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A Group Based Fuzzy MCDM for Selecting Knowledge Portal System

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Abstract**—**Despite of many scholars and practitioners recognize the knowledge management implementation in an organizations but insufficient attention has been paid by researchers to select suitable knowledge portal system (KPS) selection. This study develops a Multi Criteria Decision making model based on the fuzzy VIKOR approach to help organizations in selecting KPS. The suitable portal is the critical influential factors on the success of knowledge management (KM) implementation in an organization.

Keywords**—**Knowledge management, Knowledge portal system, Fuzzy VIKOR.

I. Introduction

IN the words of Francis Bacon, ‘‘Knowledge is power”. During recent decades, the core of organizations has moved from being capital or labor intensive to being technology intensive, and the current direction of evolution is towards becoming knowledge intensive [1]. Thus In orders to gain and sustain a competitive advantage in the global economy, today’s organizations need to effectively mobilize their knowledge resources [2]. Nowadays A knowledge-based view of a company has emerged, as an important topic in strategic management [3].

Knowledge is based on data and information. Data represents the raw facts without meaning; information obtained when data organized in a meaningful context, while knowledge is characterized as the meaningfully organized accumulation of information [4]. The types of organizational knowledge are reflected in several classification schemes. Nonaka's [5] typology of organization's knowledge types has become the most supported and referenced one. He classified the organizational knowledge into tacit and explicit knowledge. Tacit knowledge is what the knower knows, which is derived from experience and embodies beliefs and values. Tacit knowledge is actionable knowledge, and therefore the most valuable. Furthermore, tacit knowledge is the most important basis for the generation of new knowledge. Explicit knowledge is represented by some artifact, such as a document or a video, which has typically been created with the goal of communicating with another person [6]. In table 1 Kim et al. [7] review of knowledge types is presented. They conclude in a distinction between a Tacit and Explicit approach.

Concepts and practices evolved through the 1990s as managements in the postindustrial era not only realized that knowledge was perhaps the critical resource, rather than land, machines, or capital, but also that their organizations generally poorly managed it [8]. There is growing evidence that firms are increasingly investing in KM initiatives and establishing KM systems in order to acquire and better exploit this resource [9].

TABLE I
Types of Knowledge

Author	Perspective		
Polani (1966)	Epistemology	Tacit	Explicit
Anderson (1981)	Cognition	Procedural	Declarative
Blackler (1995)	Place of existence	Embodied, embedded	Embrained, encoded
Henderson and Clarck (1990)	Target	Architectural	Component
Quinn et al.(1996)	Content	Know-how, care-why	Know-what, Know-why
Tsoukas (1996)	Collectivity	Background knowledge	Knowledge
Nass(1994)	Experience	Skill	Knowledge
Wiig (1997)	Application	Factual, Conceptual	Expectational, Methodological

To manage knowledge effectively in the organization a KPS must be employed. KPS can be regarded as an extension of the enterprise information portal to knowledge management [10; 11]. There are development tools available on the market that such organization can select among them.

These tools differ in a variety of ways and they have their own advantages and disadvantages. So an ideal portal which would suit all organizations does not exist, as each organization has its own unique characteristics, So, Knowledge management implementation team need to select the most appropriate KPS on its specific. This problem labeled as the KPS selection.

Despite of many scholars and practitioners recognize the knowledge management implementation in an organization,

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insufficient attention has been paid by researchers to select suitable KPS selection. In line with the multidimensional characteristics of the KPS selection, the problem is a kind of Multi-Criteria decision-making (MCDM) problems, which requires MCDM methods for an effective problem solving.

MCDM refers to screening, prioritizing, ranking or selecting a set of alternatives under usually independent, incommensurate or conflicting attributes [12]. It can rank different portals when they are compared in terms of their overall performance.

Kreng and Wu [13] applied fuzzy AHP model which was introduced by Chang [14] to select appropriate KPS for Taiwanese stone industry. AHP method can deal with imprecision caused by the decision maker's inability to translate his/her preferences for some alternative to another into a totally consistent preference structure. In AHP, the so called consistency ratios are used in order to measure the consistency of the decision-making process. This consistency is calculated in every step of the procedure. In case pair wise comparisons in some steps appear to be inconsistent, the pair wise comparisons can be repeated. Afterwards the consistency ratio for the whole process can be calculated and, if necessary, some of the pair wise comparisons may be reconsidered [15].

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 for determining optimal KPS.

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 III an overview of the concepts of the fuzzy approach is given. Section IV will focus on the proposed model. Then a numerical example is illustrated in Section V. In the final section, some conclusions are drawn from the study.

II. VIKOR METHOD

Opricovic [16] and Opricovic and Tzeng [17] developed VIKOR, the Serbian name: VlseKriterijumska Optimizacija I Kompromisno Resenje, means Multi-criteria Optimization and Compromise Solution [18]. The VIKOR method was developed for multi-criteria optimization of complex systems [19]. 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. [20] .It introduces the multi-criteria ranking index based on the particular measure of ''closeness'' to the ''ideal'' solution [16].

According to Opricovic & Tzeng [19] the multi-criteria measure for compromise ranking is developed from the LP-metric used as an aggregating function in a compromise programming method [21]. The various J alternatives are denoted as $a_1, a_2, ..., a_J$. 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 Lp-metric:

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

Within the VIKOR method $L_{1,j}$ (as S_j in Eq. (16)) and $L_{\infty,j}$ (as R_j in Eq. (17)) are used to formulate ranking measure. $L_{1,j}$ is interpreted as 'concordance' and can provide decision makers with information about the maximum group utility' or 'majority'. Similarly, $L_{\infty,j}$ is interpreted as 'discordance' and provides decision makers with information about the minimum individual regret of the 'opponent'.

Also TOPSIS, another MCDM method, is based on aggregating function representing "closeness to ideal". In TOPSIS the chosen alternative should have the "shortest distance" from the ideal solution and the "farthest distance" from the "negative –ideal". The TOPSIS method introduces two reference points, but it does not consider the relative importance of the distances from these points. These two MCDM methods use different kinds of normalization to eliminate the units of the criterion functions, whereas the VIKOR method uses linear normalization, the TOPSIS method uses vector normalization. The normalized value in the VIKOR method does not depend on the evaluation unit of criterion function, whereas the normalized values by vector normalization in the TOPSIS method may depend on the evaluation unit [18].

III. FUZZY APPROACH

In dealing with a decision process, the decision-maker is often faced with doubts, problems and uncertainties. In other words Natural language to express perception or judgment is always subjective, uncertain or vague. To resolve the vagueness, ambiguity and subjectivity of human judgment, fuzzy sets theory [22] was introduced to express the linguistic terms in decision-making (DM) process. Zadeh and Bellman [23] developed fuzzy multi-criteria decision-making (FMCDM) methodology to resolve the lack of precision in assigning importance weights of criteria and the ratings of alternatives regarding evaluation criteria

The logical tools that people can rely on are generally considered the outcome of a bivalent logic (yes/no, true/false), but the problems posed by real-life situations and human thought processes and approaches to problem-solving are by no means bivalent [24]. Just as conventional, bivalent logic is based on classic sets, fuzzy logic is based on fuzzy sets. A fuzzy set is a set of objects in which there is no clear-cut or predefined boundary between the objects that are or are not members of the set. The key concept behind this definition is that of ''membership'': Any object may be a member of a set "to some degree"; and a logical proposition may hold true "to some degree". Each element in a set is associated with a value indicating to what degree the element is a member of the set. This value comes within the range [0, 1], where 0 and 1, respectively, indicate the minimum and maximum degree of membership, while all the intermediate values indicate degrees of ‘‘partial’’ membership [25].

This approach helps decision-makers solve complex decision-making problems in a systematic, consistent and productive way [26] and has been widely applied to tackle DM problems with multiple criteria and alternatives [27]. In short, fuzzy set theory offers a mathematically precise way of modeling vague preferences for example when it comes to setting weights of performance scores on criteria. Simply stated, fuzzy set theory makes it possible to mathematically describe a statement like: "criterion X should have a weight of around 0.8" [28].

In the following, for the purpose of reference, some important definitions and notations of fuzzy sets theory from [29-32] will be reviewed.

Let X be the universe of discourse, $X = \{x_1, x_2, ..., x_n\}$ .A fuzzy set $\tilde{A}$ of X is a set of order pairs, $\{(x_1, f_{\tilde{A}}(x_1)), (x_2, f_{\tilde{A}}(x_2)), ..., (x_n, f_{\tilde{A}}(x_n))\}$, $f_{\tilde{A}} : X \rightarrow [0,1]$ is the membership function of $\tilde{A}$, and $f_{\tilde{A}}(x_i)$ stands for the membership degree of x_i in $\tilde{A}$. The value $f_{\tilde{A}}$ is closer to 0, the degree is low. The value $f_{\tilde{A}}$ is closer to 1, the degree is high.

A fuzzy set $\tilde{A}$ of the universe of discourse X is convex if and only if for all x_1, x_2 in X ,

$$f_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \geq \min[f_{\tilde{A}}(x_1), f_{\tilde{A}}(x_2)] \qquad (2)$$

Where $\lambda \in [0,1]$, $x_1, x_2 \in X$

The height of a fuzzy set is the largest membership grade attained by any element in that set. A fuzzy set $\tilde{A}$ in the universe of discourse X is called normalized when the height of $\tilde{A}$ is equal to 1. A fuzzy number is a fuzzy subset in the universe of discourse X that is both convex and normal.

Fuzzy membership function has more types. This paper adopts the type of a trapezoidal fuzzy number. A positive trapezoidal fuzzy number (PTFN) c can be defined as (a_1, a_2, a_3, a_4) , shown in Fig. 1.

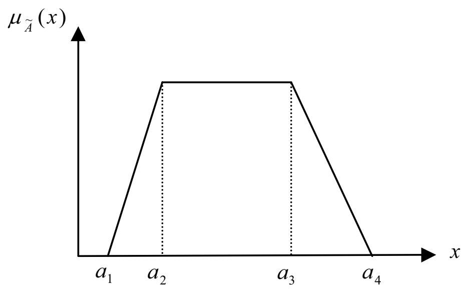

Fig. 1 Trapezoidal fuzzy number $\tilde{A}$

The membership function $\mu_{\tilde{A}}(x)$ is defined as:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < a_1 \\ \dfrac{x - a_1}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ 1, & a_2 \leq x \leq a_3 \\ \dfrac{x - a_4}{a_3 - a_4}, & a_3 \leq x \leq a_4 \\ 0, & x > a_3 \end{cases} \qquad (3)$$

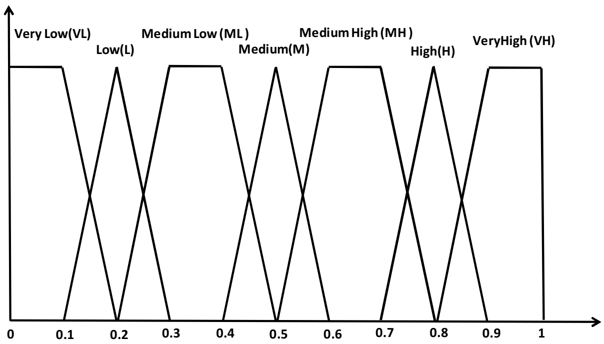

Fig. 2 Linguistic variables for importance weight of each criteria

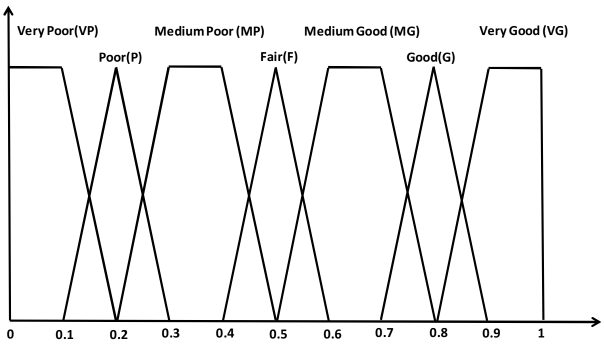

Fig. 3 Linguistic variables for ratings

A non-fuzzy number r can be expressed as (r, r, r, r) .By the extension principle, the fuzzy sum $\oplus$ and fuzzy subtraction $\ominus$ of any two trapezoidal fuzzy numbers are also trapezoidal fuzzy numbers; but the multiplication $\otimes$ of any two trapezoidal fuzzy numbers is only an approximate trapezoidal fuzzy number. Given any two positive trapezoidal fuzzy numbers, $\tilde{a} = (a_1, a_2, a_3, a_4)$, $\tilde{b} = (b_1, b_2, b_3, b_4)$ and a positive real number r, some main operations of fuzzy numbers $\tilde{A}$ and $\tilde{B}$ can be expressed as follows:

$$\tilde{A} \oplus \tilde{B} = [a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4] \qquad (4)$$

$$\tilde{A} \ominus \tilde{B} = [a_1 - b_1, a_2 - b_2, a_3 - b_3, a_4 - b_4] \qquad (5)$$

$$\tilde{A} \otimes \tilde{B} \cong [a_1 b_1, a_2 b_2, a_3 b_3, a_4 b_4] \qquad (6)$$

$$\tilde{A} \otimes r \cong [a_1 r, a_2 r, a_3 r, a_4 r] \qquad (7)$$

The operations of $\vee(\max)$ and $\wedge(\min)$ are defined as follow:

$$\tilde{A}(\vee)\tilde{B} = (a_1 \vee b_1, a_2 \vee b_2, a_3 \vee b_3) \quad (8)$$

$$\tilde{A}(\wedge)\tilde{B} = (a_1 \wedge b_1, a_2 \wedge b_2, a_3 \wedge b_3) \quad (9)$$

Also the crisp value of the fuzzy number $\tilde{A}$ based on Center of Area (COA) method can be expressed by following relation:

$$defuzz(\tilde{A}) = \frac{\int x.\mu(x)dx}{\int \mu(x)dx}$$

$$= \frac{\int_{a_1}^{a_2} (\frac{x-a_1}{a_2-a_1}).xdx + \int_{a_2}^{a_3} xdx + \int_{a_3}^{a_4} (\frac{a_4-x}{a_4-a_3}).xdx}{\int_{a_1}^{a_2} (\frac{x-a_1}{a_2-a_1})dx + \int_{a_3}^{a_3} dx + \int_{a_3}^{a_4} (\frac{a_4-x}{a_4-a_3})dx}$$

$$= \frac{-a_1a_2 + a_3a_4 + \frac{1}{3}(a_4-a_3)^2 - \frac{1}{3}(a_2-a_1)^2}{-a_1 - a_2 + a_3 + a_4} \quad (10)$$

IV. Proposed Method for KPS Selection

A systematic approach to extend the VIKOR is proposed to solve the KPS selection problem under a fuzzy environment in this section. In this paper the importance weights of various criteria and the ratings of qualitative criteria are considered as linguistic variables. Because linguistic assessments merely approximate the subjective judgment of decision-makers, we can consider linear trapezoidal membership functions to be adequate for capturing the vagueness of these linguistic assessments.

In fact, KPS selection is a group multiple-criteria decision-making (GMCDM) problem, which may be described by means of the following sets:

1. a set of K decision-makers called $E = \{D_1, D_2, ..., D_K\}$;
2. a set of m possible knowledge portal systems called $A = \{A_1, A_2, ..., A_m\}$;
3. a set of n criteria, $C = \{C_1, C_2, ..., C_n\}$, with which portal performances are measured;
4. a set of performance ratings of A_i $(i = 1,2,...,m)$ with respect to criteria C_j $(j = 1,2,...,n)$, called $X = \{x_{ij}, i = 1,2,...,m, j = 1,2,...,n\}$

The main steps of the algorithms are:

A. Identify the objectives of the decision making process and define the problem scope

Decision-making is the process of defining the decision goals, gathering relevant information and selecting the optimal alternative [33]. Thus, the first step is defining the decision goal that here is to evaluate and select a favorable KPS. Making precise statement of the problem will help to narrow it. Giving clear and careful thought to this first step is very vital to selecting process. The way in which the process is defined will deterministic the character of all the other steps. In this step, the scope of the problem is defined in terms of time frame

In this step, the scope of the problem is defined in terms of time frame for implementation, available budget, available alternatives, required functions, and other considerations for KPS. Kreng and Wu [13] discussed about previous studies about functions of KPS. It is better required functions are elicited from results of a system analyzing project.

B. Arrange the Decision Making Group and Define and Describe a Finite Set of Relevant Attributes

As mentioned previously, in KPS selection process several people and experts from different functional areas within the company are involved. So with considering the problem scope defined in previous section and its entire dimension, we must form a group of decision makers.

KPS selection first requires identification of decision attributes (criteria) then evaluation scales/metrics are determined in order to measure appositeness of the alternative. Then with considering sub-criteria for each main criterion, hierarchical form called "value tree" is structured.

C. Identify the Appropriate Linguistic Variables

In this step we must define the appropriate linguistic variables for the importance weight of criteria, and the fuzzy rating for alternatives with regard to each criterion these linguistic variables can be expressed in positive trapezoidal fuzzy numbers, as in Figs. 2 and 3. It is suggested in this paper that the decision-makers use the linguistic variables shown in Figs. 2 and 3 to evaluate the importance of the criteria and the ratings of alternatives with respect to qualitative criteria. For example, the linguistic variable ''Medium High (MH)'' can be represented as (0.5; 0.6; 0.7; 0.8), the membership function of which is:

$$\mu_{Medium\ High}(x) = \begin{cases} 0, & x < 0.5, \\ \frac{x-0.5}{0.6-0.5}, & 0.5 \le x \le 0.6, \\ 1, & 0.6 \le x \le 0.7, \\ \frac{x-0.8}{0.7-0.8}, & 0.7 \le x \le 0.8, \\ 0, & x > 0.8; \end{cases} \quad (11)$$

D. Pull the decision makers' opinions to get the aggregated fuzzy weight of criteria, and aggregated fuzzy rating of alternatives and Construct a fuzzy decision matrix

Let the fuzzy rating and importance weight of the k th decision maker be $\tilde{x}_{ijk} = (x_{ijk1}, x_{ijk2}, x_{ijk3}, x_{ijk4})$ and $\tilde{w}_{jk} = (\tilde{w}_{jk1}, \tilde{w}_{jk2}, \tilde{w}_{jk3}, \tilde{w}_{jk4})$; $i = 1,2,...,m, j = 1,2,...,n$, respectively. Hence, the aggregated fuzzy ratings ($\tilde{x}_{ij}$) of alternatives with respect to each criterion can be calculated as:

$$\tilde{x}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3}, x_{ij4}) \quad (12)$$

Where

$$x_{ij1} = \min_k \{x_{ijk1}\} \qquad x_{ij2} = \frac{1}{K}\sum_{k=1}^{K} x_{ijk2}$$

$$x_{ij3} = \frac{1}{K}\sum_{k=1}^{K} x_{ijk3} \qquad x_{ij4} = \max_k \{x_{ijk4}\}$$

The aggregated fuzzy weights ($\tilde{w}_j$) of each criterion can be calculated as:

$$\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3}, w_{j4}) \quad (13)$$

Where

$$w_{j1} = \min_k \{w_{jk1}\}, \qquad w_{j2} = \frac{1}{K}\sum_{k=1}^{K} w_{jk2},$$

$$w_{j3} = \frac{1}{K}\sum_{k=1}^{K} w_{jk3}, \qquad w_{j4} = \max_k \{w_{jk4}\}$$

A KPS selection problem can be concisely expressed in matrix format as follows:

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix}, \quad \tilde{W} = [\tilde{w}_1 \quad \tilde{w}_2 \quad \ldots \quad \tilde{w}_n]$$

where $\tilde{x}_{ij}$ the rating of alternative A_i with respect to C_j, $\tilde{w}_j$ the importance weight of the j-th criterion holds, $\tilde{x}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3}, x_{ij4})$ and $\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3}, w_{j4})$; $i = 1,2,...,m, j = 1,2,...,n$ are linguistic variables can be approximated by positive trapezoidal fuzzy numbers

E. Defuzzify the Fuzzy Decision Matrix and Fuzzy Weight of Each Criterion into Crisp Values

Deffuzzify fuzzy decision matrix and fuzzy weight of each criterion into crisp values using COA defuzzification relation proposed in section III.

F. Determine the Best f_j^* and the Worst f_j^- Values of all Criterion Ratings, $j = 1,2,...,n$

Deffuzzify fuzzy decision matrix and fuzzy weight of each criterion into crisp values using COA defuzzification relation proposed in section III.

$$f_j^* = \max_i \ x_{ij} \quad (14)$$

$$f_j^- = \min_i \ x_{ij} \quad (15)$$

G. Compute the Values S_i and R_i by the Relations

$$S_i = \sum_{j=1}^{n} w_j (f_j^* - f_{ij}) / (f_j^* - f_i^-) \quad (16)$$

$$R_i = \max_j [w_j (f_j^* - f_{ij}) / (f_j^* - f_i^-)] \quad (17)$$

H. Compute the Values Q_i by the Relations

$$Q_j = v(S_i - S^*)/(S^- - S^*) + (1-v)(R_i - R^*)/(R^- - R^*) \quad (18)$$

Where $S^* = \min_i \ S_i$, $S^- = \max_i \ S_i$, $R^* = \min_i \ R_i$, $R^- = \max_i \ R_i$ and v is introduced as a weight for the strategy of maximum group utility, whereas $1-v$ is the weight of the individual regret.

İ. Rank the Alternatives, Sorting by the Values S, R and Q in Ascending Order

J. Propose as a compromise solution the alternative ($A^{(1)}$) which is the best ranked by the measure Q (minimum) if the following two conditions are satisfied:

C1. Acceptable advantage:

$$Q(A^{(2)}) - Q(A^{(1)}) \geq DQ \quad (19)$$

Where $A^{(2)}$ is the alternative with second position in the ranking list by Q; $DQ = 1/(J-1)$.

C2. Acceptable stability in decision making:

The alternative $A^{(1)}$ must also be the best ranked by S or/and R. This compromise solution is stable within a decision making process, which could be the strategy of maximum group utility (when $v > 0.5$ is needed), or ''by consensus'' $v \approx 0.5$, or ''with veto'' ($v < 0.5$). Here, v is the weight of decision making strategy of maximum group utility.

If one of the conditions is not satisfied, then a set of compromise solutions is proposed, which consists of

- Alternatives $A^{(1)}$ and $A^{(2)}$ if only the condition C2 is not satisfied, or
- Alternatives $A^{(1)}, A^{(2)}, ..., A^{(M)}$ if the condition C1 is not satisfied; $A^{(M)}$ is determined by the relation (20) for maximum M (the positions of these alternatives are ''in closeness'')

$$Q(A^{(M)}) - Q(A^{(1)}) < DQ \quad (20)$$

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V. Numerical Example

The proposed model has been applied to a KPS selection process of a firm working in the field of oil industry in the following steps:

Step 1: The Company desires to select a KPS to fulfill its requirements in known time frame and known budget limitation. Three main considerations about KPS are indentified as functions, administration and supports. After preliminary screening, five candidate Knowledge portal systems (A1, A2, A3, A4, and A5) remain for further evaluation.

Step 2: A committee of three decision-makers, D1; D2 and D3, has been formed to select the most suitable KPS. The following criteria have been defined:

C1: creating, categorizing, storing and retrieving knowledge contents

C2: site management

C3: interface establishment

C4: component reuse

C5: authority and security

C6: consulting support, and training documents

Step 3: Three decision-makers use the linguistic weighting variables shown in Fig. 1 to assess the importance of the criteria. The importance weights of the criteria determined by these three decision makers are shown in Table II. Also the decision-makers use the linguistic rating variables shown in Fig. 2 to evaluate the ratings of candidates with respect to each criterion. The ratings of the five alternatives by the decision makers under the various criteria are shown in Table III.

Step 4: The linguistic evaluations shown in Tables II and III are converted into trapezoidal fuzzy numbers. Then the aggregated weight of criteria and aggregated fuzzy rating of alternatives is calculated to construct the fuzzy-decision matrix and determine the fuzzy weight of each criterion, as in Table IV.

Step 5: The crisp values for decision matrix and weight of each criterion are computed as shown in Table V.

Step 6: The best and the worst values of all criterion ratings are determined as Table V.

Step 7 and 8: The values of S, R and Q are calculated for all alternatives as Table VI.

Step 9: The ranking of the alternatives by S, R and Q in ascending order is shown in Table VII.

TABLE II
Importance Weight of Criteria from Three Decision-Makers

C1	D1	VH	0.8	0.9	1	1
	D2	VH	0.8	0.9	1	1
	D3	VH	0.8	0.9	1	1
C2	D1	H	0.7	0.8	0.8	0.9
	D2	MH	0.5	0.6	0.7	0.8
	D3	H	0.7	0.8	0.8	0.9
C3	D1	M	0.4	0.5	0.5	0.6
	D2	L	0.1	0.2	0.2	0.3
	D3	M	0.4	0.5	0.5	0.6
C4	D1	L	0.1	0.2	0.2	0.3
	D2	M	0.4	0.5	0.5	0.6
	D3	M	0.4	0.5	0.5	0.6
C5	D1	H	0.7	0.8	0.8	0.9
	D2	H	0.7	0.8	0.8	0.9
	D3	H	0.7	0.8	0.8	0.9
C6	D1	H	0.7	0.8	0.8	0.9
	D2	H	0.7	0.8	0.8	0.9
	D3	H	0.7	0.8	0.8	0.9

TABLE III
Ratings of the Five Alternatives by the Decision Makers under the Various Criteria

		C1	C2	C3	C4	C5	C6
A1	D1	G	MG	P	P	G	VG
	D2	G	G	M	F	G	VG
	D3	MG	VG	MP	P	G	VG
A2	D1	F	VG	G	G	VP	VG
	D2	F	VG	G	MP	VP	VG
	D3	F	VG	VG	G	P	G
A3	D1	P	MG	VG	G	VG	MG
	D2	P	G	VG	VP	VG	F
	D3	P	G	G	F	G	F
A4	D1	G	G	MG	F	MG	F
	D2	G	G	MG	F	MG	F
	D3	G	MG	G	F	G	F
A5	D1	MG	MG	G	G	MG	G
	D2	MG	G	MG	MG	MG	G
	D3	MG	G	G	MG	MG	G

TABLE IV
AGGREGATED FUZZY WEIGHT OF CRITERIA AND AGGREGATED FUZZY RATING OF ALTERNATIVES

	A1	A2	A3	A4	A5
C1	0.50	0.40	0.10	0.70	0.50
	0.73	0.50	0.20	0.80	0.60
	0.77	0.50	0.20	0.80	0.70
	0.90	0.60	0.30	0.90	0.80
C2	0.50	0.80	0.50	0.50	0.50
	0.77	0.90	0.73	0.73	0.73
	0.83	1.00	0.77	0.77	0.77
	1.00	1.00	0.90	0.90	0.90
C3	0.10	0.70	0.70	0.50	0.50
	0.43	0.83	0.87	0.67	0.73
	0.47	0.87	0.93	0.73	0.77
	0.90	1.00	1.00	0.90	0.90
C4	0.10	0.20	0.00	0.40	0.50
	0.30	0.63	0.43	0.50	0.67
	0.30	0.67	0.47	0.50	0.73
	0.60	0.90	0.90	0.60	0.90
C5	0.70	0.00	0.70	0.50	0.50
	0.80	0.07	0.87	0.67	0.60
	0.80	0.13	0.93	0.73	0.70
	0.90	0.30	1.00	0.90	0.80
C6	0.80	0.70	0.40	0.40	0.70
	0.90	0.87	0.53	0.50	0.80
	1.00	0.93	0.57	0.50	0.80
	1.00	1.00	0.80	0.60	0.90

Step 9: As it is seen in Table VII, the alternative A1 is the best ranked by Q. Also the condition C1 is satisfied $(Q_{A1} - Q_{A2} \geq \frac{1}{5-1})$.

VI. CONCLUSION

Despite of many scholars and practitioners recognize the knowledge management implementation in an organizations, insufficient attention has been paid by researchers to select suitable KPS selection. The suitable KPS is the critical influential factors on the success of knowledge management (KM) implementation in an organization. In line with the multidimensional characteristics of the KPS selection, the problem is a kind of Multi-Criteria decision-making (MCDM) problems, which requires MCDM methods for an effective problem solving.

This problem is often influenced by uncertainty in practice, and in such situation fuzzy-set theory is an appropriate tool to deal with this kind of problems. In real decision making process, the decision maker is unable (or unwilling) to express his preferences precisely in numerical values and the evaluations are very often expressed in linguistic terms. In this paper an extension of the VIKOR, a recently introduced MCDM method, in fuzzy environment is proposed to deal with the qualitative criteria and select the suitable KPS effectively. It appears this method has some advantages which may be useful in dealing with KPS selection problem.

TABLE V
THE BEST AND THE WORST VALUES OF ALL CRITERION RATINGS

	C1	C2	C3	C4	C5	C6
f^*	0.80	0.92	0.87	0.70	0.87	0.92
f^-	0.20	0.72	0.48	0.33	0.13	0.50
f* - f-	0.60	0.20	0.39	0.37	0.74	0.42

TABLE VI
THE VALUES OF S, R AND Q FOR ALL ALTERNATIVES

	S_i	R_i	Q_i
A1	1.47	0.54	0.00
A2	1.49	0.80	0.86
A3	2.53	0.92	1.37
A4	2.06	0.80	1.13
A5	1.56	0.72	0.87

TABLE VII
THE RANKING OF THE ALTERNATIVES BY S, R AND Q IN DECREASING ORDER

S	R	Q
A1	A1	A1
A2	A5	A2
A5	A4	A5
A4	A2	A4
A3	A3	A3

The proposed method is very flexible. Using this method not only enables us to determine the outranking order of KPSs, but also assess and rate the KPSs. These rating can be used in combination with mathematical programming and other methods to deal with KPS selection in multiple sourcing environments. Also the proposed method for KPS selection in fuzzy environment provides a systematic approach which can be easily extend to deal with other management decision making problems.

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