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Decision Support

A fuzzy simple additive weighting system under group decision-making for facility location selection with objective/subjective attributes

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Abstract

This work presents a new fuzzy multiple attributes decision-making (FMADM) approach, i.e., fuzzy simple additive weighting system (FSAWS), for solving facility location selection problems by using objective/subjective attributes under group decision-making (GDM) conditions. The proposed system integrates fuzzy set theory (FST), the factor rating system (FRS) and simple additive weighting (SAW) to evaluate facility locations alternatives. The FSAWS is applied to deal with both qualitative and quantitative dimensions. The FSAWS process considers the importance of each decision-maker, and the total scores for alternative locations are then derived by homo/heterogeneous group of decision-makers. Finally, a numerical example illustrates the procedure of the proposed FSAWS.

Keywords: Location selection; Fuzzy sets; Multiple attributes decision-making; Supply chain management

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1. Introduction

Effective supply chain management (SCM) is required for companies to meet continuously changing requirements in the marketplace. By reducing supply chain risk and uncertainty, companies can enhance customer service, optimize inventory levels, improve business processes and reduce cycle times, resulting in increased competitiveness and profitability. Facility location selection is one of the most critical decisions in supply chain design and management. To optimize logistical network configuration, facilities such as factories, warehouses, distribution centers (DCs) and retail outlets must be strategically located to maximize supply chain performance and profitability (Coyle et al., 2003; Simchi-Levi et al., 2003).

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Numerous attributes (factors) of potential facility locations must be considered during the location selection process, including labor costs, proximity to markets and customers, availability of suppliers, and even quality of life issues (Finch, 2003; Heizer and Render, 2004; Stevenson, 2005). These attributes can be classified into three categories (Liang and Wang, 1991; Heragu, 1997): (a) critical attributes, e.g., availability of utilities and community attitude; these attributes determine whether or not a location will be considered for further evaluation; (b) objective attributes, e.g., investment costs and labor costs, etc; these attributes are defined in monetary/quantitative terms; (c) subjective attributes, e.g., proximity to markets and customers, political stability and quality-of-life issues; these attributes are qualitative. The majority of these attributes can be assessed by human perception and human judgment. As such, facility location selection processes typically involve the imprecision and vagueness inherent in linguistic assessment and fuzzy multiple attributes decision-making (FMADM).

Recent studies have applied FST and its approaches to generate and solve facility location selection problems. Liang and Wang (1991) developed an algorithm for facility site selection based on FST concepts and hierarchical structure analysis. Kuo et al. (1999) proposed a decision support system (DSS) by integrating FST and the AHP in selecting a site for a new convenience store (CVS). Additionally, Kuo et al. (2002) developed a DSS for locating new CVSs by integrating fuzzy AHP and an artificial neural network (ANN). Liang (1999) created a fuzzy multiple attribute decision-making (FMADM) method to identify the optimal alternative based on ideal and anti-ideal point concepts. Chen (2001) developed a new FMADM approach for resolving the DC location selection problem under fuzzy environments based on a stepwise ranking procedure. Chu (2002) presented a fuzzy technique for order preference by similarity to ideal solution (TOPSIS) model to solve the facility location selection problem under GDM. Kahraman et al. (2003) used four fuzzy multi-attribute group decision-making (FMAGDM) approaches in evaluating facility locations.

Four primary conventional methods are frequently used for solving facility location selection problems: FRS, break-even analysis, center-of-gravity method and the transportation model (Finch, 2003; Kahraman et al., 2003; Heizer and Render, 2004; Stevenson, 2005). Among these four methods, only FRS is in the MADM class. The conventional factor rating system (FRS), also known as the multifactor rating system or scoring method, is a very popular and easily applied subjective decision-making method (Heragu, 1997). The simple additive weight (SAW) method, also known as the weighted sum method, is the most widely used MADM method (Hwang and Yoon, 1981; Chang and Yeh, 2001; Virvou and Kabassi, 2004). The basic principle of SAW is to obtain a weighted sum of the performance ratings of each alternative under all attributes (MacCrimmon, 1968; Chen and Hwang, 1992). The SAW consists of two basic steps (Hwang and Yoon, 1981; Kabassi and Virvou, 2004): (1) scale the values of all attributes to make them comparable; (2) sum up the values of the all attributes for each alternative.

The logic of the SAW method is used in FRS to derive total scores for individual alternatives which allows ranking by order of preference (Heragu, 1997; Finch, 2003; Heizer and Render, 2004; Stevenson, 2005). Although these conventional FRS approaches have been successfully applied to select facility locations, these approaches are less effective when dealing with the inherent imprecision of linguistic valuation in the decision-making process (Liang and Wang, 1991; Chen, 2001; Kahraman et al., 2003).

As indicated by literature review, many concepts and approaches have been integrated with the FST to enhance its capability to handle MADM problems with imprecise attributes. Variations of FST, FRS, and SAW can also be integrated to solve the facility selection problem under GDM. Integration of these methods has six key advantages.

First, from the perspective of a practical operating mechanism, decision-making or problem-solving procedures in the PDCA (plan, do, check, and action) management cycle should be easily understood and applied by any organization (Stevenson, 2005). A simulation by Zanakis et al. (1998) evaluated eight MADM methods: SAW; multiplicative exponential weighting (MEW); TOPSIS; elimination and (et) choice translating reality (ELECTRE); and four AHPs. The rank-reversal dimension indices in the simulation disclosed the following performance order for these eight methods: SAW and MEW performed the best, followed by TOPSIS and AHPs. The ELECTRE method performed the worst. In addition, Chang and Yeh (2001) confirmed the superiority of SAW in an empirical study of the three evaluation methods (SAW method, weighted product and TOPSIS). The findings of these studies suggest that simpler evaluation techniques are often superior. Second, the logic and principle of the SAW method is reflected in the FRS procedure; therefore both quali-