A hybrid MCDM algorithm for personnel evaluation using information culture criteria

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***Abstract* - The aim of this paper is to evaluate personnel using MCDM techniques. For personnel evaluation, we have used five criteria of information culture. In this paper entropy method is used to calculate the weights of criteria. Then TOPSIS method is used for the final ranking of the personnel,.**

Keywords - personnel evaluation, modified TOPSIS, entropy method, information culture criteria.

I. Introduction

In recent years, with the rapid development of e-government, the new types of industry of post-Fordist economy has been gradually formed, the core content of this kind of industry includes knowledge, information, creativity, design and symbolic value, etc. [1]. In this information society age, the future survival of organizations depends mainly on the contribution of their personnel to companies. Employee or personnel performances such as knowledge, capability, skill and other abilities play an important role in the success of an organization. Therefore, in order to remain a place in the market, it is necessary for companies to put more emphasis on personnel selection process [2, 3]. Personnel selection plays an important role in human resource management policy in any company which determines the input quality of personnel. Personnel selection is the process of choosing among the alternatives applying for a defined job in the company, the ones who have the qualifications required to perform the job in the best way [4-6].

It is known that selecting the best alternative among many alternatives is a multi-criteria decision making (MCDM) problem. MCDM is one of the most widely used decision methodologies in science, business, and engineering worlds. MCDM methods aim at improving the quality of decisions by making the process more explicit, rational, and efficient [7, 8]. A typical MCDM problem involves a number of alternatives to be evaluated and a number of criteria to evaluate the alternatives. MCDM methods deal with problems of compromise selection of the best solutions from the set of available alternatives according to objectives.

Recently studies state that an information culture plays an important role in the success of the modern organizations [9, 10]. Information culture is an important factor that must be stimulated in all type of modern organization management. Authors of the work [11] state that information culture of personnel may be characterized by a set of five criteria: 1) information gathering and perception skill 2) information memorization skill 3) information handling skill 4) information protection and security skill 5) information presentation skill. So, in this study, for personnel selection we have used these criteria. In this paper, a hybrid model was proposed for the personnel selection process. In selection process we have used the above mentioned information culture criteria. Both modified TOPSIS [12] and entropy methods were utilized within the framework of the proposed model. The entropy method is used to determine the relative weight of the criteria; the modified TOPSIS method is used to rank the alternatives in terms of overall performance with respect to multiple information culture criteria. For personnel selection we have used criteria

II. Related Work

Numerous fuzzy MCDM methods have been developed and there is no best method for the general fuzzy MCDM problem. Most fuzzy number ranking methods suffer from various drawbacks such as (a) lack of sensitivity when comparing similar fuzzy numbers, (b) counterintuitive outcomes in certain circumstances, and (c) complex computational processes [13, 14]. Therefore, in recent years, researchers have attempted to combine different methods to select the best alternative. For example, [1] combined fuzzy AHP and fuzzy TOPSIS to evaluate and select the creative ideas or solutions in different formation stages of complex creative solutions. For supporting the personnel selection process in the manufacturing systems [15] proposed a hybrid model which employs ANP and modified TOPSIS. [16] combined ANP with fuzzy data envelopment analysis and proposed an integrated method to solve the personnel selection problem. [17] proposed fuzzy MCDM approach integrated with fuzzy real option value theory. In [18], for solving a personnel selection problem the new hybrid MULTIMOORA-FG method is proposed to cope with group decision making by employing fuzzy weighted averaging operator. Further in [19], the MULTIMOORA method was extended by employing type-2 fuzzy sets with generalized interval-valued trapezoidal fuzzy numbers. The new fuzzy MULTIMOORA method, as in the case of the crisp MULTIMOORA, consists of the three parts, namely the Ratio System, the Reference Point, and the Full Multiplicative Form, representing different approaches of data aggregation.

III. The TOPSIS+Entropy Model

Let A_i $(i=\overline{1,n})$ be a finite set of n decision alternatives which are to be evaluated by a group of K decision makers

DM_k ($k=\overline{1,K}$) with respect to a set of m evaluation criteria C_j ($j=\overline{1,m}$). The evaluation criteria are measurable quantitatively or assessable qualitatively, and are independent of each other. Assessments are to be made by each decision maker DM_k to determine (a) weight vector $\mathbf{W}^k=(w_1^k,w_2^k,\ldots,w_m^k)$, and (b) the decision matrix $\mathbf{X}^k=\left\|x_{ij}^k\right\|$. The weight vector $\mathbf{W}^k$ represents the weights of the criteria C_j, which are given by the decision makers DM_k using a cardinal scale. The decision matrix $\mathbf{X}^k$ represents the performance ratings assigned to alternative A_i with respect to criteria C_j, which are either objectively measured (for quantitative criteria) or subjectively (for qualitative criteria) assessed by the decision maker DM_k using cardinal values [20].

A. Fuzzy TOPSIS Method

The TOPSIS method [21] is based on the intuitive principle that the best alternatives should have the shortest distance from the positive-ideal alternative and the farthest distance from the negative-ideal alternative. The positive-ideal solution is a hypothetical solution for which all criteria values correspond to the maximum criteria values comprising the satisfying solutions. The negative-ideal solution is a hypothetical solution for which all criteria values correspond to the minimum criteria values comprising the unsatisfying solutions.

The TOPSIS method consist the following steps [22, 23], [12]:

Step 1.*Determine the weighting of evaluation criteria*. This study proposes the entropy method to calculate the weights of criteria. This method will be described below.

Step 2.*Construct a decision matrix for the ranking*. The decision matrix $\mathbf{X}^k$ can be constructed as follows:

$$\mathbf{X}^k=\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_n \end{array}\begin{array}{c} \begin{matrix} C_1 & C_2 & \cdots & C_m \end{matrix} \\ \left\|\begin{matrix} x_{11}^k & x_{12}^k & \cdots & x_{1m}^k \\ x_{21}^k & x_{22}^k & \cdots & x_{2m}^k \\ \vdots & \vdots & \cdots & \vdots \\ x_{n1}^k & x_{n2}^k & \cdots & x_{nm}^k \end{matrix}\right\| \end{array}, \qquad (1)$$

where x_{ij}^k is the performance rating of alternative A_i with respect to criterion C_j evaluated by k th decision maker DM_k.

Step 3.*Choose the appropriate linguistic variables for the criteria and the alternatives with the respect to criteria.*

Due to the uncertainty, the decision maker prefers to give his opinions in linguistic variables. A linguistic variable is a variable whose values are linguistic terms. Each linguistic value can be represented by a fuzzy number which can be assigned to a membership function. Among the various shapes of a fuzzy number, triangular fuzzy number (TFN) is the most popular one. It is a fuzzy number represented with three points as follows: $x_{ij}^k=(l_{ij}^k,m_{ij}^k,u_{ij}^k)$, where m_{ij}^k is the most possible assessment value, l_{ij}^k and u_{ij}^k are the lower and upper values respectively for reflecting the fuzziness of the assessment.

Step 4. *Aggregate the weights of the criteria*. The aggregated weights $\mathbf{W}=\left\|w_j\right\|$, $w_j=(lw_j,mw_j,uw_j)$, of criteria C_j assessed by the committee of K decision-makers using the following equations [12]:

$$lw_j=\min_{k=1,2,\ldots K}\{lw_j^k\},\ mw_j=\frac{1}{K}\sum_{k=1}^{K}mw_j^k$$

$$uw_j=\max_{k=1,2,\ldots K}\{uw_j^k\}, \qquad (2)$$

where $w_j^k=(lw_j^k,mw_j^k,uw_j^k)$ is the weight of the criterion C_j, which is given by the decision maker DM_k, where lw_{ij}^k, mw_{ij}^k and uw_{ij}^k are the lower, middle and upper values respectively for reflecting the fuzziness of the assessment, $0\le lw_{ij}^k\le mw_{ij}^k\le uw_{ij}^k$.

Step 5.*Calculate aggregate fuzzy ratings for the alternatives.* Let the fuzzy ratings of all decision makers are described as TFNs $x_{ij}^k=(l_{ij}^k,m_{ij}^k,u_{ij}^k)$, then the aggregated fuzzy rating $\tilde{x}_{ij}=(\tilde{l}_{ij},\tilde{m}_{ij},\tilde{u}_{ij})$ can be defined as follows (Patil& Kant, 2014):

$$\tilde{l}_{ij}=\min_{k=1,2,\ldots K}\{l_{ij}^k\},\ \tilde{m}_{ij}=\frac{1}{K}\sum_{k=1}^{K}x_{ij}^k,\ \tilde{u}_{ij}=\max_{k=1,2,\ldots K}\{u_{ij}^k\}, \quad (3)$$

Step 6.*Normalize the aggregate fuzzy decision matrix*. The normalized aggregate fuzzy decision matrix denoted by $\mathbf{Y}=\left\|y_{ij}\right\|$ we define as follows:

$$y_{ij}=(l_{ij},m_{ij},u_{ij})=\left(\frac{\tilde{l}_{ij}}{\tilde{u}_j^+},\frac{\tilde{m}_{ij}}{\tilde{u}_j^+},\frac{\tilde{u}_{ij}}{\tilde{u}_j^+}\right),\ \tilde{u}_j^+=\max_{i=1,2,\ldots n}\{\tilde{u}_{ij}\} \quad (4)$$

Step 7.*Construct the weighted normalized fuzzy decision matrix.*The weighted normalized fuzzy decision matrix $\mathbf{Y}^{\mathrm{w}}=\left\|y_{ij}^{\mathrm{w}}\right\|$ is constructed by multiplying the normalized aggregate fuzzy decision matrix $\mathbf{Y}=\left\|y_{ij}\right\|$ with the associated weights $\mathbf{W}=\left\|w_j\right\|$:

$$y_{ij}^{w}=y_{ij}\otimes w_j,\ i=\overline{1,n};\ j=\overline{1,m}. \qquad (5)$$

Note that y_{ij}^{w} is a TFN represented by $y_{ij}^{\mathrm{w}}=(l_{ij}^{\mathrm{w}},m_{ij}^{\mathrm{w}},u_{ij}^{\mathrm{w}})$.

Step 8.*Determine the fuzzy positive-ideal solution and fuzzy negative-ideal solution*. The fuzzy positive-ideal solution $A^{\mathrm{w}+}$ and the fuzzy negative-ideal solution $A^{\mathrm{w}-}$ are determined based on the weighted normalized ratings as follows:

$$A^{\mathrm{w}+}=(a_1^{\mathrm{w}+},a_2^{\mathrm{w}+},\ldots,a_m^{\mathrm{w}+}),\ a_j^{\mathrm{w}+}=(u_j^{\mathrm{w}+},u_j^{\mathrm{w}+},u_j^{\mathrm{w}+}),$$

$$u_j^{\mathrm{w}+}=\max_{i=1,2,\ldots n}\{u_{ij}^{\mathrm{w}}\}, \qquad (6)$$

$$A^{w-}=(a_1^{w-},a_2^{w-},...,a_m^{w-}),\ a_j^{w-}=(l_j^{w-},l_j^{w-},l_j^{w-}),$$
$$l_j^{w-}=\min_{i=1,2,...,n}\{l_{ij}^{w}\}, \quad (7)$$

Step 9.*Calculate the distance of each alternative from the fuzzy positive-ideal solution and fuzzy negative-ideal solution.* We compute the separation distance of each alternative $A_i=(y_{i1}^{w},y_{i2}^{w},...,y_{im}^{w})$ from the fuzzy positive-ideal solution $A^{w+}=(a_1^{w+},a_2^{w+},...,a_m^{w+})$ based on Euclidean distance using the distance measurement between two fuzzy numbers

$$D_i^{+}=\sqrt{\sum_{j=1}^{m}(\mathrm{dist}(y_{ij}^{w},a_j^{w+}))^2}\,. \quad (8)$$

Similarly, the separation distance of each alternative $A_i=(y_{i1}^{w},y_{i2}^{w},...,y_{im}^{w})$ from the fuzzy negative-ideal solution $A^{w-}=(a_1^{w-},a_2^{w-},...,a_m^{w-})$ can be calculated as:

$$D_i^{-}=\sqrt{\sum_{j=1}^{m}(\mathrm{dist}(y_{ij}^{w},a_j^{w-}))^2}\,. \quad (9)$$

The distances $\mathrm{dist}(y_{ij}^{w},a_j^{w+})$ and $\mathrm{dist}(y_{ij}^{w},a_j^{w-})$ between are calculated, respectively, as:

$$\mathrm{dist}(y_{ij}^{w},a_j^{w+})=$$
$$=\sqrt{\frac{1}{3}\left[(l_{ij}^{w}-u_j^{w+})^2+(m_{ij}^{w}-u_j^{w+})^2+(u_{ij}^{w}-u_j^{w+})^2\right]}, \quad (10)$$

$$\mathrm{dist}(y_{ij}^{w},a_j^{w-})=$$
$$=\sqrt{\frac{1}{3}\left[(l_{ij}^{w}-l_j^{w-})^2+(m_{ij}^{w}-l_j^{w-})^2+(u_{ij}^{w}-l_j^{w-})^2\right]}. \quad (11)$$

Step 10.*Calculate the closeness index* (CI_i) *of each alternative*. The closeness index CI_i represents distances to the fuzzy positive-ideal solution A^{+} and the fuzzy negative-ideal solution A^{-} simultaneously. The closeness index CI_i of each alternative A_i is evaluated as follows:

$$\mathrm{CI}_i=\frac{D_i^{-}}{D_i^{-}+D_i^{+}},\ i=\overline{1,n}. \quad (12)$$

Since $D_i^{+}\geq 0$ and $D_i^{-}\geq 0$, then, clearly, the value of CI_i lies between 0 and 1. The larger the index value of CI_i, the better performance of the alternatives.

Step 11.*Rank the alternatives*. Rank the alternatives A_i in accordance with the values of CI_i in descending order and select the alternative with the highest CI_i value.

B. Entropy Method. To calculate the weights of criteria we use Shannon entropy based on the proportion for the j th column of the decision matrix $\mathbf{X}^k=\left\|x_{ij}^k\right\|$:

$$P_{ij}^{k}=\frac{x_{ij}^{k}}{\sum_{l=1}^{n}x_{lj}^{k}},\ i=\overline{1,n};\ j=\overline{1,m};\ k=\overline{1,K}. \quad (13)$$

For the j th column the entropy is computed as:

$$\varphi_j^k=-\frac{1}{\log n}\sum_{i=1}^{n}\log(\tilde{P}_{ij}^k), \quad (14)$$

where $\tilde{P}_{ij}^k$ is the defuzzified value of the $P_{ij}^k=(lP_{ij}^k,mP_{ij}^k,uP_{ij}^k)$. The center-of-area method is the most popular and commonly used method to defuzzify a TFN. The defuzzification value using this method is obtained by:

$$\tilde{P}_{ij}^k=\frac{lP_{ij}^k+mP_{ij}^k+uP_{ij}^k}{3}, \quad (15)$$

The quantity φ_j^k essentially provides a measure of closeness of the different proportions. The smaller value of φ_j^k, the larger the variation among the proportions for classifying the rows. So, we can select the weights as:

$$w_j^k=\frac{(1-\varphi_j^k)}{\sum_{s=1}^{m}(1-\varphi_s^k)},\ j=\overline{1,m};\ k=\overline{1,K}. \quad (16)$$

IV. Conclusion

MCDM has been widely used in the solution of real word decision making problems. By considering the fact that, in some cases, determining precisely the exact values of alternatives with respect to the criteria or/and the exact values for the weights of criteria, is difficult or impossible. Then, the values of alternatives with respect to the criteria or/and the values of criteria weights are considered as fuzzy values. So the conventional approaches for solving these MCDM problems tend to be less effective in dealing with the imprecise or vagueness nature of the linguistic assessment. In such conditions, the fuzzy MCDM methods are applied for solving fuzzy MCDM problems. To address the disadvantages of traditional personnel evaluation methods, this paper proposed the use of a hybrid fuzzy group decision making method. This paper proposed hybrid fuzzy Topsis+Entropy method. An empirical study on the personnel selection problem is used to illustrate how the approach works. With its simplicity in both concept and computation, the approach can be applied in general fuzzy group decision problems solvable by many fuzzy group MCDM methods. It is particularly suited to large-scale fuzzy group MCDM problems where the ranking outcomes produced by different methods differ significantly. Further studies should focus on development of the weighted hybrid MCDM method to solve the ranking inconsistency problem in fuzzy group MCDM.

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