A Problem Solving Perspective on Evaluating Knowledge Management Technologies: Using Fuzzy Linear Programming Technique for Multiattribute Group Decision Making with Fuzzy Decision Variables*

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Abstract--The aim of this paper is to develop a framework to aid in the *evaluation and selection of KM tools and technologies*. In this paper, we investigate the fuzzy linear programming technique (FLP) for multiple attribute group decision making (MAGDM) problems with preference information on alternatives. To reflect the decision maker's subjective preference information and to determine the weight vector of attributes, the linear programming technique for multidimensional analysis of preference (LINMAP) is used. The LINMAP method is based on pairwise comparisons of alternatives given by decision makers and generates the best compromise alternative as the solution that has the shortest distance to the positive ideal solution. Our aim is to develop a LINMAP in MAGDM problem, where decision makers (DM) give their preferences on alternatives in a fuzzy relation. Through the proposed methodology in this research, enterprises can reduce the mismatch between the capability and implementation of the KM technology, and greatly enhance the effectiveness of implementation of the KMS. Finally, the developed model is applied to a real case of assisting decision-makers in a leading logistics company in Turkey to illustrate the use of the proposed method.

I. INTRODUCTION

The concept of knowledge management (KM) is a tried and tested management science that has been implemented by numerous organizations, some with more success than others. Many KM objectives have been identified in the literature. In analyzing the objectives why organizations want to manage knowledge, investigating only objectives is not enough, as this will only provide a superficial understanding of what drives KM. Organizations operate in different business contexts and drivers of KM are often unique. Therefore if organizations do not fully comprehend what drives the need for KM and how to select the necessary technological infrastructure, they may fall into the trap of creating an inefficient KM strategy and operational plans which are often based on experiences of other organizations. In absence of this understanding, KM will just be another cliché concept. However it can be concluded that the activities of KM should enable the creation, communication, and application of knowledge; and they should drive the capability of creating and adding a greater value to the core business competencies. However, despite the growing body of theory, there are relatively few KM texts that make an explicit connection between KM activities and corporate performance [13]. As organizations realizing the importance of KM, many are developing knowledge management systems (KMS) that offer various benefits to facilitate KM activities. KMS are the IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application [1;4]. As a matter of fact KMS are largely governed around how information flows within and around an organization to provide sophisticated document management rather than actual KM. But knowledge focused organizations require information systems that maximize knowledge, not just manage data [17]. Some researchers [16; 18] cite examples where it was found that there is no direct correlation between information technology investments and KM or business performance. In other words, companies are not exploiting the full potential of the technology they already possess. To this end, KMS have proven to be ''ineffective'' or ''a waste of money''—thereby resulting in failures to meet company objectives and customer demands, challenges to internal and interface integration, extreme cost overruns, and resistance to change. Before embarking on a knowledge management journey, organizations therefore has to understand what it is that they would like to achieve with KMS and what value each alternative KMS will add to the organization with respect to KM. For this particular reason, there is no blueprint for implementing KM in organizations. This suggests that organizations need to focus of a well-defined business strategy in order to establish the appropriate priorities. With this in mind, it is important to consider a number of critical issues when selecting a set of technologies for KM. Therefore, it is valuable to investigate how managers can eliminate vast numbers of technologies to support KM. However, no framework currently exists to aid in the evaluation and selection of KM technologies and to avoid performance gaps concerning technological infrastructure right in the beginning of the selection phase.

The aim of this paper is to develop a framework to aid in the evaluation and selection of KM technologies. Most multiattribute decision making problems include both quantitative and qualitative attributes which are using imprecise data and human judgments. KM decision-making problems are often associated with evaluation of alternative KM tools under multiple objectives and multiple criteria. Because organizations operate in different business contexts and drivers of KM are often unique for each company. Most multiattribute decision making problems include both quantitative and qualitative attributes which are often assessed using imprecise data and human judgments. We proposed a linear programming technique for

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multidimensional analysis of preferences under fuzzy environment in evaluating KM technologies. Fuzzy set theory is well suited to dealing with such decision problems [22, 25]. In this paper, we investigate the fuzzy linear programming technique (FLP) for multiple attribute group decision making (MAGDM) problems with preference information on alternatives. To reflect the decision maker's subjective preference information and to determine the weight vector of attributes the linear programming technique for multidimensional analysis of preference (LINMAP) [20]. The LINMAP method is based on pairwise comparisons of alternatives given by decision makers and generates the best compromise alternative as the solution that has the shortest distance to the positive ideal solution. Our aim is to develop a LINMAP in MAGDM problem, where decision makers (DM) give their preferences on alternatives in a fuzzy relation. Through the proposed methodology in this research, enterprises can reduce the mismatch between the capability and implementation of the KM system, and greatly enhance the effectiveness of implementation of the KMS. Finally, the developed model is applied to a real case of assisting decision-makers in a leading logistics company in Turkey to illustrate the use of the proposed method.

II. THE TYPE OF PERFORMANCE GAPS IN KM AND THEIR MAIN CAUSES

Firstly, the enterprise should review their internal and external environment to determine the knowledge required to enhance its competitiveness [7]. Due to unrealized environments and the properties of knowledge management, the perceptions of top managers about the competitiveness that can be acquired from KM may be too optimistic or too pessimistic to formulate a suitable goal for the KM [15]. Failure to do so may result in a gap between the knowledge required to enhance the competitiveness of an enterprise as perceived by the upper management and the knowledge actually required (i.e. Gap 1). Secondly, upper management may not be able to define clearly what they need. This results in Gap 2, which is the mismatch between the perception of the top managers and the enactment of the plan for the knowledge management system. Thirdly, if employees do not understand the KM plan while engaging in KM, they will be afraid that their personal value might be negatively affected after sharing their knowledge this may result in Gap 3. Fourthly, failure to evaluate the KM system may result in a gap between the results of implementation and the enterprise's competitiveness (i.e. Gap 4). Finally, within a company there may be gaps between perceptions of the upper management and that of the employees due to difference in position, role, and professional knowledge (i.e. Gap 5). Based on the literature it's concluded that the path of the relationships between gaps and performance is described as follows [15]:

A concise summary of the primary causes for Gap 1 is described as follows:

1. Failure to understand the enterprise's position.
2. Difficulty in acquiring valuable information due to the communication barriers between the top managers and line employees.
3. Lack of awareness of what core knowledge the firm needs to possesses.

A concise summary of the causes for Gap 2 as follows:

1. Inability by the enterprise to describe or recognize its core knowledge required for competitiveness.
2. Knowledge management goal is not relevant to the organization's objectives.
3. Difficulty in transferring the necessary knowledge to the KM plan due to non-standardization.

A concise summary of the causes for Gap 3 are as follows:

1. Lack of awareness, comprehension or willingness by employees to share their knowledge.
2. Lack of top management commitment to KM.

A concise summary of the causes for Gap 4 are as follows.

1. Limited employee involvement during initial document review resulting from difficulty in attracting participants.
2. Failure to evaluate the results of KM to determine whether or not it meets the expectations.
3. The existing accounting system is not appropriate for measuring knowledge assets.

A concise summary of the causes for Gap 5 are as follows.

1. Different perceptions of KM of the top managers and other employees due to differences in position, role, and professional knowledge.
2. The employees at different levels have distinct attitude toward planning, responsibility, accountability, and authority.

III. OBJECTIVES OF KM

Many knowledge management objectives have been identified in the literature. Knowledge management is aimed at getting people to innovate, to collaborate, and to make good decisions efficiently [10]. The main objective of knowledge management is to arrange, orchestrate and organize an environment in which people are invited and facilitated to apply, develop, share, combine and consolidate knowledge [21]. Knowledge management is, in a nutshell, aimed at achieving business value [9]. In summary, the basic objective of knowledge management lies in create, share, harvest and leverage knowledge in order to improve work efficiency, i.e. increased organizational capacity through:

- Improved decision making.
- Improved customer service.
- Improved solution of business problems.
- Increased productivity.
- Improved leveraging of corporate and individual knowledge.

IV. IDENTIFICATION OF THE CRITERIA FOR THE EVALUATION OF KM TECHNOLOGIES AND ALTERNATIVES

In order to formulate the multiattribute evaluation model, it is necessary to identify the factors that influence KM practitioners' choice of KM technologies. After discussions with four KM consultants and the operations manager, we studied the features of the KM technologies provided by vendors, reviewed the literature for selecting software, and identified three essential evaluation criteria to use in selecting the best KM technologies: cost, functionality and vendors with sub-criteria and their attributes. The identified criteria were validated by the KM responsible for the firm's KM program.

A. Cost

Cost is a common factor influencing the purchaser to choose the software [6]. It is simply the expenditure associated with KMS and includes product, license, training, maintenance and software subscription costs. Technically, these costs can be grouped under two major criteria, namely, capital expenditures and operating expenditures.

B. Functionality

Functionality refers to those features that the KM technology performs and, generally, to how well the software can meet the user's needs and requirements. Based on a review of the literature and on consultations with KM practitioners, we identified six key functional elements of a KM technology: document management, collaboration, communication, measurement, workflow management and scalability.

1. Document management

Document management, which mainly involves searching for and organizing knowledge, consists of the following six basic features: storage, publishing, subscription, reuse, collaboration and communication [5].

2. Collaboration

Collaboration is one of the key aspects of KM, since collaborative problem solving, conversation and teamwork generate a significant proportion of knowledge assets.

3. Communication

The communication function provided in a KM tool helps users to work together and share knowledge.

4. Measurement

'Measurement' is the keeping of records on activities and changes in managed knowledge.

5. Workflow management

Workflow management allows the movement of documents in information processes among individuals and applications to be specified according to a predefined process [24].

6. Scalability

Scalability refers to the ability to scale up without degradation in performance when the number of workspaces, knowledge bases and users grows.

C. Vendor

The quality of vendor support and its characteristics are of major importance in the selection of software, such as in [2]. It is also critical for the successful installation and maintenance of the software. The important factors affecting the decision to select a KM technology are vendor reputation, the training provided, the implementation vendor, KM consulting services and support, maintenance, upgrades and integration.

D. Alternatives KM Technologies

Alternative 1. Knowledger: Knowledge Associates Ltd is a technology and consulting organization that provides KM solutions consisting of KM education, KM consulting, KM software systems (e.g. Knowledger) the use of the Internet and groupware technologies. Knowledger consists of components that support personal KM, team KM, and organizational KM. The benefit of these components is that, through the knowledge portal, it is possible to manage, collaborate, capture and convey information and so forth to the teams or organization. It integrates KM solutions with a high-level framework, methodologies, systems and tools to optimize working with knowledge at all levels.

Alternative 2. eRoom; eRoom technology focuses exclusively on providing Internet collaboration solutions to the extended enterprise. The eRoom software is a digital workplace that allows organizations to quickly assemble a project team, wherever people are located and to manage the collaborative activities that drive the design, development and delivery of their products and services. In addition, it is a secure extranet or Intranet which, by enabling teams to discuss ideas, share information and make decisions all within a central location, also provides a valuable KM solution.

Alternative 3. Microsoft SharePoint Portal Server; Microsoft offers a wide range of products and services designed to empower people through software at any time, any place and on any device. It is currently the worldwide leader in software, services and Internet technologies for personal and business computing. SharePoint Portal Server software is a KM tool that is an end-to-end solution for managing documents, developing custom portals and aggregating content from multiple sources into a single location.

V. METHODOLOGY

In multiple attribute decision making (MADM) problems, the decision maker's preference information is used to rank alternatives. This paper offers a methodology for analyzing individual and multidimensional preferences with linear programming technique in multiattribute group decision making under fuzzy environments [3;12]. The main focus of this paper is to provide a linear programming model for multidimensional analysis of preferences (LINMAP). The LINMAP method is based on pairwise comparisons of alternatives given by decision makers and generates the best compromise alternative as the solution that has the shortest distance to the positive ideal solution [20].

A method is proposed to solve the MADM problem, where the decision maker (DM) gives his/her preference on alternatives in a fuzzy relation. The use of fuzzy linear programming (FLP) to knowledge management will be discussed and this approach to KM problems has not been appeared in the literature.

Consider a MADM problem with n alternatives $A_i, i=1,2,...A_n$, and m decision attributes (criteria), $X_j, j=1,2,...m$. x_{ij}, component of a decision matrix denoted by $D=(x_{ij})_{n\times m}$, is the rating of alternative A_i with respect to attribute X_j. Let $w=(w_1, w_2, ..., w_n)^T$ be the vector of weights, where $\sum_{j=1}^{n} w_j = 1, w_j \geq 0, j=1,2,...m$ and w_j denotes the weight of attribute C_j [23].

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdot \\ \cdot \\ \cdot \\ A_n \end{array} \begin{array}{c} \begin{array}{ccccc} X_1 & X_2 & . & . & . & X_m \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \end{array}$$

The classical MADM solution methods assume all values are crisp numbers. But in reality, crisp data are insufficient to model real life-decision problems. The attributes could be quantitative and qualitative. The MADM problem contains a mixture of crisp, fuzzy and/or linguistic data. In this methodology, linguistic variables are used to model human judgments. These linguistic variables can be described by triangular fuzzy numbers, $\tilde{x}_{ij} = \left(a_{ij}, b_{ij}, c_{ij}\right)$ [25].

A. Basic concepts

Distance between two triangular fuzzy numbers;

Let $\tilde{m}=(m_1,m_2,m_3)$ and $\tilde{n}=(n_1,n_2,n_3)$ be two triangular fuzzy numbers, then the vertex method is defined to calculate the distance between them as [23].

$$d(\tilde{m},\tilde{n}) = \sqrt{\frac{1}{3}\left[(m_1-n_1)^2+(m_2-n_2)^2+(m_3-n_3)^2\right]} \qquad (1)$$

If both $\tilde{m}$ and $\tilde{n}$ are real numbers, then the distance measurement $d(\tilde{m},\tilde{n})$ is identical to the Euclidean distance [19]. Suppose that both $\tilde{m}=(m_1,m_2,m_3)$ and $\tilde{n}=(n_1,n_2,n_3)$ are two real numbers, then let $m_1=m_2=m_3=m$ and $n_1=n_2=n_3=n$. The distance measurement $(d(\tilde{m},\tilde{n}))$ can be calculated as

$$\begin{aligned} d(\tilde{m},\tilde{n}) &= \sqrt{\frac{1}{3}\left[(m_1-n_1)^2+(m_2-n_2)^2+(m_3-n_3)^2\right]} \\ &= \sqrt{\frac{1}{3}\left[(m-n)^2+(m-n)^2+(m-n)^2\right]} \\ &= \sqrt{(m-n)^2} \\ &= |m - n| \end{aligned}$$

Normalization;

Suppose the rating of alternative $A_i\ (i=1,2,...n)$ on attribute $X_j\ (j=1,2,...m)$ given by DM $P_p\ (p=1,2,...P)$ is $\tilde{x}_{ij}^p = \left(a_{ij}^p, b_{ij}^p, c_{ij}^p\right)$. A fuzzy multiattribute group decision making problem can be expressed in matrix format as follows:

$$\tilde{D}^p = \left(\tilde{x}_{ij}^p\right)_{n\times m} = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdot \\ \cdot \\ \cdot \\ A_n \end{array} \begin{array}{c} \begin{array}{ccccc} X_1 & X_2 & . & . & . & X_m \end{array} \\ \begin{bmatrix} \tilde{x}_{11}^p & \tilde{x}_{12}^p & \cdot & \tilde{x}_{1n}^p \\ \tilde{x}_{21}^p & \tilde{x}_{22}^p & \cdot & \tilde{x}_{2n}^p \\ \vdots & \vdots & & \vdots \\ \tilde{x}_{m1}^p & \tilde{x}_{m2}^p & \cdots & \tilde{x}_{mn}^p \end{bmatrix} \end{array} \quad p=1,2,...,P$$

$\tilde{D}^p$ is decision matrix for DM p.

$$a_j^{max} = max\left\{ a_{ij}^p ; a_{ij}^p \in \tilde{x}_{ij}^p = (a_{ij}^p, b_{ij}^p, c_{ij}^p),\ i=1,2,...,n;\ p=1,2,...,P\right\}$$
$$a_j^{min} = min\left\{ a_{ij}^p ; a_{ij}^p \in \tilde{x}_{ij}^p = (a_{ij}^p, b_{ij}^p, c_{ij}^p),\ i=1,2,...n;\ p=1,2,...,P\right\}$$

$b_j^{max}, b_j^{min}, c_j^{max}, c_j^{max}$ have also same meaning.

In MADM problems, there are benefit (B) and cost (C) attributes. Using the linear scale transformation, the various criteria scales are transformed into a comparable scale.

$$\tilde{r}_{ij}^p = \left(\frac{a_{ij}^p}{c_j^{max}}, \frac{b_{ij}^p}{b_j^{max}}, \frac{c_{ij}^p}{a_j^{max}}\right) \text{ for } j \in B \qquad (2)$$

and

$$\tilde{r}_{ij}^p = \left(\frac{a_j^{min}}{c_{ij}^p}, \frac{b_j^{min}}{b_{ij}^p}, \frac{c_{ij}^{min}}{a_{ij}^p}\right) \text{ for } j \in C \qquad (3)$$

We can obtain the normalized fuzzy decision matrix denoted by $\tilde{R}^p$.

$$\tilde{R}^p = \left(\tilde{r}_{ij}^p\right)_{n\times m} \qquad p=1,2,...,P; \qquad (4)$$

where $\tilde{r}_{ij}^p = \left(a_{ijL}^p, a_{ijM}^p, a_{ijR}^p\right)$ are normalized triangular fuzzy numbers.

B. Fuzzy group LINMAP model

Let $\tilde{a}^* = \left(\tilde{a}_1^*, \tilde{a}_2^*, \ldots\ldots\ldots\tilde{a}_m^*\right)$ is the fuzzy positive ideal solution, where $\tilde{a}_j^* = (\tilde{a}_{jL}^*, \tilde{a}_{jM}^*, \tilde{a}_{jR}^*)$ are triangular fuzzy numbers, the square of the weighted Euclidean distance between $\tilde{R}_i^p$ and $\tilde{a}^*$ can be calculated as

$$S_i^p = \sum_{j=1}^{m} w_j \left[d\left(\tilde{r}_{ij}^p, \tilde{a}_j^*\right)\right]^2 \quad (5)$$

S_i^p can be rewritten using triangular fuzzy numbers $\tilde{a}_j^*$ as [14].

$$S_i^p = \frac{1}{3}\sum_{j=1}^{m} w_j \left[(a_{ijL} - a_{jL}^*)^2 + (a_{ijM} - a_{jM}^*)^2 + (a_{ijR} - a_{jR}^*)^2 \right]$$

Suppose that the DM $P_p (p = 1,2,\ldots,P)$ gives the preference relations between alternatives by $\Omega^p = \left\{(k,l); A_k \rho_p A_l,\ k,l = 1,2,\ldots,n)\right\}$ where ρ_p is a preference relation given by the DM P_p.

$$S_k^p = \sum_{j=1}^{m} w_j \left[d\left(\tilde{r}_{kj}^p, \tilde{a}_j^*\right)\right]^2$$
$$S_l^p = \sum_{j=1}^{m} w_j \left[d\left(\tilde{r}_{lj}^p, \tilde{a}_j^*\right)\right]^2 \quad (6)$$

are squared $(s_i = d_i^2)$ weighted Euclidean distances between each pair of alternative (k,l) and the fuzzy positive ideal solution $\left(\tilde{a}^*\right)$. For every ordered pair $(k,l) \in \Omega^p$, the solution would be consistent with the weighted distance model if $S_l^p \geq S_k^p$ [20]. If $S_l^p < S_k^p$, $\left(S_k^p - S_l^p\right)$ gives the error. If we define

$(S_l^p - S_k^p)^- = 0$ if $S_l^p \geq S_k^p$ and

$(S_l^p - S_k^p)^- = S_k^p - S_l^p$ if $S_l^p < S_k^p$,

$(S_l^p - S_k^p)^- = max\left\{0, S_k^p - S_l^p\right\}$

then $(S_l^p - S_k^p)^-$ denotes the error of the pair (k,l). For all the pairs in Ω^p, the total inconsistency is

$$B^p = \sum_{(k,l)\in\Omega} (S_l^p - S_k^p)^-$$

and the total poorness of fit for the group (B) is

$$B = \sum_{p=1}^{P} B^p = \sum_{p=1}^{P} \sum_{(k,l)\in\Omega} (S_l^p - S_k^p)^- \quad (7)$$

Our objective is to minimize the sum of errors for all pairs in Ω^p. Similarly, if $S_l^p \geq S_k^p$ for the pair, (k,l), $(S_l^p - S_k^p)$ may be designated as the goodness of fit for this pair. Defining $(S_l^p - S_k^p)^+ = S_l^p - S_k^p$ if $S_l^p \geq S_k^p$ and $(S_l^p - S_k^p)^+ = 0$ if $S_l^p < S_k^p$, goodness of fit for pair (k,l) is $(S_l^p - S_k^p)^+$. The total goodness (G) of fit for the group is

$$G = \sum_{p=1}^{P} G^p = \sum_{p=1}^{P} \sum_{(k,l)\in\Omega} (S_l^p - S_k^p)^+ \quad (8)$$

By definition of $(S_l^p - S_k^p)^+$ and $(S_l^p - S_k^p)^-$

$(S_l^p - S_k^p) = (S_l^p - S_k^p)^+ - (S_l^p - S_k^p)^-$.

$$\sum_{(k,l)\in\Omega^p} (S_l^p - S_k^p)^+ - \sum_{(k,l)\in\Omega^p} (S_l^p - S_k^p)^- = \sum_{(k,l)\in\Omega^p} (S_l^p - S_k^p) = h$$

Substituting for B and G from (7) and (8);

$$G - B = h \quad (9)$$

The problem of finding the best solution $(w, \tilde{a}^*)$ reduces to finding the solution (w,v) [8] which maximizes Equation (10) subject to the constraints [14].

$$\begin{aligned} &max && \left\{ \sum_{p=1}^{P} \sum_{(k,l)\in\Omega^p} max\left\{0, S_l^p - S_k^p\right\} \right\} \\ &s.t. && \begin{cases} G - B \geq h \\ \sum_{j=1}^{m} w_j = 1 \\ w_j \geq 0, \quad j = 1,2,\ldots\ldots\ldots\ldots,m \end{cases} \end{aligned} \quad (10)$$

where h is strictly positive.

Let $Z_{kl}^p = max\left\{0, S_l^p - S_k^p\right\}$ for each $(k,l) \in \Omega^p$ and with $Z_{kl}^p \geq 0$, we have $Z_{kl}^p \geq S_l^p - S_k^p$, Equation (10) can be rewritten as

$$\begin{aligned} &maximize && \left\{ \sum_{p=1}^{P} \sum_{(k,l)\in\Omega^p} max\, Z_{kl}^p \right\} \\ &subject\ to && \sum_{(k,l)\in\Omega^p} (S_l^p - S_k^p)^+ - \sum_{(k,l)\in\Omega^p} (S_l^p - S_k^p)^- \geq h \\ & && Z_{kl}^p + S_k^p - S_l^p \geq 0 \qquad (k,l) \in \Omega^p; p = 1,2,\ldots,P \\ & && Z_{kl}^p \geq 0 \\ & && \sum_{j=1}^{m} w_j = 1 \\ & && w_j \geq 0, \quad j = 1,2,\ldots,m \end{aligned}$$

Using $V = \left\{v_j\right\} = (w_j \tilde{a}_j^*)$ we can write as $v_{jL} = w_j a_{jL}^*$, $v_{jM} = w_j a_{jM}^*$ and $v_{jR} = w_j a_{jR}^*$.

By solving this linear programming, $w_j, v_{jL}, v_{jM}, v_{jR}$ are obtained and $\tilde{a}_j^*$ is computed.

VI. APPLICATION

The proposed method is currently applied to solve KM tools selection problem and the computational procedure is summarized as follows:

Step1: The experts $P_p\,(p=1,2,3)$ give their preference judgments between alternatives with paired comparisons as $\Omega^1=\{(1,2),(2,3)\}$, $\Omega^2=\{(1,2),(1,3)\}$, $\Omega^3=\{(2,1),(3,2)\}$ i.e., 1 is preferred to 2, 2 is preferred to 3, etc.

Step2: The experts use the linguistic rating variables (shown in Table 1) to evaluate the rating of alternatives with respect to each attribute. The data and ratings of all alternatives on every attribute are given by the three experts P_1,P_2,P_3 as in Table 2.

TABLE 1 LINGUISTIC VARIABLE FOR THE RATINGS

Very Poor (VP)	(0, 0.1, 0.3)
Poor (P)	(0.2, 0.3, 0,4)
Fair (F)	(0.4, 0.5, 0.6)
Good (G)	(0.6, 0.7, 0.8)
Very Good (VG)	(0.8, 0.9, 1.0)

TABLE 2 DECISION INFORMATIONS AND RATINGS OF THE THREE ALTERNATIVES

Criteria	*Alternatives*	*Decision Makers*		
		P_1	P_2	P_3
C_1 ($\$x10^3$)	A_1	50,000	50,000	50,000
	A_2	35,000	35,000	35,000
	A_3	25,000	25,000	25,000
C_2	A_1	Good	Very G	Fair
	A_2	Poor	Fair	Poor
	A_3	Very G	Good	Good
C_3	A_1	Very G	Fair	Good
	A_2	Good	Good	Very G
	A_3	Good	Fair	Good

Step3: Constructing the normalized fuzzy decision matrix $\tilde{R}^1$ for expert1 (using Eqs.(2) and (3))

$$\tilde{R}^1 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array}\begin{array}{c} \begin{array}{ccc} X_1 & X_2 & X_3 \end{array} \\ \begin{bmatrix} (0.5,0.5,0.5) & (0.6,0.77,1.0) & (0.8,1.0,1.0) \\ (0.71,0.71,0.71) & (0.2,0.33,0.5) & (0.6,0.77,1.0) \\ (1.0,1.0,1.0) & (0.8,1.0,1.0) & (0.6,0.77,1.0) \end{bmatrix}\end{array}$$

We can obtain the normalized decision matrices $\tilde{R}^2$ and $\tilde{R}^3$ of the experts P_2 and P_3 (Eqs. 2 and 3). To obtain the best weights and ideal point, taking $h=1.0$ and using $\tilde{R}^p$ and Ω^p we solve linear programming problem (Eq.(10)).

$w_1 = 0.284$ $w_2 = 0.398$ $w_3 = 0.318$ and

$\tilde{a}^* = ((0.27, 0.27, 0.27), (0.19, 0.20, 0.22), (0.23, 24, 0.25))$

Using Eq. (6), the distances between $\tilde{R}_i^p$ and the positive ideal $\tilde{a}^*$ can be obtained. According these distances, the ranking orders of the three alternatives for the three experts are as follows:

For $P_1 : A_2\, \rho\, A_3\, \rho A_1$
For $P_2 : A_3\, \rho A_1\, \rho A_2$
For $P_3 : A_3\, \rho A_2\, \rho A_1$

The group ranking order of all alternatives can be obtained using social choice functions such as Copeland's function [11]. Copeland's function ranks the alternatives in the order of the value of $f_{cp}(x)$, Copeland's score, which is the number of alternatives in alternative set that X has a strict simple majority over, minus the number of alternatives that have strict simple majorities over X.

TABLE 3 COPELAND'S SCORES

Alternatives		*Decision Makers*			
		P_1	P_2	P_3	*Copeland's scores*
A_1		-1,-1	-1, 1	-1, -1	-4
A_2		1, 1	-1,-1	-1, 1	0
A_3		1,-1	-1, 1	1, 1	2

According to the Copeland's scores, the ranking order of the three alternatives is A_3, A_2, A_1. The best alternative is A_3.

VII. CONCLUSION AND IMPLICATIONS

Through the proposed methodology in this research, enterprises can reduce the mismatch between the capability and implementation of the KM system, and greatly enhance the effectiveness of implementation of the KMS. The development of a KMS is still relatively new to many organizations. With the rise of the organization came a strong interest in KM, and KM tools assumed an important role in supporting KM. KM tools can capture, organize, share and leverage knowledge elements, along with the necessary support and training to insure a successful launch of KM solutions within an organization. In this paper, a systemic approach is proposed using fuzzy linear programming to evaluate an appropriate KM tool for the organization. The model was developed and implemented for a real problem situation at a leading logistic company in Turkey. The usefulness of the model was examined through observing its effect on the decision-making process in selecting an appropriate KM tool. To reflect the DM's subjective preference information, a fuzzy LINMAP model is constructed to determine the weight vector of attributes and then to rank the alternatives. This study has several implications for KM practitioners who intend to evaluate KM tools to build a KMS.

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