Application of TOPSIS Method in Decision-Making Support of Personnel Management Problems

Masuma Mammadova[1], Zarifa Jabrailova[2], Sabina Nobari[3]
Institute of Information Technology of ANAS, Baku, Azerbaijan
depart15@iit.ab.az

***Abstract*—Application of TOPSIS method for evaluation and regulation of alternatives based on hierarchically structured criteria of qualitative character by multiple experts to intellectually support decisions made in staff management issues is reviewed in the article. Candidate selection experiment based on criteria system formed using TOPSIS method for evaluation of candidates during solution of hiring problems at Iran Khadro car plant were reviewed and obtained results were compared with results obtained using Matlab program package.**

***Keywords*— personnel management; decision-making support; fuzzy evaluation model; TOPSIS method; personnel employment task**

I. INTODUCTION

Correct solution of staff management issues, making objective and democratic decisions allow to achieve global targets set before the organization. But, use of information technologies during solution of these problems, development of systems supporting decision making are faced with several problems. Within the framework of computer technologies these problems stand exposed during consideration of quality coefficients as well as quantity coefficients during generation and selection of staff management problems, their hierocracy, i.e. their definition with multiple indicators of different weights, realization of capabilities related to knowledge, intuition, experience etc of decision making people and experts [1]. Elimination of these problems primarily requires modeling of management issues and development of relevant solution problems.

II. CHARACTERISTIC FEATURES AND GENERALIZED MODEL OF STAFF MANAGEMENT ISSUES

Characteristic features of commonly encountered and evaluation based staff management problems such as: hiring staff, relevance of staff to entitled position, awarding of staff, promotion, stimulation issues in modeling direction have been determined. Such issues have multi-criteria; criteria have hierarchic characteristics, i.e. they are also characterized by multiple indicators; criteria indicators both carry quality and quantity characters; univocal definition of criteria is difficult and consideration of high changeability of their changing borders; importance of criteria characterizing evaluated objects and criteria indicators in relevance with each other, consideration of their relative importance due to difference in importance, and attraction of experts as carrier (sources) of information for realization of evaluation process is required. Above listed load staff management issues to "fuzzy environment" and substantiate to evaluation the decisions made during their solutions by referring to expert knowledge. So, following must be known for solution of evaluation issue in solution of staff management issues requiring intellectual support.

$$X = \{x_1, x_2, \ldots, x_n\} = \{x_i, i = \overline{1,n}\}$$

is set of evaluated alternatives; $K = \{K_1, K_2, \ldots, K_m\} = \{K_j, j = \overline{1,m}\}$ is set of criteria characterizing alternatives; $K_j = \{k_{j1}, k_{j2}, \ldots, k_{jT}\} = \{k_{jt}, t = \overline{1,T}\}$ is set of evaluable indicators characterizing each criteria; Y is value range of each evaluable indicator; E is expert group participating in evaluation; P is relations in X, K and E sets; L is linguistic expressions reflecting the level of relevance and relation of alternatives to criteria indicators; W — relative relations in same-group indicators and criteria sets.

Listed components of selection are united in below relative-set model:

$$Ms=(X, K, Y, E, P, L, W).$$

Solution of evaluation and selection issue based on this model requires development of a relevant method, which refers to solution methods of multi-criteria issues using fuzzy mathematical formalism for this purpose. Scalar optimization (here optimization is considered as best solution method of multi-criteria issues, not as mathematical optimization) solution method of these issues was proposed in [2-4].

Current article reviews the application issue of TOPSIS method for evaluation and regulation of alternatives (selected, regulated) evaluated for intellectual support of decisions made in staff management issues based on hierarchically structured criteria of qualitative character by multiple experts.

III. TOPSIS METOD

Realization of selection issue, the level of relevance and relation of alternatives to criteria indicators, based on conversion of linguistic expressions of quality of our natural language to a fuzzy number (triangle or trapeze) based on proximity to an ideal solution and remoteness from an extremely bad solution traditional are carried out using TOPSIS (Technique for Order Performance by similarity to ideal solution) method allowing discovery of the best solution and ranging of alternatives.In the reviewed case, trapeze fuzzy number has been used.

In order to apply this method, each evaluable criterion indicator is graduated in accordance with 7 level quality evaluation degrees and their trapeze fuzzy number conversion principal is referred to (fig. 1).

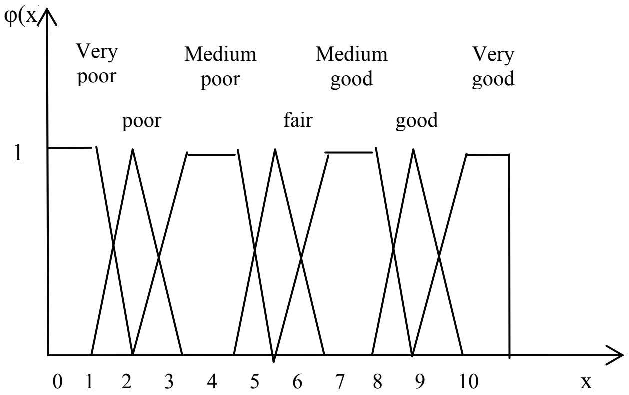

Figure 1. Conversion of linguistic expressions to fuzzy number.

Trapeze fuzzy evaluation table of linguistic quality degrees is as following.

TABLE 1. CONVERSION OF LINGUISTIC EXPRESSIONS TO FUZZY NUMBER BASED ON RATING

Linguistic expression	Fuzzy number
Very poor	(0,0,1,2)
Poor	(1,2,2,3)
medium poor	(2,3,4,5)
fair	(4,5,5,6)
medium good	(5,6,7,8)
Good	(7,8,8,9)
Very good	(8,9,10,10)

Based on Table 1, a fuzzy number can be found for each linguistic expression. For example, the fuzzy number of "medium good" linguistic expression is defined as (5, 6, 7, 8) out of 10 point rating. Then the fuzzification of "medium good" can be demonstrated as following:

$$\varphi_{medium \quad good}(x) = \begin{cases} 0 & x < 5 \\ \frac{x-5}{6-5} & 5 \le x \le 6, \\ 1 & 6 \le x \le 7 \\ \frac{x-8}{7-8} & 7 \le x \le 8 \\ 1 & x > 8 \end{cases} .$$

IV. Application of TOPSIS Method in Solution of Staff Management Issues

To provide correctness and objectiveness of decisions made in relation with staff management in the organization, decision options in relevance with each problem statement are defined and evaluation objects – alternatives and characterizing criteria, indicator system defining these criteria is formed, they are evaluated by finding the relevance degree of alternatives to these indicators and depending on this value, decision option related to them (alternatives) is selected. Thus, let's assume that:

1. $X = \{x_i, \ i = \overline{1, n}\}$ — is a set of evaluated alternatives and the best alternative must be chosen, for example, candidates to be hired in the hiring issue, evaluated activities of employees in awarding issue etc;
2. $K = \{k_j, j = \overline{1, m}\}$ — is a set of criteria with different weights relevant to criteria (for example criteria characterizing hired people or criteria characterizing professional activities in awarding issue) and these criteria are also defined based on multiple indicators with different weights;
3. $k_j = \{k_{jt}, t = \overline{1, s}\}$ — evaluable criteria indicators with different weights (for example, criteria of scientific activity of a scientist can be defined based on indicators such as his articles, scientific works, reports at conferences and symposiums, inventions, doctoral and degree candidate trainings etc);
4. $E = \{e_l, l = \overline{1, g}\}$ — set of experts evaluating the relevance of alternatives to criteria indicators

Objective: evaluation and regulation of alternatives based on linguistic expressions of quality used by the experts reflecting the relevance of alternatives to criteria indicators with different weights.

Solution of the Problem

Step 1. Referring to methods described in [5], importance coefficient ($\sum_{j=1}^{m} w_j = 1$) of each $k_j, j = \overline{1, m}$ and $w_{jt}, t = \overline{1, s}, j = \overline{1, m}$ importance coefficients of $k_{jt}, \ j = \overline{1, m}, \ t = \overline{1, s}$ criteria indicators characterizing each criteria are defined. Later, by referring to hierarchic analysis method, weight – weight coefficient of each $k_{jt}, j = \overline{1, m}, \ t = \overline{1, s}$ criteria indicator in generalizing $K = \{k_j, j = \overline{1, m}\}$criteria is defined [6]: $w_{jt}^{K} = w_{jt} \cdot w_j$.

Step 2. Relevance level of alternatives to criteria indicators are expressed in accordance with seven quality levels of our language (very poor, poor, medium poor, fair, medium good, good, very good). Each such expression is a quality level forming relevance - $\{\varphi_{kjt}(x_i)\}$ of k_{jt} evaluable criteria indicator of x_i alternative, and is expressed in relevant trapeze $R^l = (r_{ijt}^l) = (a_{ijt}^l, b_{ijt}^l, c_{ijt}^l, d_{ijt}^l)$ with a fuzzy number. For example, if relevance of x_i alternative to any k_j criteria is evaluated by expert l as "good", then, its conversion to a fuzzy number in trapeze is expressed as "good" $r_{ij}^l = (7, 8, 8, 9)$.

Linguistic expression of relevance of alternatives to criteria indicators by experts result in $R = \left[r_{ij}^l\right]_{i \times j \times l}$ matrix with $i \times j \times l$ dimensions.

Step 3. Based on individual evaluation of experts - $E = \{e_l, l = \overline{1, g}\}$, single-generalized matrix referring to g

number of matrixes defined by trapeze fuzzy numbers expressing relevance of x_i alternative to k_{jt} criteria is defined. i.e.:

$$R^l = \left[r_{ijt}^l \right], l = \overline{1, g} \Leftrightarrow \left\{ a_{ijt}^l, b_{ijt}^l, c_{ijt}^l, d_{ijt}^l \right\}, l = \overline{1, g} \Rightarrow R_{ijt} = = \left[r_{ijt} \right] \Leftrightarrow \left\{ a_{ijt}, b_{ijt}, c_{ijt}, d_{ijt} \right\} . \quad (1)$$

Here:

$$a_{ijt} = \left\{ \min a_{ijt}^l, l = \overline{1, g} \right\}, \; b_{ijt} = \frac{1}{g} \sum_{l=1}^{g} b_{ijt}^l ;$$

$$c_{ijt} = \frac{1}{g} \sum_{l=1}^{g} c_{ijt}^l ; \quad d_{ijt} = \left\{ \max d_{ijt}^l, l = \overline{1, g} \right\}.$$

As a result we obtain a $i \times j$ dimensional $R_{ij} = \left[r_{itj} \right]$ matrix.

Step 4. $R_{ijt} = \left[r_{ijt} \right] \Leftrightarrow \left\{ a_{ijt}, b_{ijt}, c_{ijt}, d_{ijt} \right\}$ fuzzy number matrix is normalized. For this, values with different dimensions in [0,1] interval are converted into fuzzy numbers using Hsu and Chen method [7]. Based on this method, $d_{jt}^+ = \max d_{ijt}, i = \overline{1, n}$ is defined, elements of normalized matrix are defined using following formulas:

$$R_{ijt}^n = \left[r_{ijt}^n \right] \Leftrightarrow \left\{ a_{ijt}^n, b_{ijt}^n, c_{ijt}^n, d_{ijt}^n \right\} \Leftrightarrow \left\{ \frac{a_{ijt}}{d_{jt}^+}, \frac{b_{ijt}}{d_{jt}^+}, \frac{c_{ijt}}{d_{jt}^+}, \frac{d_{ijt}}{d_{jt}^+} \right\}. \quad (2)$$

Step 5. All elements of normalized $R_{ijt}^n = \left[r_{ijt}^n \right] \Leftrightarrow \left\{ a_{ijt}^n, b_{ijt}^n, c_{ijt}^n, d_{ijt}^n \right\}$ matrix are multiplied by weights of criteria indicators. Let's define fuzzy number matrix by consideration of weight coefficients of criteria indicators: $\overline{R}_{ijt} = \left[\overline{r}_{ijt} \right] \Leftrightarrow \left\{ \overline{a}_{ijt}, \overline{b}_{ijt}, \overline{c}_{ijt}, \overline{d}_{ijt} \right\}$. Here

$$\begin{aligned} \overline{a_{ijt}} &= a_{ij} \cdot w_{jt}^K ; \\ \overline{b_{ijt}} &= b_{ij} \cdot w_{jt}^K ; \\ \overline{c_{ijt}} &= c_{ij} \cdot w_{jt}^K ; \\ \overline{d_{ijt}} &= d_{ij} \cdot w_{jt}^K . \end{aligned} \quad (3)$$

Step 6. On grounds of existing alternatives, trapeze fuzzy numbers of X^* - ideal solution option (ISO) in accordance with each criteria indicator is calculated. For this, each $d_p^* = \left\{ \max \overline{d_{ijt}}, i = \overline{1, n} \right\}$ is selected by $\overline{r} = \left\{ \overline{a_{ijt}}, \overline{b_{jt}}, \overline{c_{ijt}}, \overline{d_{ijt}} \right\}$ fuzzy number in accordance with $k_{jt}, j = \overline{1, m}, \; t = \overline{1, s}$ criteria indicator of each x_i alternative and as a result, following single matrix based on fuzzy number relevant to criteria indicators of ideal solution option is determined:

$$X^* = \left[d_p^* \right] = \left[(d_1^*, d_1^*, d_1^*, d_1^*), \ldots, (d_p^*, d_p^*, d_p^*, d_p^*) \right].$$

Here *p*- is the general number of criteria indicators.

Step 7. On grounds of existing alternatives, trapeze fuzzy numbers of X^- - extremely bad solution (EBS) in accordance with each criteria indicator is calculated. For this, $a_p^- = \left\{ \min \overline{a_{ijt}}, i = \overline{1, n} \right\}$ based on $\overline{r}_{ijt} = (\overline{a_{ijt}}, \overline{b_{ijt}}, \overline{c_{ijt}}, \overline{d_{ijt}})$ - fuzzy number in accordance with $k_{jt}, j = \overline{1, m}, \; t = \overline{1, s}$ criteria indicator of each x_i alternative is found and following single matrix is developed:

$$X^- = \left[a_P^- \right] = \left[(a_1^-, a_1^-, a_1^-, a_1^-), \ldots, (a_p^-, a_p^-, a_p^-, a_p^-) \right].$$

Step 8. At this stage, fuzzy number matrix reflecting proximity of alternatives to ideal solution option is developed. $x_i = \overline{r}_{ijt} = (\overline{a_{ijt}}, \overline{b_{ijt}}, \overline{c_{ijt}}, \overline{d_{ijt}})$ of each x_i alternative is defined by fuzzy number proximity of any k_{jt} criteria indicator to ISO as following [8]:

$$D_j^*(x_i, X^*) = \sqrt{\frac{1}{4}((\overline{a_{ij}} - d_p^*)^2 + (\overline{b_{ij}} - d_p^*)^2 + (\overline{c_{ij}} - d_p^*)^2 + (\overline{d_{ij}} - d_p^*)^2)}$$

$\left[D^* \right]$ ISO proximity matrix with $i \times j$ dimensions reflecting obtained results is developed.

Step 9. Fuzzy number reflecting remoteness of alternatives to EBS are found.

$$D_j^-(x_i, X^-) = \sqrt{\frac{1}{4}((\overline{a_{ij}} - a_p^-)^2 + (\overline{b_{ij}} - a_p^-)^2 + (\overline{c_{ij}} - a_p^-)^2 + (\overline{d_{ij}} - a_p^-)^2)}$$

$\left[D^- \right]$ EBS remoteness matrix with $i \times j$ dimensions reflecting obtained results is developed

Step 10. Proximity of each alternative of all criteria to ISO is calculated with following formula:

$$D^*(x_i) = \sum_{j=1}^{m} D_j^*(x_i, X^*)$$

Step 11. Remoteness of each alternative from EPS in accordance with all criteria is calculated with following formula:

$$D^-(x_i) = \sum_{j=1}^{m} D_j^-(x_i, X^-) .$$

Step 12. Based on values of proximity of alternatives to ISO and their remoteness from EBS, numerical value of their relevance to ideal solution is calculated is normalized.

$$D(x_i) = D^*(x_i) + D^-(x_i)$$

$$\varphi_K(x_i) = \frac{D^-(x_i)}{D(x_i)} .$$

Regulated order of obtained results from maximum to minimum (or vice versa) is relevant to regulated order of alternatives from good to bad (or vice versa).

V. Application of TOPSIS Method for Decision Making in Hiring Issues

Referring to fuzzy logic formalism, in Iran Khodro Car Plant, fuzzy TOPSIS method was used for evaluation and selection of alternatives in realization of decision making support system in hiring issues of candidates. For realization of the system, primarily a general criteria system is formed in order to evaluate hired employees to the plant. This system contains criteria and characterizing indicators allowing evaluating candidates hiring to any department or position at the plant. Candidate evaluation issue for hiring to human resource management department of the plant has been reviewed during conducted experiment. For this purpose, criteria and criteria indicators were determined from the general criteria system with participation of 45 experts for appointment to the position. Results obtained from evaluation of these indicators – will define the value of chance – *K*-hiring chance of the candidate.

Result to be obtained based on fuzzy TOPSIS Method - $\varphi_K(x_i)$, will express the hiring chance of x_i candidate as a value defined in [0,1] interval. Depending on this value, experts pre-form following hiring decision options:

1. If $\varphi_K(x_i) \in [0, 0.25)$, then this candidate decidedly cannot be hired;
2. If $\varphi_K(x_i) \in [0.25, 0.45)$, hiring of this candidate carries great risk;
3. If $\varphi_K(x_i) \in [0.45, 0.62)$, hiring of this candidate carries a bit of risk;
4. If $\varphi_K(x_i) \in [0.62, 0.8)$, this candidate can be hired;
5. If $\varphi_K(x_i) \in [0.8, 1]$, this candidate is unconditionally hired.

In the next stage, importance coefficients of these criteria and their characterizing indicators relatively to each other are defined, for this objective paired comparison method is referred to, detection of contradictions in experts' evaluation is reviewed [5]. Based on obtained results, weight coefficients of criteria indicators have been defined in accordance with hierarchic analysis method (table 2).

TABLE 2. WEIGHT COEFFICIENTS OF CRITERIA INDICATORS

Criteria	*Importance coefficients of criteria*	*Criteria indicator*	*Importance coefficients of criteria indicators*	*Weight coefficients of criteria indicators*
K_1	0.11	k_{11}	0.54	0.06
		k_{12}	0.46	0.05
K_2	0.08	k_{21}	0.47	0.04
		k_{22}	0.53	0.04
K_3	0.4	k_{31}	0.2	0.08
		k_{32}	0.22	0.13
		k_{33}	0.26	0.10
		k_{34}	0.32	0.09
K_4	0.1	k_{41}	0.63	0.06
		k_{42}	0.37	0.04
K_5	0.31	k_{51}	0.35	0.11
		k_{52}	0.65	0.20

Relevance of hiring of 3 candidates to listed criteria indicators has been evaluated in accordance with table 2 with participation of 4 experts.

Based on formula (1), single trapeze matrix is developed based on individual evaluation of experts. Results of single trapeze fuzzy matrix in accordance with k_{11} and k_{12} criteria indicators are provided below.

Based on (2) formula, single trapeze matrix is formed and all its elements are multiplied by weight coefficients of criteria in accordance with formula (3).

ISO and EBS single matrixes are developed on existing grounds of alternatives. ISO proximity matrix $\lfloor D^* \rfloor$ with $i \times j$ dimensions reflecting obtained results is as following: ISO and EBS single matrixes are developed on existing grounds of alternatives. ISO proximity matrix $\lfloor D^* \rfloor$ with $i \times j$ dimensions reflecting obtained results is as.

EBS remoteness proximity $\lfloor D^- \rfloor$ with $i \times j$ dimensions reflecting remoteness of alternatives from EBS is as.Numerical value of proximity to ISO, remoteness from EXP and relevance to ideal solution of each alternative in accordance with all criteria is calculated and normalized (table 3).

TABLE 3. NUMERICAL VALUE OF PROXIMITY TO ISO, REMOTENESS FROM EXP AND RELEVANCE TO IDEAL SOLUTION

	X^*	X^-	X^*+X^-	$\varphi_K(x_i)$
$D(x_1X^-)$	5.59	7.02	12.61	0.55
$D(x_2X^-)$	5.23	7.08	12.31	0.58
$D(x_3X^-)$	4.56	7.76	12.32	0.63

Based on obtained results, the best solution option is x_3 alternative and the value of its hiring chance is $\varphi_K(x_3) = 0.63$. In accordance with decision options of the experts: this candidate can be hired.

In accordance with next listing, x_2 alternative is $\varphi_K(x_2) = 0.58$ and x_1 alternatives equal to $\varphi_K(x_1) = 0.55$ and their hiring chance value matches the identical decision option: hiring of this candidate can carry a bit of risk.

VI. CONCLUSION

Matlab program package has been used in order to verify the correctness of obtained results based on TOPSIS method. In this case, triangle fuzzy numbers have been used for conversion of linguistic values to fuzzy number.

As a result, x_3 alternative with 8.74 value, 7.53 value of x_2 and 7.21 value of x_1 are the most priority based in Matlab software calculations, which are in relevance with TOPSIS method results in accordance with their listing from the best to worst.

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