Knowledge-Based Systems 24 (2011) 796–808

Contents lists available at ScienceDirect

Knowledge-Based Systems

journal homepage: www.elsevier.com/locate/knosys

Consolidating SWOT analysis with nonhomogeneous uncertain preference information

Chang-Yuan Gao, Ding-Hong Peng *

School of Management, Harbin University of Science and Technology, 150040 Harbin, PR China

ARTICLE INFO

Article history:
Received 15 September 2010
Received in revised form 12 January 2011
Accepted 1 March 2011
Available online 6 March 2011

Keywords:
SWOT
Multiple criteria group decision-making (MCGDM)
Priority
Nonhomogeneous uncertain preference information
Transform functions
Uncertain OWA operator

ABSTRACT

SWOT analysis is an important support tool for decision-making, and is commonly used to systematically analyze organizations' internal and external environments. However, one of its deficiencies is in the measurement and evaluation of prioritization of the factors and strategies. This paper is aimed to present a novel quantified SWOT analytical method based multiple criteria group decision-making (MCGDM) concept, in which the priorities of SWOT factors and groups are derived by multiple decision makers (DMs) with nonhomogeneous uncertain preference information (NUPI), such as interval multiplicative preference relations, interval fuzzy preference relations, and uncertain linguistic preference relations. In this method, the SWOT analysis provides a basic frame within which to perform analyses of decision situations, in turn, MCGDM methods assist in carrying out SWOT more analytically and in elaborating the results of the analyses so that SWOT factors and groups can be prioritized with respect to the entire SWOT. The uniform and aggregation of the NUPI and the derivation of priorities for SWOT groups and factors are investigated in detail. Finally, an example is to validate the procedure of the proposed method.

1. Introduction

SWOT (the acronym standing for Strengths, Weaknesses, Opportunities and Threats) analysis is an important decision-making support tool, and is commonly used to systematically analyze the strategic situations and identify the level of organizations from their internal and external environments [15,16,22,36]. It involves systematic thinking and comprehensive diagnosis of factors relating to for any organization, project, or individual. Specifically, it allows strategists to diagnose with greater detail all factors influencing the internal and external environment, to categorize these factors into internal (strengths, weaknesses) and external (opportunities, threats) as they relate to a decision and thus enable them to compare opportunities and threats with strengths and weaknesses. Through SWOT analysis, organizations can identify their positive and negative factors and then develop and adopt a strategy resulting in a good fit these factors. If used correctly, SWOT can provide a good basis for successful strategy formulation. When undertaking SWOT, unfortunately, often the analysis merely pinpointing the number of factors in strength, weakness, opportunity or threat groups and the expression of individual factors is often of a very general nature and brief [9,16]. It includes no means of analytically determining the relative importance of factors or of comprehensively assessing the fit between SWOT factors and decision alternatives [14–16]. In other words, the result of SWOT analysis is too often only a superficial and imprecise listing or an incomplete qualitative examination of internal and external factors, or is simply discarded after the analysis [9]. Consequently, it has been reported that SWOT analysis cannot comprehensively appraise the strategic decision-making process [11,45].

In order to overcome the limitations mentioned above and improve the usability of SWOT analysis, several attempts have been made to expand SWOT with quantitative methods recently [1,3,4,8,10,15–19,21,22,27,28,45,46]: besides classic external factor evaluation (EFE) matrix and internal factor evaluation (IFE) matrix, Kurttila et al. [17] proposed a hybrid SWOT method with AHP to make factors commensurable and to support a more quantitative basis in the strategic planning process. The idea of the hybrid SWOT-AHP method, in recent years, has been extensively applied and subsequently studied in various fields: from the view of applications, the SWOT-AHP method has been used to analyze the suitability of a community-based management (CBM) approach [21], strategic planning of natural resource management [22], analyze the global competitiveness of manufacturers of machine tools [27], formulate the strategy of the safe carriage of bulk liquid chemicals in maritime tankers [3], and analyze the bioenergy development [8].

From the view of the subsequent studies, some quantified SWOT methods have been proposed by integrating SWOT with

* Corresponding author. Tel.: +86 13766937834.
E-mail address: pengdinghong2009@163.com (D.-H. Peng).

0950-7051/$ - see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.knosys.2011.03.001

SMART (simple multi-attribute rating technique) method [15], SMAA-O (the stochastic multicriteria acceptability analysis with ordinal criteria) method [16], the MCDM concept and fuzzy AHP method [18], statistical preference analysis techniques [19], MADM (multi-attribute decision making) technique based on the concept of grand strategy matrix [4], ANP (analytic network process) [45], FAHP (fuzzy analytic hierarchy process) [46], fuzzy logic and fuzzy linear programming [1]. Moreover, the fuzzy SWOT method [10], and the quantified methods [28], which is integrated SWOT with AHP, subjective probabilities, defuzzification, entropy, and the theory of displaced ideal.

As Zaerpour et al. [46] pointed out that the integration of SWOT and MCDM is a quite novel method and has not received enough attentions in studies and applications. According to reviewed above, additionally, it is clearly that the hybrid SWOT–MCDM methods are indeed favorable because they both overcome the limitation and improve the usability of SWOT. The integration of MCDM and SWOT cannot only as the general framework assist to structure the problem and keep the entire decision-support process under the decision-makers' control, but also measure quantitatively priorities of the factors included in SWOT analysis and make them commensurable as regards their intensities [17]. Furthermore, the pairwise comparisons between SWOT factors which are used to estimate priorities can force DMs to think over the importance of different factors and analyze the situation more precisely and in more depth [17].

However, in some practical cases, the DMs participating SWOT analysis may belong to distinct areas and will, then, have different backgrounds, levels of knowledge, experiences, cultures and circumstances. Therefore, they tend to use different representation formats to express their personal preferences for each pair of factors. Moreover, due to time pressure, lack of knowledge, and the expert's limited expertise about the problem domain [39], it is sometimes unrealistic and infeasible to require DMs to provide exact judgments, on the other hand, if forcing DMs to state their preference in single and exact format could lead to more biased and time-consuming estimates of true preferences than when applying multiple uncertain formats. Therefore, it might be more natural and convenient for multiple DMs to express their preference in multiple uncertain formats, i.e. nonhomogeneous uncertain preference information, for parts or all of the SWOT factors. All of the hybrid SWOT methods mentioned above, however, will be unsuitable for dealing with such situations. Therefore, it is valuable to pay attention to this situation.

In this paper, we investigate a novel quantified SWOT analytical method that the preference information on SWOT factors and groups are given by multiple DMs with three common uncertain preference formats, such as, interval multiplicative preference relations, interval fuzzy preference relations, and uncertain linguistic preference relations, to provide more effective and flexible decision support and to further improve the usability of SWOT analysis. The rest of this paper is set out as follows. Section 2 of this paper briefly introduces relevant theories of nonhomogeneous uncertain preference information, investigates the uniform, aggregation of the nonhomogeneous uncertain preference information and the derivation of priorities in detailed. Section 3 presents a novel quantified SWOT method and describes its steps. Section 4 illustrates an application of the method with a numerical example, thereafter, verifies the validation of the proposed method. Section 5 concludes this paper.

2. Nonhomogeneous uncertain preference information

Preference relations are usually used by DMs to express their preference information based on pairwise comparisons of criteria or alternatives. Up to date different preference formats in MCDM problems have received increasingly attentions, such as, preference orderings [5,6,13,20,23,41,47], utility values [5,6,13,20,23,41,47], fuzzy preference relations [5–7,9,12,13,20,23,41,47], multiplicative preference relations [6,7,9,13,20,23,41,47], linguistic preference relations [7,12,37,47], as well as their interval formats [12,34,35,37] and incomplete formats [24,36,41]. Owing to multiplicative preference relations, fuzzy preference relations and linguistic preference relations are mostly common preference structures, as well as considering the complexity and uncertainty involved in real-world decision problems and the inherent subjective nature of human judgments. In this section, we introduce relevant theories of three well-known types of uncertain preference relations (interval multiplicative preference relations, interval fuzzy preference relations and uncertain linguistic preference relations).

2.1. Nonhomogeneous uncertain preference information

2.1.1. Interval multiplicative preference relations (IMPR) [14,26,35,36]

In this case, a DM's preference information on X is described by an interval multiplicative preference relation $\widetilde{A} = (\tilde{a}_{ij})_{n\times n} \subset X \times X$, which satisfies:

$$\tilde{a}_{ij} = \left[\tilde{a}_{ij}^L, \tilde{a}_{ij}^U\right], \quad \tilde{a}_{ij}^U \geqslant \tilde{a}_{ij}^L \geqslant 0, \quad \tilde{a}_{ij}^L \tilde{a}_{ji}^U = \tilde{a}_{ij}^U \tilde{a}_{ji}^L = 1,$$
$$\tilde{a}_{ii}^L = \tilde{a}_{ii}^U = 1, \quad \forall i,j = 1,2,\ldots,n \tag{1}$$

where $\tilde{a}_{ij}$ indicates the interval-valued preference degree of the alternative x_i over x_j, it is interpreted as x_i is $\tilde{a}_{ij}$ times as good as x_j, $\tilde{a}_{ij}^L$ and $\tilde{a}_{ij}^U$ are the lower and upper limits of $\tilde{a}_{ij}$, respectively. The measurement of $\tilde{a}_{ij}^L$, $\tilde{a}_{ij}^U$ can be described using a ratio scale, and in particular, Saaty's ratio scale is used, $\tilde{a}_{ij}^L, \tilde{a}_{ij}^U \in \left[\frac{1}{9}, \ldots, \frac{1}{2}, 1, 2, \ldots, 9\right]$. In particular, if $\tilde{a}_{ij}^L = \tilde{a}_{ij}^U$, for all $i, j = 1, 2, \ldots, n$, then $\tilde{a}_{ij}$ is reduced to a multiplicative preference relation.

2.1.2. Interval fuzzy preference relations (IFPR) [12,30,36,38]

In this case, a DM's preference information on X is described by an interval fuzzy preference relation $\widetilde{R} = (\tilde{r}_{ij})_{n\times n} \subset X \times X$, which satisfies:

$$\tilde{r}_{ij} = \left[\tilde{r}_{ij}^L, \tilde{r}_{ij}^U\right], \quad \tilde{r}_{ij}^U \geqslant \tilde{r}_{ij}^L \geqslant 0, \quad \tilde{r}_{ij}^L + \tilde{r}_{ji}^U = \tilde{r}_{ij}^U + \tilde{r}_{ji}^L = 1,$$
$$\tilde{r}_{ii}^L = \tilde{r}_{ii}^U = 0.5, \quad \forall i,j = 1,2,\ldots,n \tag{2}$$

where $\tilde{r}_{ij}$ indicates the interval-valued preference degree of the alternative x_i over x_j, $\tilde{r}_{ij}^L$ and $\tilde{r}_{ij}^U$ are the lower and upper limits of $\tilde{r}_{ij}$, respectively. In particular, if $\tilde{r}_{ij}^L = \tilde{r}_{ij}^U$, for all $i, j = 1, 2, \ldots, n$, then $\tilde{r}_{ij}$ is reduced to a fuzzy preference relation.

2.1.3. Uncertain linguistic preference relation (ULPR) [34–37]

Let $S = \{s_\alpha | \alpha = -t, \ldots, t\}$ be a finite and totally ordered discrete term set, where t is a non-negative integer. Each term, s_α represents a possible value for a linguistic variable, and it shall have the following characteristics:

(1) The set is ordered: $s_\alpha > s_\beta$ if $\alpha > \beta$.
(2) There is the negation operator: $neg(s_\alpha) = s_{-\alpha}$, especially, $neg(s_0) = s_0$.

To preserve all the given information, Xu [31] extend the discrete term set S to a continuous term set $\overline{S} = \{s_\alpha | \alpha \in [-q, q]\}$, where $q (q > t)$ is a sufficiently large positive integer. If $s_\alpha \in S$, then we call s_α the original term, otherwise, we call s_α the virtual term.

Consider any two linguistic terms $s_\alpha, s_\beta \in \overline{S}$, and μ, μ_1, $\mu_2 \in [0, 1]$, we introduce some operational laws as follows [32]: