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International distribution center selection from a foreign market perspective using a weighted fuzzy factor rating system

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Abstract

This study investigated six international distribution center (DC) selection factors from a foreign market perspective and presented a weighted fuzzy factor rating system (FRS) suitable for solving such problems. An evaluation procedure is illustrated to demonstrate that our procedure is an effective approach in a group decision-making process. In contrast with classic decision-making theory, this method applies fuzzy weighting to assess individual decision makers (DMs) which allows managers to consider the professional or experience of each DM in the decision-making procedure. In the example presented here, the final solution is then obtained by identifying the best international distribution center for further evaluation and negotiation.

Keywords: International distribution center; Fuzzy sets; Weighted fuzzy factor rating system; Decision-making; Supply chain management

1. Introduction

Global competition in international trade poses significant challenges to companies which must rapidly respond to changing marketplace requirements. Effective supply chain management (SCM) enables companies to satisfy such requirements. International distribution centers (DCs) offer numerous advantages to shippers, including storage, inland transport service, customs clearance service, consolidation, packaging, labeling and assembly services. In supply chain design and management, especially worldwide SCM, the role of international distribution centers is increasingly important in transportation and distribution of merchandise.

Classic decision-making theory assumes that managers investigating a potential distribution center (DC) would first identify relevant evaluative criteria appropriate for appraising a range of foreign market options. Managers would then assign importance weights to the identified criteria. Specific information about international DC reality or performance related to relevant criteria would then be collected. Finally, one or more criteria would be applied to identify the best target international DC (Armstrong, 1970; Green & White, 1976; Harrell & Kiefer, 1981; Hodgson & Uyterhoeven, 1962). The majority of these criteria, weight and decision rules are evaluated by human perceptions and judgments which cannot be quantified precisely (Dubrin, 2002). As such, international distribution center selection (DCS) processes typically involve the imprecision/vagueness inherent in linguistic assessment and multiple attribute decision-making (MADM).

In MADM, a given set of alternatives to be assessed with respect to specific attributes is assumed. In reality, the importance of individual decision makers (DMs) against a decision-making attribute may not be equal or uniform. Sometimes there are DMs/experts on specific issues in a decision group, such as the executive manager of operations department on DC selection issues, or some experts who are more experienced than others. Notably, the final outcome of the group decision-making (GDM) process may be markedly influenced by the degree of

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importance of such individual DMs. A good method for aggregating the various influences of individual opinions, evaluation, and rating from multiple DMs thus must be considered in DC selection problems. This study therefore proposes a fuzzy weight assessment to individual DMs adequately respond to multiple expert opinions.

This study investigates three aspects of fuzzy decision-making procedure from a foreign market perspective for international DC selection problems with GDM processes. The initial inquiry is the evaluative criteria experts generally consider relevant for appraising an international DC. Second, the important weights of different DMs on specific attributes/criteria and on the ratings of alternatives need not be uniform where fuzzy assessments and multiple expert opinions are considered. Third, once potential criteria are identified, the proposed decision support system employs simple fuzzy methodology incorporating a judgmental decision-making process to evaluate such criteria and is also appropriate for appraising alternative target international DC. Specifically, this study presents empirical evidence which elucidates the perceived relative importance of potential evaluative criteria within the international DC selection decision-making process.

The remainder of this paper is organized as follows. Section 2 discusses the related literature. Section 3 then describes a review of fuzzy set theory (FST). Next, Section 4 introduces and describes the procedures of the proposed weighted fuzzy factor rating system (FRS) under GDM situation. Subsequently, Section 5 illustrates the procedures of the proposed system using an empirical example. Finally, conclusions are drawn in Section 6.

2. Literature review

In this study, an "international DC" is defined as a place which integrates the operations of manufacturing with land, sea and air transportation, storage, port and customs operations in order to achieve the efficient distribution of commodities (Lu, 2003). The specific focus of this study is international DCs at public airports and seaports including warehouses or DCs at airports and seaports. From a foreign market perspective, international DCs offer value-added functions in an integrated logistics system such as labeling, assembly, logistics processing and inland transportation which can provide an advanced base in a foreign market (Johnson & Wood, 1996).

Recent studies have applied fuzzy set theory (FST) and its techniques to solve location or DC selection problems. Chen (2001) developed a novel MADM method based on the stepwise ranking procedure for resolving the location selection problem under fuzzy environments. Liang (1999) created a fuzzy MADM based on ideal and anti-ideal point concepts to identify the optimal alternative. Kuo, Chi, and Kao (1999) proposed a decision support system (DSS) by integrating FST and the analytical hierarchy process (AHP) in selecting a site for a new convenience store (CVS). Kuo and Chen (2006) using a fuzzy synthetic to evaluate and select mobile value-added services. The majority of the existing approaches, such as AHP based methods, require involved and complex computations. While in today's computing environment this does not pose a serious problem, it may deter the management from using fuzzy MADM method (Ölçer & Odabaşi, 2005).

In numerous situations, crisp data cannot capture real-life attributes; for example, since human judgments are often vague, they cannot be fully represented by crisp values. To overcome the shortcomings in traditional approaches, FST, which allows for vague and/or imprecision boundaries, provides a mechanism to utilize fuzziness in subjective or imprecise determination of preferences, constraints, goals and group decisions (Kahraman, Ruan, & Dogan, 2003; Wang, 1992; Yager, 1982). This approach is based on the idea that decision-making is not always a matter of black and white, true or false. It frequently involves gray areas where the term "maybe" is more appropriate. In fact, decision-making processes are often unstructured, playful, contentious, or rambling.

Chu (2002) presented a fuzzy technique for order preference by similarity to ideal solution (TOPSIS) model under group decisions to solve the facility locations selection problem. Kahraman et al. (2003) utilized four fuzzy multi-attribute GDM approaches in evaluating facility locations. Both of the above assumed that DMs preferences were of an equal weight explicitly. Furthermore, they did not discuss the effectiveness of GDM problems influenced by the size of the decision group.

Four primary conventional methods are used for solving facility location selection problems: FRS, break-even analysis, center-of-gravity method and the transportation model (Finch, 2003; Heizer & Render, 2004; Kahraman et al., 2003; Stevenson, 2005). Among these four methods, only FRS is in the MADM class. The conventional 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 logic of the simple additive weighting (SAW) method is used in FRS to derive total scores for individual alternatives which allows ranking by order of preference (Heizer & Render, 2004; Heragu, 1997; Stevenson, 2005). A simulation by Zanakis, Solomon, Wishart, and Dublish (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.

As indicated by the literature reviews, the FST is incorporated into many concepts and procedures when enhanc-