et al., 2006). Hence this problem is a kind of multiple criteria decision making problem (MCDM) which requires MCDM methods for an effective problem-solving. Due to nature of the problem, the techniques of MCDM are coherently derived to

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Table 1
Supplier selection methods and examples.

Category	Approach	Example
MADM	AHP	Narasimhan (1983), Barbarosoglu and Yazgaç (1997); Nydick and Hill (1992), Tam (2001), Lee et al. (2001), Liu and Hai (2005)
	ANP	Sarkis and Talluri (2002)
	MAUT	Min (1994)
	Outranking method	de Boer et al. (1998)
	TOPSIS	Chena et al. (2006)
Mathematical programming	LP	Pan (1989)
	GP	Bufa and Jackson (1983), Karpak et al. (1999)
	MIP	Weber and Ellram (1993), Chaudhry et al. (1993)
	DEA	Weber (1996)
Statistical/ probabilistic		Hinkle et al. (1969)
		Ronen and Trietsch (1998)
		Soukup (1987)
Artificial intelligence	Neural Networks	Albino and Garavelli (1998), Choy et al. (2002)
	Case-based reasoning	Cook (1997)
	Expert System	Vokurka et al. (1996)
Hybrid and innovative approaches	AHP–LP	Ghodsypour and O'Brien (1998)
	ANP–MIP	Demirtas and Üstün (n.d)
	ANP–TOPSIS	Shyur and Shih (2006)
	Fuzzy–QFD	Bevilacqua et al. (2006)

manage it. de Boer, Labro, and Morlacchi (2001) and Aissaoui, Haouari, and Hassini (2007) gave a good review and classification of the methods for supporting supplier selection. We can roughly divide these methods into six main categories: multi-attribute decision making (MADM), multi-objective decision making and mathematical programming (MP), statistics/probabilistic approaches, intelligent approaches, hybrid approaches and others. Six categories, each with their own related approaches and examples, are listed in Table 1.

Methods of the first category concentrate on selection activities. They select a limited and countable number of predetermined alternatives through multiple attributes or criteria. These methods involves multi attribute utility theory (MAUT), outranking methods, analytical hierarchy process (AHP) and its sophisticated version, analytical network process (ANP) and technique for order performance by similarity to ideal solution (TOPSIS). Among these methods, it is difficult to obtain a mathematical representation of the decision maker's utility function for using MAUT (Opricovic & Tzeng, 2007). The outranking methods are normally not used for the actual selection of alternatives, but they are very suitable for the initial screening process (to categorize alternatives into acceptable or unacceptable). After the screening process another method must be used to get a full ranking or actual recommendations among the alternatives (Loken, 2007). Also AHP and ANP have their own problems: rank reversal and difficulty in accommodating a great many candidates. The other method in this category, TOPSIS, is discussed in Section 2.

The methods in the second category optimize the interactions and tradeoffs among different factors of interest by considering constraints and different issues like discount, single or multiple sourcing and logistic costs; which allow the buyer to make an effective decision usually by determining the best order quantity/period from the suitable supplier/suppliers. Several optimization methods such as goal programming, linear programming, mixed integer and data envelopment analysis have been applied in this area. A significant problem with using mathematical programming methods is that most of them are too complex for practical use by operating managers. The other fallback of these methods is their lack to consider qualitative factors. Furthermore the methods in this category are mainly used in multiple sourcing environments for assigning order quantities between supplier/suppliers.

Statistical studies incorporate uncertainty; there are not many articles in the literature that utilize statistics in the supplier selection process. The published statistical models only accommodate for uncertainty with regard to one criterion at a time (de Boer et al., 2001).

Artificial Intelligence (AI) based models are based on computer-aided systems that in one way or another can be trained by a purchasing expert or historic data, however, the complexity of the system is not suitable for enterprises to solve the issue efficiently without high capability in advanced computer programs.

The fifth category is hybrid and innovative methods which authors integrate one or more methods together to utilize their both advantages. However the disadvantages of combined methods affect the effectiveness of hybrid models.

In other way the VIKOR method, a recently introduced new MCDM method developed to solve multiple criteria decision making (MCDM) problems with conflicting and non-commensurable (different units) criteria (Opricovic & Tzeng, 2007), may provide the basis for developing supplier selection models that can effectively deal with characteristics of this problem. In this paper, we used the concept of fuzzy set theory and linguistic values to overcome uncertainty and qualitative factors. Then, a hierarchy MCDM model based on fuzzy sets theory and VIKOR method is proposed to deal with the supplier selection problems in the supply chain system.

The rest of this paper is structured as follows. In the next section, an overview and background of the VIKOR method is presented. In Section 3, an overview of the concepts of the fuzzy approach is given. Section 4 will focus on the proposed model. Then a numerical example is illustrated in Section 5. In the final section, some conclusions are drawn for the study.

2. VIKOR method

Opricovic (1998), Opricovic and Tzeng (2002) developed VIKOR, the Serbian name: VlseKriterijumska Optimizacija I Kompromisno Resenje, means multi-criteria optimization and compromise solution (Chu, Shyu, Tzeng, & Khosla, 2007). The VIKOR method was developed for multi-criteria optimization of complex systems (Opricovic & Tzeng, 2004). This method focuses on ranking and selecting from a set of alternatives, and determines compromise solutions for a problem with conflicting criteria, which can help the decision makers to reach a final decision. Here, the compromise solution is a feasible solution which is the closest to the ideal, and a compromise means an agreement established by mutual concessions (Opricovic & Tzeng, 2007). It introduces the multi-criteria ranking index based on the particular measure of "closeness" to the "ideal" solution (Opricovic, 1998).

According to (Opricovic & Tzeng, 2004) the multi-criteria measure for compromise ranking is developed from the PL_p-metric used as an aggregating function in a compromise programming method (Yu, 1973). The various J alternatives are denoted as $a_1, a_2, \ldots, a_J$. For alternative a_j, the rating of the i th aspect is denoted by f_{ij}, i.e. f_{ij} is the value of i th criterion function for the alternative a_j; n is the number of criteria. Development of the VIKOR method started with the following form of L_p-metric:

$$L_{p,j} = \left\{ \sum_{i=1}^{n} [w_i (f_i^* - f_{ij})/(f_i^* - f_i^-)]^p \right\}^{1/p}, \quad (1)$$
$$1 \leqslant p \leqslant \infty; \quad j = 1, 2, \ldots, J.$$

Within the VIKOR method $L_{1,j}$ (as S_j in Eq. (15)) and $L_{\infty,j}$ (as R_j in Eq. (16)) are used to formulate ranking measure. $L_{1,j}$ is interpreted as