academicJournals

Vol. 7(15), pp. 1209-1217, 21 April, 2013
DOI: 10.5897/AJBM11.2309
ISSN 1993-8233 © 2013 Academic Journals
http://www.academicjournals.org/AJBM

African Journal of Business Management

Review

Developing a linguistic multi-criteria group decision support system by integrating fuzzy analytic hierarchy process (AHP) and Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR) methods

Sun, Chia Chi

Department of International Business, Grade Institute, Tamkang University, Taipei County 25137, Taiwan R.O.C.

Accepted 28 November, 2011

Multi-criteria group decision support system aims to support preference-based decision over the available alternatives that are characterized by multiple criteria in a group. This research adopts the fuzzy analytic hierarchy process as the analytical tool that determines the weights of each criterion. The fuzzy analytic hierarchy process method is used to determine the weightings for evaluating criteria among decision makers. Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR) is to find out the best solution among these alternatives. Fuzzy theory provides a proper tool to encounter with uncertainties and complex environment. The purpose of this paper is to use the fuzzy AHP and VIKOR method based on fuzzy sets in solving MCDM problems. A practical numerical example is provided to demonstrate the usefulness of this study. The proposed method enables decision analysts to better understand the complete evaluation process and provide a more accurate, effective and systematic decision support tool.

Key words: MCDM, fuzzy analytic hierarchy process, Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR), fuzzy number.

INTRODUCTION

Multi-criteria group decision support system aims to support preference-based decision over the available alternatives that are characterized by multiple criteria in a group. This research adopts the fuzzy analytic hierarchy process as the analytical tool that determines the weights of each criterion.

In the literature, there are few fuzzy logic method aimed at prioritizing the shopping websites. The main purpose of this paper is to provide practitioners with a fuzzy point of view to traditional research for dealing with imprecision and at obtaining the prioritization of criteria measurement dimensions. We take the shopping websites of Taiwan for pursuing our case purposes. This research invites twelve experts that evaluate different shopping websites via the proposed fuzzy AHP method. The fuzzy AHP is used to determine the weights of evaluation criterion. Then this research adopts the Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR) to rank the alternatives of four shopping websites.

This research looks forward to provide some empirical tactics in order to enhance management performance for the website shopping industry.

FUZZY ANALYTIC HIERARCHY PROCESS METHOD

Analytic hierarchy process (AHP) is a powerful method to solve complex decision problems. Any complex problem can be decomposed into several sub-problems using AHP in terms of hierarchical levels where each level

E-mail: samsun0712@gmail.com, ccsun@mail.tku.edu.tw. Tel: +886-2-2621-5656 ext: 2851. Fax: +886-2-2620-9730.

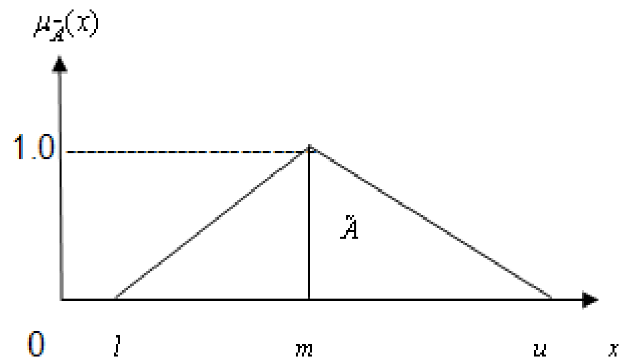

Figure 1. The membership functions of the triangular fuzzy number.

represents a set of criteria or attributes relative to each sub-problem. The AHP method is a multi-criteria method of analysis based on an additive weighting process, in which several relevant attributes are represented through their relative importance. AHP has been extensively applied by academics and professionals, mainly in engineering applications involving financial decisions associated to non-financial attributes (Saaty, 1996). Through AHP, the importance of several attributes is obtained from a process of paired comparison, in which the relevance of the attributes or categories of drivers of intangible assets are matched two-on-two in a hierarchic structure.

However, the pure AHP model has some shortcomings (Yang and Chen, 2004). They pointed out that the AHP method is mainly used in nearly crisp-information decision applications; the AHP method creates and deals with a very unbalanced scale of judgment; the AHP method does not take into account the uncertainty associated with the mapping of human judgment to a number by natural language; the ranking of the AHP method is rather imprecise; and the subjective judgment by perception, evaluation, improvement and selection based on preference of decision-makers have great influence on the AHP results. To overcome these problems, several researchers integrate fuzzy theory with AHP to improve the uncertainty. Hence, Buckley (1985) used the evolutionary algorithm to calculate the weights with the trapezoidal fuzzy numbers. The fuzzy AHP based on the fuzzy interval arithmetic with triangular fuzzy numbers and confidence index α with interval mean approach to determine the weights for evaluative elements.

Determining the evaluation dimensions weights

This research employs fuzzy AHP to fuzzify hierarchical analysis by allowing fuzzy numbers for the pair-wise comparisons and find the fuzzy preference-weights. Here, we briefly review concepts for fuzzy hierarchical evaluation. Then, we further introduce the computational process about fuzzy AHP in detail.

Establishing fuzzy number

Fuzzy sets are sets whose elements have degrees of membership. Fuzzy sets have been introduced by Zadeh (1965) as an extension of the classical notion of set. In classical set theory, the membership of elements in a set is assessed in binary terms according to a bivalent condition - an element either belongs or does not belong to the set (Wu and Lee, 2007; Liou et al., 2008). The mathematics concept is borrowed from Hsieh et al. (2004), Liou et al. (2008) and Wu (2008).

A fuzzy number $\tilde{A}$ on $\mathbb{R}$ to be a TFN if its membership function $\mu_{\tilde{A}}(x):\mathbb{R} \to [0,1]$ is equal to Equation 1:

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-l)/(m-l), & l \le x \le m \\ (u-x)/(u-m), & m \le x \le u \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

From Equation 1, l and u mean the lower and upper bounds of the fuzzy number $\tilde{A}$, and m is the modal value for $\tilde{A}$ (Figure 1). The TFN can be denoted by $\tilde{A}$ = (l,m,u). The operational laws of TFNs $\tilde{A}_1 = (l_1, m_1, u_1)$ and $\tilde{A}_2 = (l_2, m_2, u_2)$ are displayed as Equations 2 to 5.

Addition of the fuzzy number $\oplus$

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (2)$$

Multiplication of the fuzzy number $\otimes$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 l_2, m_1 m_2, u_1 u_2) \text{ for } l_1, l_2 > 0;\ m_1, m_2 > 0;\ u_1, u_2 > 0 \quad (3)$$

Subtraction of the fuzzy number Θ

$$\tilde{A}_1 \Theta \tilde{A}_2 = (l_1, m_1, u_1) \Theta (l_2, m_2, u_2) = (l_1 - u_2, m_1 - m_2, u_1 - l_2) \quad (4)$$

Division of a fuzzy number $\varnothing$

$$\tilde{A}_1 \varnothing \tilde{A}_2 = (l_1, m_1, u_1) \varnothing (l_2, m_2, u_2) = (l_1 / u_2, m_1 / m_2, u_1 / l_2)$$

for $l_1, l_2 > 0;\ m_1, m_2 > 0;\ u_1, u_2 > 0$

Table 1. Membership function of linguistic scale (example).

Fuzzy number	Linguistic	Scale of fuzzy number
9	Perfect	(8,9,10)
8	Absolute	(7,8,9)
7	Very good	(6,7,8)
6	Fairly good	(5,6,7)
5	Good	(4,5,6)
4	Preferable	(3,4,5)
3	Not bad	(2,3,4)
2	Weak advantage	(1,2,3)
1	Equal	(1,1,1)

Reciprocal of the fuzzy number

$$\tilde{A}^{-1} = (l_1, m_1, u_1)^{-1} = (1/u_1, 1/m_1, 1/l_1) \quad \text{for} \quad l_1, l_2 > 0;\ m_1, m_2 > 0;\ u_1, u_2 > 0 \tag{5}$$

Determining the linguistic variables

Linguistic variables take on values defined in its term set: its set of linguistic terms. Linguistic terms are subjective categories for the linguistic variables. A linguistic variable is a variable whose values are words or sentences in a natural or artificial language. Here, we use this kind of expression to compare two building cluster policy evaluation dimension by nine basic linguistic terms, as "perfect," "absolute," "very good," "fairly good," "good," "preferable," "not bad," "weak advantage" and "equal" with respect to a fuzzy nine level scale. In this paper, the computational technique is based on the following fuzzy numbers defined by Gumus (2008) in Table 1. Here, each membership function (scale of fuzzy number) is defined by three parameters of the symmetric triangular fuzzy number, the left point, middle point and right point of the range over which the function is defined. The use of linguistic variables is currently widespread and the linguistic effect values of cluster policy alternatives found in this study are primarily used to assess the linguistic ratings given by the evaluators.

Fuzzy analytic hierarchy process (AHP)

Step 1

Construct pair-wise comparison matrices among all the elements/criteria in the dimensions of the hierarchy system. Assign linguistic terms to the pair-wise comparisons by asking which is the more important of each two dimensions, as following matrix $\tilde{\boldsymbol{A}}$

$$\tilde{\boldsymbol{A}} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{\boldsymbol{n1}} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{\boldsymbol{12}} & \cdots & \tilde{a}_{\boldsymbol{1n}} \\ 1/\tilde{a}_{\boldsymbol{12}} & 1 & \cdots & \tilde{a}_{\boldsymbol{2n}} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{\boldsymbol{1n}} & 1/\tilde{a}_{\boldsymbol{2n}} & \cdots & 1 \end{bmatrix} \tag{6}$$

where

$$\tilde{a}_{ij} = \begin{cases} \tilde{9}^{-1}, \tilde{8}^{-1}, \tilde{7}^{-1}, \tilde{6}^{-1}, \tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{1}^{-1}, \tilde{1}, \tilde{2}, \tilde{3}, \tilde{4}, \tilde{5}, \tilde{6}, \tilde{7}, \tilde{8}, \tilde{9}, & i \neq j \\ 1, & i = j \end{cases} \tag{7}$$

Step 2

Use geometric mean technique to define the fuzzy geometric mean and fuzzy weights of each criterion by Hsieh et al. (2004):

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \cdots \otimes \tilde{a}_{ij} \otimes \cdots \otimes \tilde{a}_{in})^{1/n}$$
$$\tilde{w}_i = \tilde{r}_i \otimes [\tilde{r}_1 \oplus \cdots \oplus \tilde{r}_i \oplus \cdots \oplus \tilde{r}_n]^{-1} \tag{8}$$

where $\tilde{a}_{ij}$ is fuzzy comparison value of dimension i to criterion j, thus, $\tilde{r}_i$ is a geometric mean of fuzzy comparison value of criterion i to each criterion j and $j = 1, 2, ..., n$, $\tilde{w}_i$ is the fuzzy weight of the i-th criterion and $i = 1, 2, ..., n$, can be indicated by a TFN, $\tilde{w}_i = (lw_i, mw_i, uw_i)$. The lw_i, mw_i and uw_i stand for the lower, middle and upper values of the fuzzy weight of the i-th dimension respectively.

There are numerous studies that apply fuzzy AHP method to solve different managerial problems. Huang et al. (2008) adopt a fuzzy analytic hierarchy process method and utilize crisp judgment matrix to evaluate subjective expert judgments made by perception. Pan (2008) applied fuzzy AHP model for selecting the suitable bridge construction method. Cakir and Canbolat (2008) propose an inventory classification system based on the fuzzy analytic hierarchy process. Wang and Chen (2008) applied fuzzy linguistic preference relations to construct a pairwise comparison matrix with additive reciprocal property and consistency. Sambasivan and Fei (2008) evaluate the factors and sub-factors critical to the successful implementation of ISO 14001-based environmental management system and benefits. Sharma et al. (2008) used AHP method to optimize the selection of delivery network design followed by relevant choices for decision making of home plus distribution center.

Costa and Vansnick (2008) discussed the meaning of the priority vector derived from the principal eigenvalue method used in AHP. Firouzabadi et al. (2008) presented a decision support methodology for strategic selection decisions used a combination of analytic hierarchy process and zero-one goal programming to address the selection problem from the point of view of an individual stakeholder. Wang et al. (2008) showed by examples that the priority vectors determined by the analytic hierarchy process method. Kuo et al. (2007) proposed group decision making based on concepts of TOPIS technique for location section in fuzzy environment. Gumus (2008) evaluate hazardous waste transportation firms containing the methods of fuzzy-AHP and TOPSIS. Armillotta (2008) described a computer-based tool for the selection of techniques used in the manufacture of prototypes and limited production runs of industrial products. The underlying decision model based on the AHP methodology, Dagdeviren and Yuksel (2008) presented fuzzy AHP approach to determine the level of faulty behavior risk in work systems. Chen et al. (2008) used fuzzy analytic hierarchy process to determine the weighting of subjective/perceptive judgments for each criterion and to derive fuzzy synthetic utility values of alternatives in a fuzzy multi-criteria decision-making environment. Lin et al. (2008) proposed a framework that integrates the analytical hierarchy process and the technique for order preference by similarity to ideal solution to assist designers in identifying customer needs/requirements and design characteristics and help achieve an effective evaluation of the final design solution for achieving the aspired/desired levels.

THE VLSEKRITERIJUMSKA OPTIMIZACIJA I KOMPROMISNO RESENJE (VIKOR) METHOD

This research applies VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) to find out the best solution among these alternatives. The basic idea of VIKOR is to find out the positive ideal solution and negative ideal solution. This method determines the compromise ranking-list, the compromise solution, and the weight stability intervals for preference stability of the compromise solution obtained with the initial (given) weights (Opricovic and Tzeng, 2004). Furthermore, we can prioritize the order from the set of the alternatives and then determine the best one in the presence of conflicting criteria. Further, we show the computational procedure of VIKOR. The mathematics concept is borrowed from Opricovic and Tzeng (2004) and Tzeng et al. (2005).

Step 1

Calculate the normalized value. For the process of normalized value, when x_{ij} is the original value of the ith option and jth the dimension, the formula is as follows:

$$f_{ij} = X_{ij} / \sqrt{\sum_{i=1}^{m} X_{ij}^{2}}, i = 1,2,\ldots,m;\ j = 1,2,\ldots,n \tag{9}$$

Step 2

Determine the best rating f_i^+ and the worst rating f_i^- for all the criteria. If the criterion ith is a benefit, then:

$$f_i^+ = \max_j f_{ij}, \quad f_i^- = \min_j f_{ij} \tag{10}$$

Step 3

Compute the S_j and R_j values for $j = 1, \ldots, m$, which represent the average and the worst group scores for the alternative A_i, with the relations:

$$S_j = \sum_{i=1}^{n} w_i \left(\frac{f_i^+ - f_{ij}}{f_i^+ - f_i^-} \right), \quad S_j \in [0,1]$$

$$R_j = \max_i \left[w_i \frac{\left(f_i^+ - f_{ij} \right)}{\left(f_i^+ - f_i^- \right)} \right], \quad R_j \in [0,1] \tag{11}$$

where w_i are the weights of criteria, expressing their relative importance.

Step 4

Compute the values Q_j, $j = 1, 2, \ldots, J$, by the relation:

$$Q_j = \frac{v(S_j + S^+)}{(S^- - S^+)} + \frac{(1-v)(R_j - R^+)}{(R^- - R^+)}$$

$$where\ S^+ = \min_j S_j, \quad S^- = \max_j S_j$$

$$R^+ = \min_j R_j, \quad R^- = \max_j R_j \tag{12}$$

where v is the weight of the decision-making of the major of criteria, here $v = 0.5$.

Step 5

Rank the alternatives by sorting each S, R and Q values in an increasing order. The result is a set of three ranking lists denoted as $S_{[\cdot]}$, $R_{[\cdot]}$ and $Q_{[\cdot]}$.

Step 6

Propose as a compromise solution, the alternative (a') which is ranked the best by the measure Q if the following two conditions are satisfied:

C1: "acceptable advantage":

$$Q(a') - Q(a') \geq DQ$$

where a'' is the alternative with second position in the ranking list by Q; $DQ = 1/(J-1)$; J is the number of alternatives.

C2: "Acceptable stability in decision making": Alternative a' must be the best ranked by S or R.

This compromise solution is stable within a decision making process, which could be: "Voting by major rule" (when $v > 0.5$), or "by consensus" $v \approx 0.5$, or "with veto" (when $v < 0.5$). Here, v is the weight of decision making strategy "the majority of criteria".
If one of the condition is not satisfied, then a set of compromise solution is proposed, which consists of:

i. Alternatives a' and a'' if only condition C2 is not satisfied, or

ii. Alternatives $a', a'', \ldots, a^{(M)}$ if condition C1 is not satisfied; and $a^{(M)}$ is determined by the relation $Q(a^{(M)}) - Q(a') < DQ$ for maximum M.

There are also many researches that adopt the VIKOR model to investigate the complex managerial problems. Sayadi et al. (2008) extended the VIKOR method for decision making problems with interval number. Büyüközkan and Ruan (2008) applied VIKOR method to evaluate of software development projects. Chu et al. (2007) demonstrated the anticipated achievements of knowledge communities (KC) through simple average weight (SAW), "Technique for order preference by similarity to an ideal solution" and "VlseKriterijumska Optimizacija I Kompromisno Resenje" (VIKOR). Opricovic and Tzeng (2007) compared with four multicriteria decision making methods: TOPSIS, PROMETHEE, ELECTRE and VIKOR, and find out the best method evaluation method is VIKOR. Tzeng et al. (2005) applied TOPSIS and VIKOR to determine the best compromise alternative fuel mode. Opricovic and Tzeng (2004) tried to reveal and compare the procedural basis of these two MCDM methods, TOPSIS and VIKOR.

NUMERICAL EXAMPLE

In this paper, attention will be given mainly to online B2C transactions. This study begins by establishing a conceptual framework through a review of related theories and literatures. Through the literature investigation and experts' opinions, the committee finally adopted 12 criteria. This research framework includes three dimen-sions and twelve evaluation criteria. The dimensions are technology acceptance factor (D_1), website service quality (D_2) and specific holdup cost (D_3) and the evaluation criteria are efficiency (C_1), practical (C_2), ease use (C_3), time-saving (C_4), communication (C_4), confident (C_6), security (C_7), trust (C_8), familiar (C_9), past experience (C_{10}), proficiency (C_{11}) and knowledgeable (C_{12}). In addition, there are four alternatives of shopping websites that encompass Taiwan Yahoo (A_1), PChome (A_2), Unimall (A_3) and eBay (A_4).
After the construction of the hierarchy, the different priority weights of each criteria, attributes and alternatives are calculated using the fuzzy AHP and VIKOR approaches. The comparison of the importance or preference of one criterion, attribute or alternative over another can be done with the help of the questionnaire. The method of calculating priority weights of the different decision alternatives is discussed further.

The weights of evaluation dimensions

We adopt fuzzy AHP method to evaluate the weights of different dimensions and evaluation criteria for the competitive advantage of shopping websites. Following the construction of fuzzy AHP model, it is extremely important that experts fill the judgment matrix. In this study, two website designers, three software engineers, two shopping websites owners and five engineer management information systems experts are involved. Further discuss demonstrates the computational procedure of the weights of dimensions:

i. According to the committee with ten representatives about the relative importance of different dimensions and evaluation criteria, then the pair-wise comparison matrices will be obtained. We apply the fuzzy numbers defined in Table 1. We transfer the linguistic scales to the corresponding fuzzy numbers.

ii. Computing the elements of synthetic pair-wise comparison matrix by using the geometric mean method suggested by Buckley (1985), that is: $\tilde{a}_{ij} = (\tilde{a}^1_{ij} \otimes \tilde{a}^5_{ij} \otimes \ldots \otimes \tilde{a}^{12}_{ij})$, for $\tilde{a}_{12}$ as the example:

$$\begin{aligned}\tilde{a}_{12} &= (1,2,3) \otimes (3,4,5) \otimes \cdots \otimes (1,2,3)^{1/12} \\ &= ((1\times 3\times \cdots \times 3)^{1/12}, (2\times 4\times \cdots \times 2)^{1/12}, (3\times 5 \cdots \times 3)^{1/12}) \\ &= (1.085, 1.730, 2.556)\end{aligned}$$

The other matrix elements can be obtained by the same computational procedure, therefore, the synthetic pair-wise comparison matrices will be constructed as follows matrix A:

$$A = \begin{array}{c} \\ D_1 \\ D_2 \\ D_3 \end{array}\begin{array}{c} \begin{array}{ccc} D_1 & D_2 & D_3 \end{array} \\ \begin{bmatrix} (1,1,1) & (1.085,1.730,2.556) & (1.134,1.414,1.477) \\ (0.429,0.612,0.922) & (1,1,1) & (0.922,1.367,1.373) \\ (0.587,0.724,0.913) & (0.553,0.731,1.085) & (1,1,1) \end{bmatrix}\end{array}$$

iii. To calculate the fuzzy weights of dimensions, the computational procedures are displayed thus:

$$\begin{aligned}\tilde{r}_1 &= (\tilde{a}_{11} \otimes \tilde{a}_{12} \otimes \tilde{a}_{13})^{1/3} \\ &= (1\times 1.085 \times 1.134)^{1/3}, (1\times 1.730\times 1.414)^{1/3}, (1\times 2.556\times 1.477)^{1/3} \\ &= (1.0715, 1.3475, 1.5572)\end{aligned}$$

Similarly, we can obtain the remaining $\tilde{r}_i$, there are:

$$\tilde{r}_2 = (0.7338, 0.9425, 1.0817)$$
$$\tilde{r}_3 = (0.6873, 0.8091, 1.1527)$$

For the weight of each dimension, they can be done as follows:

$$\begin{aligned}\tilde{D}_1 &= \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3)^{-1} \\ &= (1.0715, 0.7338, 0.6873) \otimes (1/(1.5572+1.0817+1.1527), 1/(1.3475+0.9425+0.8091), \\ &\quad 1/(1.0715+0.7338+0.6873)) \\ &= (0.2826, 0.4348, 0.6247)\end{aligned}$$

We also can calculate the remaining $\tilde{w}_i$, there are:

$$\tilde{D}_2 = (0.1935, 0.3041, 0.4340)$$
$$\tilde{D}_3 = (0.1813, 0.2611, 0.4625)$$

iv. To apply the COA method to compute the BNP value of the fuzzy weights of each dimension:

To take the BNP value of the weight of D_1 (factor condition) as an example, the calculation process is as follows:

$$\begin{aligned}BNP_{D_1} &= \left[(U_{w_1} - L_{w_1}) + (M_{w_1} - L_{w_1})\right]/3 + L_{w_1} \\ &= \left[(0.6247 - 0.2826) + (0.4348 - 0.2826)\right]/3 + 0.2826 \\ &= 0.4474\end{aligned}$$

Then, the dimensions and weights for the remaining dimensions can be found as shown in Table 2. Table 2 shows the relative weight of different dimensions and evaluation criteria for the competitive advantage of shopping websites, which obtained by fuzzy AHP method.

The weights for each criterion are: C_1 (0.1332), C_2 (0.1216), C_3 (0.1089), C_4 (0.1578), C_5 (0.0934), C_6 (0.0642), C_7 (0.1217), C_8 (0.0735), C_9 (0.0799), C_{10} (0.1132), C_{11} (0.0456) and C_{12} (0.0445). From the fuzzy AHP results, we can understand that the first two important factors for the competitive advantage of shopping websites are C_4 (0.1578) and C_1 (0.1332). Moreover, the less important factor is C_{12} (0.0445).

Estimating the performance and ranking the alternatives

This paper focuses on determining the best shopping website; so, we assume that the questionnaires were completely collected and we will start working on the dataset that are collected. We had collected the questionnaires of 12 experts in the sample and we used them to construct the dataset with VIKOR method.

As mentioned previously, the experts express their preference for criteria weights and alternatives linguistically. The consensus weights of criteria identified through the fuzzy AHP methodology are shown in Table 2 and each expert's evaluation of alternatives are given in Table 3.

The decision matrix is constructed with the evaluations of experts. Then, the aggregated fuzzy ratings of alternatives are calculated through the weighted fuzzy AHP methodology. In addition, this research calculates the normalized value and the results are shown in Table 4.

Each shopping website will be computed in this step by VIKOR. First, add the distances from the ideal solution, then obtain the distances from PIS (S_i) and NIS (R_i) (Table 5).

Table 6 represents the preferred shopping websites by ranking the results. From the alternative evaluation results in Table 6, the best shopping websites are Yahoo Taiwan and PCHome.

Table 2. Weights of dimensions and criteria.

Dimensions and criteria	Local weights	Overall weights	BNP
Technology acceptance factor	(0.2826, 0.4348, 0.6247)		0.4474
Efficiency (C_1)	(0.1705, 0.2587, 0.3823)	(0.0482, 0.1125, 0.2388)	0.1332
Practical (C_2)	(0.1533, 0.2312, 0.3539)	(0.0433, 0.1005, 0.2211)	0.1216
Ease use (C_3)	(0.1427, 0.2071, 0.3144)	(0.0403, 0.0900, 0.1964)	0.1089
Time-saving (C_4)	(0.1964, 0.3030, 0.4578)	(0.0555, 0.1318, 0.2860)	0.1578
Website service quality	(0.1935, 0.3041, 0.4340)		0.3105
Communication (C_5)	(0.1786, 0.2786, 0.3707)	(0.0346, 0.0847, 0.1609)	0.0934
Confident (C_6)	(0.1349, 0.1791, 0.2583)	(0.0261, 0.0545, 0.1121)	0.0642
Security (C_7)	(0.2409, 0.3413, 0.4948)	(0.0466, 0.1038, 0.2147)	0.1217
Trust (C_8)	(0.1473, 0.2011, 0.3014)	(0.0285, 0.0612, 0.1308)	0.0735
Specific holdup cost	(0.1813, 0.2611, 0.4625)		0.3016
Familiar (C_9)	(0.1968, 0.2817, 0.2823)	(0.0357, 0.0735, 0.1306)	0.0799
Past experience (C_{10})	(0.2738, 0.4151, 0.3928)	(0.0496, 0.1084, 0.1817)	0.1132
Proficiency (C_{11})	(0.1135, 0.1569, 0.1628)	(0.0206, 0.0410, 0.0753)	0.0456
Knowledgeable (C_{12})	(0.1130, 0.1463, 0.1620)	(0.0205, 0.0382, 0.0749)	0.0445

Table 3. Effective value of four shopping websites.

Variable	(C_1)	(C_2)	(C_3)	(C_4)	(C_5)	(C_6)	(C_7)	(C_8)	(C_9)	(C_{10})	(C_{11})	(C_{12})
(A_1)	82.75	78.31	73.31	76.08	66.39	77.81	75.58	72.89	79.97	76.08	79.83	74.69
(A_2)	77.25	79.50	78.58	73.64	68.94	66.08	74.83	73.64	77.00	76.42	79.83	74.06
(A_3)	66.36	68.17	65.03	67.67	59.47	58.78	63.17	65.25	73.17	65.03	70.25	67.61
(A_4)	64.06	67.22	66.14	62.81	60.33	59.89	64.75	60.72	52.39	53.25	55.72	58.47

Table 4. Normalized value s of four shopping websites.

Variable	(C_1)	(C_2)	(C_3)	(C_4)	(C_5)	(C_6)	(C_7)	(C_8)	(C_9)	(C_{10})	(C_{11})	(C_{12})
(A_1)	0.171	0.162	0.152	0.157	0.137	0.161	0.156	0.151	0.165	0.157	0.165	0.154
(A_2)	0.160	0.164	0.163	0.152	0.143	0.137	0.155	0.152	0.159	0.158	0.165	0.153
(A_3)	0.137	0.141	0.134	0.140	0.123	0.122	0.131	0.135	0.151	0.134	0.145	0.140
(A_4)	0.132	0.139	0.137	0.130	0.125	0.124	0.134	0.126	0.108	0.110	0.115	0.121

DISCUSSION AND MANAGERIAL IMPLICATIONS

The paper ends with some final comments, based on the main research results aforementioned. The aim of this research is to construct a fuzzy AHP and VIKOR model to evaluate different shopping website and to support the selection of priority mix that is efficient. These factors are to generate a final evaluation ranking for priority among these shopping websites of the proposed model. The importance of the criterion is evaluated by experts and the uncertainty of human decision-making is taken into account through the fuzzy concept.

From the proposed method, fuzzy AHP and VIKOR, we find out the factors of time-saving (C_4) and efficiency (C_1) are the most two important factors for improving the competitive advantage of shopping website. Moreover, the research obtains different ranking orders of R_k according to (v=0), (v=0.5) and (v=1). When the strategy of maximum group utility is adopted and the individual regret ignored, (v=1) can be selected for the calculation, whereas when the individual regret is considered and the strategy of maximum group utility ignored, (v=0) can be selected. Generally speaking, when decision makers simultaneously are concern about the strategy of maximum group utility and the minimum individual regret,

Table 5. Distances from PIS and NIS.

Variable	(A_1)	(A_2)	(A_3)	(A_4)
(C_1)	0.000	0.039	0.117	0.133
(C_2)	0.012	0.000	0.112	0.122
(C_3)	0.042	0.000	0.109	0.100
(C_4)	0.000	0.029	0.100	0.158
(C_5)	0.025	0.000	0.093	0.085
(C_6)	0.000	0.040	0.064	0.060
(C_7)	0.000	0.007	0.122	0.106
(C_8)	0.004	0.000	0.048	0.073
(C_9)	0.000	0.009	0.020	0.080
(C_{10})	0.002	0.000	0.056	0.113
(C_{11})	0.000	0.000	0.018	0.046
(C_{12})	0.000	0.002	0.019	0.045
PIS	0.09	0.13	0.88	1.12
NIS	0.04	0.04	0.12	0.16

Table 6. Performance value and ranking of different shopping websites.

Websites	VIKOR(v= 0.5)	Rank
Taiwan Yahoo (A_1)	0.98794	1
PCHome (A_2)	0.98061	2
Unimall (A_3)	0.26980	3
eBay (A_4)	0.00000	4

then v = 0.5 should be selected. This selection is decided based on the preference (concern) of the decision makers. In this case, we can understand that the Yahoo Taiwan and PC home rank the best two shopping websites (based on v = 0.5).

Our research outcome has provided direct support to the notion that the effect of time-saving and efficiency factors on competitive advantages of shopping websites and this is in large part accordant with previous research results. As noted earlier, technology and function offered by website operators certainly involve online consumer welfare and convenience in regard to their online purchasing behavior. Thus, shopping websites should provide proper website-related functions in accordance with the customers' needs. Shopping website features should be considered primary in every site design to generate positive perceptions of usefulness, while avoiding irritation; thus enabling consumers to understand the site layout and navigate in their search for products and services offered at the site.

Shopping website managers also need to provide useful information about the shopping website to be adopted and to diffuse users' positive experience of using the shopping website to achieve the highest levels of market performance. Moreover, they should encourage customers share the use experience and provide various incentives to make voluntary propositions on effective shopping website implementation. Shopping website designers may add human features such as the use of humor, appealing graphics, or 3d virtual models to attract, retain and motivate consumers to purchase from the site. Therefore, shopping website service providers should continue to improve user friendliness, making the tools easy to use and accessible. This allows the customers to save more time and effort but have a higher shopping efficiency, resulting in enhanced customer satisfaction as well as loyalty. If a shopping website operator wishes particularly to attract non-Internet shoppers, he or she must think of means to increase the website's usefulness. For example, the shopping website can be made simple and easy to understand in order to reduce the customer's shopping time and make Internet shopping more effective. This is because for those e-shoppers who have a high level of internet familiarity, the website operators might need to pay more efforts in meeting their satisfaction and then winning their loyalty.

CONCLUSIONS AND REMARKS

The topic discussed in this study is still developing at present; it is hoped to be continually explored with the addition of other factors such as cultural and social factors affecting competitive advantages, thus enriching the research contents. Therefore, we hope that succeeding studies can adopt a wider range of constructs to make the whole study share more benefits. Finally, internet products' distinctions can also affect customers' decisions to shop on the websites or not. From a management perspective, consumer's in fact treat high-involvement and low-involvement products with different behavioral models. The product's unit price influences the desires of consumer for internet shopping as well. Thus, we propose that much research is needed to discover the effects of different product characteristics on customer e-shopping. Furthermore, the further research can explore that how to improve the gaps in each criteria based on network relationship map (NRM) and capture the complex relationships among these evaluation criteria. The NRM is not only to find out the most important driving force for the growth of industrial clusters but also to measure the relationships among these criteria.

REFERENCES

Armillotta A (2008). Selection of layered manufacturing techniques by an adaptive AHP decision model. Robot. Comput. Integr. Manuf. 24:450-461.

Buckley JJ (1985). Fuzzy hierarchical analysis. Fuzzy Sets Syst. 17(1):233-247.

Büyüközkan G, Ruan D (2008). Evaluation of software development projects using a fuzzy multi-criteria decision approach. Math. Comput. Simul. 77(5-6):464-475.

Cakir O, Canbolat MS (2008). A web-based decision support system for multi-criteria inventory classification using fuzzy AHP methodology.

Expert Syst. Appl. 35:1367-1378.
Chen MF, Tzeng GH, Ding CG (2008). Combining fuzzy AHP with MDS in identifying the preference similarity of alternatives. Appl. Soft Comput. 8:110-117.
Chu MT, Shyu J, Tzeng GH, Khosla R (2007). Comparison among three analytical methods for knowledge communities group-decision analysis. Expert Syst. Appl. 33(4):1011-1024.
Costa CAB, Vansnick JC (2008). A critical analysis of the eigenvalue method used to derive priorities in AHP. Eur. J. Oper. Res. 187:1422-1428.
Dagdeviren M, Yuksel I (2008). Developing a fuzzy analytic hierarchy process (AHP) model for behavior-based safety management. Info. Sci. 178:1717-1733.
Davis FD (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly, 13(3): 319-340.
Firouzabadi SMAK, Henson B, Barnes C (2008), A multiple stakeholders'approach to strategic selection decisions. Comput. Ind. Eng. 54:851-865.
Hsieh TY, Lu ST, Tzeng GH (2004). Fuzzy MCDM approach for planning and design tenders selection in public office buildings. Int. J. Proj. Manage., 22(7):573-584.
Huang CC, Chu PY, Chiang YH (2008). A fuzzy AHP application in government-sponsored R&D project selection. Omega 36:1038-1052.
Lin MC, Wang CC, Chen MS, Chang CA (2008). Using AHP and TOPSIS approaches in customer-driven product design process. Comput. Ind. 59:17-31.
Opricovic S, Tzeng GH (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. Eur. J. Oper. Res. 156(2):445-455.
Pan NF (2008). Fuzzy AHP approach for selecting the suitable bridge construction method. Autom. Constr. 17:958-965.
Saaty TL (1996). The Analytic Network Process. REW Publications.
Sambasivan M, Fei NY (2008). Evaluation of critical success factors of implementation of ISO 14001 using analytic hierarchy process (AHP): a case study from Malaysia. J. Clean. Prod. 16:1424-1433.
Sayadi MK, Heydari M, Shahanaghi K (2008). Extension of VIKOR method for decision making problem with interval numbers. Applied Mathematical Modelling, In Press.
Sharma MJ, Moon I, Bae H (2008). Analytic hierarchy process to assess and optimize distribution network. Appl. Math. Comput. 202:256-265.
Tzeng GH, Lin CW, Opricovic S (2005). Multi-criteria analysis of alternative-fuel buses for public transportation. Energy Policy 33(11):1373-1383.
Wang TC, Chen YH (2008). Applying fuzzy linguistic preference relations to the improvement of consistency of fuzzy AHP. Inform. Sci. 178:3755-3765.
Wang YM, Luo Y, Hua Z (2008). On the extent analysis method for fuzzy AHP and its applications. Eur. J. Oper. Res. 186:735-747.
Wu WW, Lee YT (2007). Developing global managers' competencies using the fuzzy DEMATEL method. Expert Syst. Appl. 32(2):499-507.
Yang CC, Chen BS (2004). Key quality performance evaluation using fuzzy AHP. J. Chin. Inst. Ind. Eng. 21(6):543-550.
Zadeh LA (1965). Fuzzy sets. Inform. Control 8(2):338-353.