

Application of TOPSIS Method in Support of Decisions Made in Staff Management Issues

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Abstract: Evaluation model was proposed which refers to fuzzy formalism of the personnel management issues taking account their specific characteristics. Application of TOPSIS (technique for order Performance by similarity to ideal solution) 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 reviewed and obtained results were compared with results obtained using Matlab program package.

Keywords: Personnel management, multi-criteria evaluation, criteria coefficients, decision making, fuzzy number, TOPSIS method.

1. Introduction

Correct solution of staff management issues, making objective and democratic decisions allows 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.

To overcome the listed complications at the decision of administrative problems, it is required to develop methods allowing modeling of administrative decisions and introducing of intellectual decision-making support system on their basis. Present article offers method of scalar optimization for solution of personnel management problems for working out of intellectual decision-making support system [1].

Personnel management problems constitute a foundation of manpower policy. Correct solution of these problems, acceptance of objective and democratic decisions on administrative problems allows to reach the global purposes put forward before the organization [2]. The major direction of personnel work is a purposeful process of conformity definition of personnel qualitative characteristics (abilities, motivation and properties) to position or workplace requirements. It is impossible to achieve positive results of activity of the entire organization as a unit, and each employee separately without objective estimation of the administrative personnel. In this connection, the application of modern methods of personnel estimation possesses special significance today. As to the number of personnel management, problems most frequently confronted in

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practice can be attached to the following issues such as: selection of applicant on a vacant position; compliance of workers to requirements of a workplace, a position; determination of payment level and stimulation forms; formation of a personnel reserve and planning of vocational advancement, career; selection of people on key positions in operation of business; distribution of the rights between members of collective; distribution of duties between members of collective; work distribution between members of collective; awarding, compensation of employees, etc..

The problems to be solved in the sphere of personnel management are intricate and various. They are united by the fact that the final number of estimated objects (workers, trainee, divisions, etc.) characterized by structured set of heterogeneous features is used as initial data.

In fact, at the employment, it is necessary to define availability or lack of some qualities of an applicant necessary for effective work and to give the description of his peculiarities. Thus, the applicants applying for work (position) refer to the number of estimated objects, but direct object of the estimation is knowledge, abilities, personal qualities of the person and it is problematic enough to give an unequivocal quantitative estimation to the latter.

Moreover, knowledge, abilities and personal qualities of the person are characterized by many factors and indicators [3].

The paper is organized as follows: Section 2 presents characteristic features and the generalized model of staff management issues; Section 3 describes TOPSIS (technique for order performance by similarity to ideal solution) method; Section 4 gives step-by-step application of TOPSIS method in solution of staff management issues; Section 5 shows application of TOPSIS method for decision making in hiring issues; Section 6 presents results; Section 7 gives conclusions.

2. Characteristic Features and Generalized Model of Staff Management Issues

Characteristic features 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 are required. The above listed load staff management issues to “fuzzy environment” and substantiate to evaluation the decisions made during their solutions by referring to expert knowledge. Thus, an evaluation model referring to fuzzy formalism for development of an intellectual system supporting decision making person and reflecting expert knowledge must be proposed [4, 5]. So, following must be known for solution of evaluation issue in solution of staff management issues requiring intellectual support:

- (1) Set of evaluated alternatives— $X = \{x_1, x_2, \dots, x_n\} = \{x_i, i = \overline{1, n}\}$;
- (2) Set of criteria characterizing alternatives— $K = \{K_1, K_2, \dots, K_m\} = \{K_j, j = \overline{1, m}\}$;
- (3) Set of evaluable indicators characterizing each criteria— $K_j = \{k_{j1}, k_{j2}, \dots, k_{jT}\} = \{k_{jt}, t = \overline{1, T}\}$;
- (4) Value range of each evaluable indicator— Y ;
- (5) Expert group participating in evaluation (decision making process)— E ;
- (6) Relations in X, K and E sets— P ;
- (7) Linguistic expressions reflecting the level of relevance and relation of alternatives to criteria indicators— L ;

(8) Relative relations in same-group indicators and criteria sets— W ;

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

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

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 [6-9]. Scalar optimization solution method of these issues was proposed in Refs. [10-12] (Here optimization is considered as best solution method of multi-criteria issues, not as mathematical optimization).

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.

3. TOPSIS Method

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 method allowing discovery of the best solution and ranging of alternatives. In the reviewed case, trapeze fuzzy number has been used.

Definition 1: Trapeze fuzzy number membership function is a fuzzy set depicted as below (Fig. 1).

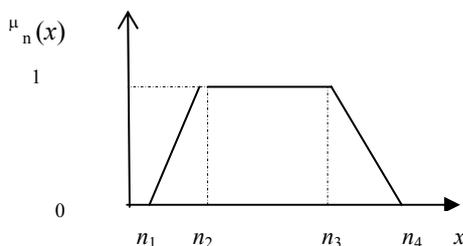


Fig. 1 Trapeze fuzzy number.

Trapeze fuzzy number is indicated as n_1, n_2, n_3 and n_4 quadruple and here n_1, n_2, n_3 and n_4 —are real numbers. Fuzzification of trapeze fuzzy number is defined as below:

$$\mu(x) = \begin{cases} 0, & x < n_1, \\ \frac{x - n_1}{n_2 - n_1}, & n_1 \leq x \leq n_2, \\ 1, & n_2 \leq x \leq n_3, \\ \frac{x - n_4}{n_3 - n_4}, & n_3 \leq x \leq n_4, \\ 0, & x > n_4. \end{cases}$$

If $n_2 = n_3$ in $\bar{n} = (n_1, n_2, n_3, n_4)$ trapeze fuzzy number, then it converts into a \bar{n} triangle fuzzy number.

While using TOPSIS method, some operations on fuzzy numbers must be paid attention to. Let's assume that we are given two trapeze fuzzy numbers $\bar{n} = (n_1, n_2, n_3, n_4)$ and $\bar{m} = (m_1, m_2, m_3, m_4)$. Following extensibility principal must be met for their fuzzy sum, difference and multiplication:

$$\begin{aligned} \bar{n} \oplus \bar{m} &= [n_1 + m_1, n_2 + m_2, n_3 + m_3, n_4 + m_4], \\ \bar{n} - \bar{m} &= [n_1 - m_4, n_2 - m_3, n_3 - m_2, n_4 - m_1] \\ \bar{n} \otimes \bar{m} &\cong [n_1 m_1, n_2 m_2, n_3 m_3, n_4 m_4] \\ \bar{n} \otimes r &= [n_1 r, n_2 r, n_3 r, n_4 r]. \end{aligned} \tag{1}$$

Definition 2: Let's assume that two $\bar{n} = (n_1, n_2, n_3, n_4)$ and $\bar{m} = (m_1, m_2, m_3, m_4)$ trapeze fuzzy numbers are given. The distance between them is calculated as following [13, 14].

$$d_c(\bar{n}, \bar{m}) = \sqrt{\frac{1}{4}((n_1 - m_1)^2 + (n_2 - m_2)^2 + (n_3 - m_3)^2 + (n_4 - m_4)^2)} \tag{2}$$

If \bar{n} and \bar{m} are similar (same) fuzzy numbers, then $d_c(\bar{n}, \bar{m}) = 0$.

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. 2).

Trapeze fuzzy evaluation table of linguistic quality degrees is as following (Table 1).

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

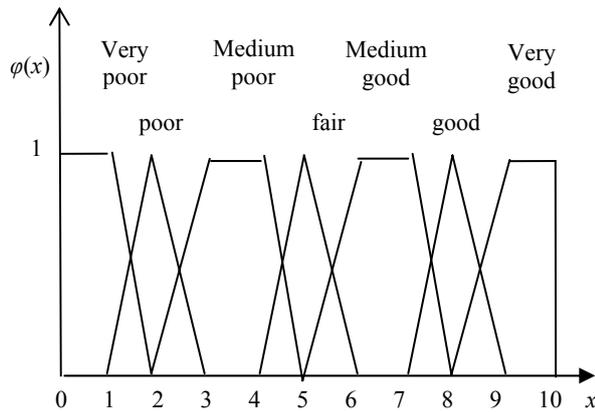


Fig. 2 Conversion of linguistic expressions to fuzzy number based on rating.

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)

defined as (5, 6, 7, 8) out of 10 point rating. Then the fuzzification of “medium good” can be demonstrated as following:

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

4. 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) $X = \{x_i, i = \overline{1, n}\}$ —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) $K = \{k_j, j = \overline{1, m}\}$ —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) $k_{jt} = \{k_{jt}, t = \overline{1, s}\}$ —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.

The objective is 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.

The following is the solution of the problem.

1st Step: Referring to methods described in Ref. [15], 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 [16].

$$w_{jt}^K = w_{jt} \cdot w_j$$

2nd Step: Relevance level of alternatives to criteria indicators is 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— $\{\varphi_{ijt}(x_i)\}$ 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” $r_{ij}^l = (7, 8, 8, 9)$, and if evaluated as “very good” is expressed as “very good”; $r_{ij}^l = (8, 9, 10, 10)$.

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

3rd Step: 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.:

$$R^l = [r_{ijt}^l], l = \overline{1, g} \Leftrightarrow \{a_{ijt}^l, b_{ijt}^l, c_{ijt}^l, d_{ijt}^l\}, l = \overline{1, g} \Rightarrow R_{ijt} = [r_{ijt}] \Leftrightarrow \{a_{ijt}, b_{ijt}, c_{ijt}, d_{ijt}\}$$

Here:

$$\begin{aligned} a_{ijt} &= \{\min a_{ijt}^l, l = \overline{1, g}\} \\ b_{ijt} &= \frac{1}{g} \sum_{l=1}^g b_{ijt}^l; \\ c_{ijt} &= \frac{1}{g} \sum_{l=1}^g c_{ijt}^l; \\ d_{ijt} &= \{\max d_{ijt}^l, l = \overline{1, g}\}. \end{aligned} \tag{3}$$

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

4th Step: $R_{ijt} = [r_{ijt}] \Leftrightarrow \{a_{ijt}, b_{ijt}, c_{ijt}, d_{ijt}\}$ 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 [17]. Based on this method, $d_{jt}^+ = \max d_{ijt}, i = \overline{1, n}$ is defined, elements of normalized matrix are defined using following formulas:

$$R_{ijt}^n = [r_{ijt}^n] \Leftrightarrow \{a_{ijt}^n, b_{ijt}^n, c_{ijt}^n, d_{ijt}^n\} \Leftrightarrow \left\{ \frac{a_{ijt}}{d_{jt}^+}, \frac{b_{ijt}}{d_{jt}^+}, \frac{c_{ijt}}{d_{jt}^+}, \frac{d_{ijt}}{d_{jt}^+} \right\} \tag{4}$$

5th Step: All elements of normalized $R_{ijt}^n = [r_{ijt}^n] \Leftrightarrow \{a_{ijt}^n, b_{ijt}^n, c_{ijt}^n, d_{ijt}^n\}$ matrix are multiplied by weights of criteria indicators. For this, $\bar{n} \otimes r \equiv [n_1 r, n_2 r, n_3 r, n_4 r]$ phrase from Eq. (1) is used. Let's define fuzzy number matrix by consideration of

weight coefficients of criteria indicators:

$$\bar{R}_{ijt} = [r_{ijt}] \Leftrightarrow \{\bar{a}_{ijt}, \bar{b}_{ijt}, \bar{c}_{ijt}, \bar{d}_{ijt}\}.$$

Here:

$$\begin{aligned} \bar{a}_{ijt} &= a_{ij} \cdot w_{jt}^K; \\ \bar{b}_{ijt} &= b_{ij} \cdot w_{jt}^K; \\ \bar{c}_{ijt} &= c_{ij} \cdot w_{jt}^K; \\ \bar{d}_{ijt} &= d_{ij} \cdot w_{jt}^K. \end{aligned} \tag{5}$$

6th Step: On grounds of existing alternatives, trapeze fuzzy numbers of X^* —ISO (ideal solution option) in accordance with each criteria indicator is calculated.

For this, each $d_p^* = \{\max \bar{d}_{ijt}, i = \overline{1, n}\}$ is selected based

on $\bar{r} = \{\bar{a}_{ijt}, \bar{b}_{jt}, \bar{c}_{ijt}, \bar{d}_{ijt}\}$ 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:

$$X^* = [d_p^*] = [(d_1^*, d_1^*, d_1^*, d_1^*), \dots, (d_p^*, d_p^*, d_p^*, d_p^*)] \tag{6}$$

Here p is the general number of criteria indicators.

7th Step: On grounds of existing alternatives, trapeze fuzzy numbers of X^- —EBS (extremely bad solution) in accordance with each criteria indicator is calculated.

For this, $a_p^- = \{\min \bar{a}_{ijt}, i = \overline{1, n}\}$ based on $\bar{r}_{ijt} = (\bar{a}_{ijt}, \bar{b}_{ijt}, \bar{c}_{ijt}, \bar{d}_{ijt})$ —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:

$$X^- = [a_p^-] = [(a_1^-, a_1^-, a_1^-, a_1^-), \dots, (a_p^-, a_p^-, a_p^-, a_p^-)]$$

8th Step: At this stage, fuzzy number matrix reflecting proximity of alternatives to ideal solution option is developed.

$x_i = \bar{r}_{ijt} = (\bar{a}_{ijt}, \bar{b}_{ijt}, \bar{c}_{ijt}, \bar{d}_{ijt})$ of each x_i alternative is defined based on fuzzy number (2) formula reflecting proximity of any k_{jt} criteria indicator to ISO as following:

$$D_j^*(x_i, X^*) = \sqrt{\frac{1}{4}((\bar{a}_{ij} - d_p^*)^2 + (\bar{b}_{ij} - d_p^*)^2 + (\bar{c}_{ij} - d_p^*)^2 + (\bar{d}_{ij} - d_p^*)^2)}$$

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

9th Step: Fuzzy number reflecting remoteness of alternatives to EBS is found.

$$D_j^-(x_i, X^-) = \sqrt{\frac{1}{4}((\bar{a}_{ij} - \bar{a}_p^-)^2 + (\bar{b}_{ij} - \bar{a}_p^-)^2 + (\bar{c}_{ij} - \bar{a}_p^-)^2 + (\bar{d}_{ij} - \bar{a}_p^-)^2)}$$

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

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

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

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

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

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

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

Referring to fuzzy logic formalism, 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, following criteria and criteria indicators were

determined from the general criteria system with participation of experts for appointment to the position:

K_1 —science and education criteria and indicators characterizing it: k_{11} —relevance of completed education to corresponding job; k_{12} —character of investigator.

K_2 —behavior and appearance criteria and indicators characterizing it: k_{21} —lanced; k_{22} —well-conducted and polite.

K_3 —personal psychological criteria and indicators characterizing it: k_{31} —hardworking, industrious; k_{32} —creative; k_{33} —loyal; k_{34} —high intelligence.

K_4 —functional activity criteria and indicators characterizing it: k_{41} —work capability; k_{42} —learning capability.

K_5 —medical criteria and indicators characterizing it: k_{51} —physical health; k_{52} —spiritual and psychological health.

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 [14, 15]. 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_{31}	0.2	0.08
K_3	0.4	k_{32}	0.22	0.13
		k_{33}	0.26	0.10
		k_{34}	0.32	0.09
		k_{41}	0.63	0.06
K_4	0.1	k_{42}	0.37	0.04
		k_{51}	0.35	0.11
K_5	0.31	k_{52}	0.65	0.20

Relevance of hiring of three candidates to listed criteria indicators has been evaluated in accordance with Table 3 with participation of four experts.

Based on Eq. (3), 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 (Table 4).

Based on Eq. (4), single trapeze matrix is formed and all its elements are multiplied by weight coefficients of criteria in accordance with Eq. (5) (Table 5).

ISO and EBS single matrixes are developed on existing grounds of alternatives. ISO proximity matrix $[D^*]$ with $i \times j$ dimensions reflecting obtained results is Table 6:

EBS remoteness proximity $[D^-]$ with $i \times j$ dimensions reflecting remoteness of alternatives from EBS is as following (Table 7):

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 8).

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.

6. Results

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.

The window expressing the relevance of x_1 alternative to criteria indicator system with fuzzy numbers in the program and determination of its status is described as below:

Statuses of other alternatives are defined in relevant order. 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.

7. Conclusions

The proposed method for multi-criteria assessment and ranking can be applied for solving the problems of personnel management, as well as for other problems arising from the human activity. However, the criteria, assessment indicators characterizing assessed objects should be formed previously and their importance coefficients should be determined using appropriate methods.

Table 3 Evaluation of criteria indicators.

Criteria indicators	Alternatives	Expert 1	Expert 2	Expert 3	Expert 4
k_{11}	x_1	good	good	good	good
	x_2	good	very good	fair	medium good
	x_3	good	good	very good	good
k_{12}	x_1	very good	very good	good	very good
	x_2	medium good	good	very good	medium good
	x_3	good	very good	very good	medium
k_{21}	x_1	good	good	fair	medium good
	x_2	good	very good	very good	good
	x_3	very good	good	good	very good
k_{22}	x_1	medium good	good	very good	good
	x_2	very good	very good	very good	very good
	x_3	good	very good	good	good
k_{31}	x_1	good	medium good	very good	good
	x_2	very good	good	good	very good
	x_3	good	very good	very good	good
k_{32}	x_1	good	good	very good	good
	x_2	very good	medium good	good	very good
	x_3	medium good	good	very good	medium good
k_{33}	x_1	very good	very good	very good	very good
	x_2	good	very good	good	good
	x_3	good	good	fair	medium good
k_{34}	x_1	good	very good	very good	fair
	x_2	good	very good	good	good
	x_3	medium good	good	very good	good
k_{41}	x_1	very good	good	good	very good
	x_2	good	good	very good	good
	x_3	very good	medium good	good	very good
k_{42}	x_1	medium good	good	very good	medium good
	x_2	good	very good	very good	fair
	x_3	good	very good	good	good
k_{51}	x_1	very good	good	good	good
	x_2	medium good	good	very good	good
	x_3	very good	very good	very good	very good
k_{52}	x_1	good	very good	good	good
	x_2	good	good	fair	medium good
	x_3	good	very good	very good	good

Table 4 Single trapeze fuzzy matrix in accordance with k_{11} and k_{12} criteria indicators.

Criteria indicators	Alternatives	Expert 1	Expert 2	Expert 3	Expert 4	Generalized single trapeze fuzzy number
k_{11}	x_1	(7, 8, 8, 9)	(7, 8, 8, 9)	(7, 8, 8, 9)	(7, 8, 8, 9)	(7, 8, 8, 9)
	x_2	(7, 8, 8, 9)	(8, 9, 10, 10)	(4, 5, 5, 6)	(5, 6, 7, 8)	(4, 7, 7.5, 10)
	x_3	(7, 8, 8, 9)	(7, 8, 8, 9)	(8, 9, 10, 10)	(7, 8, 8, 9)	(7, 8.3, 9, 10)
k_{12}	x_1	(8, 9, 10, 10)	(8, 9, 10, 10)	(7, 8, 8, 9)	(8, 9, 10, 10)	(7, 8.8, 9.5, 10)
	x_2	(5, 6, 7, 8)	(7, 8, 8, 9)	(8, 9, 10, 10)	(5, 6, 7, 8)	(5, 7.3, 8, 10)
	x_3	(7, 8, 8, 9)	(8, 9, 10, 10)	(8, 9, 10, 10)	(4, 5, 5, 6)	(4, 7.8, 8.3, 10)

Table 5 Normalized fuzzy number of relevance of alternatives to indicators of criteria.

Criteria indicators	Alternatives	Normalized single trapeze fuzzy number	Weight coefficients of k_{ji}	Normalized fuzzy number of relevance of alternatives
k_{11}	x_1	(0.7, 0.8, 0.8, 0.9)	0.06	0.042, 0.048, 0.048, 0.054
	x_2	(0.4, 0.7, 0.75, 1)		0.024, 0.042, 0.045, 0.06
	x_3	(0.7, 0.83, 0.9, 1)		0.042, 0.05, 0.054, 0.06
k_{12}	x_1	(0.7, 0.88, 0.95, 1)	0.05	0.035, 0.044, 0.098, 0.05
	x_2	(0.5, 0.73, 0.8, 1)		0.025, 0.037, 0.04, 0.05
	x_3	(0.4, 0.78, 0.83, 1)		0.02, 0.039, 0.042, 0.05

Table 6 ISO proximity matrix $[D^+]$.

Criteria indicators	$D(x_1X^*)$	$D(x_2X^*)$	$D(x_3X^*)$
k_{11}	0.45	0.51	0.4
k_{12}	0.34	0.49	0.49
k_{21}	0.57	0.36	0.4
k_{22}	0.67	0.27	0.35
k_{31}	0.48	0.37	0.37
k_{32}	0.56	0.49	0.43
k_{33}	0.37	0.4	0.47
k_{34}	0.5	0.39	0.37
k_{41}	0.37	0.39	0.29
k_{42}	0.49	0.49	0.39
k_{51}	0.39	0.47	0.27
k_{52}	0.4	0.6	0.33

Table 7 EBS remoteness proximity $[D^-]$.

Criteria indicators	$D(x_1X)$	$D(x_2X)$	$D(x_3X)$
k_{11}	0.55	0.56	0.68
k_{12}	0.7	0.6	0.6
k_{21}	0.52	0.68	0.66
k_{22}	0.53	0.65	0.71
k_{31}	0.52	0.51	0.6
k_{32}	0.52	0.53	0.67
k_{33}	0.63	0.66	0.62
k_{34}	0.59	0.67	0.62
k_{41}	0.51	0.59	0.64
k_{42}	0.6	0.6	0.67
k_{51}	0.59	0.52	0.51
k_{52}	0.74	0.51	0.64

Table 8 Normalized relevance to ideal solution of each alternative.

	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

Basing on the proposed model and method, the key features of more objective and transparent management decisions of the personnel are as follows:

The number of criteria and criteria indicators characterizing the issue are not restricted;

The quality of criteria indicators characterizing the issue, the importance and advantage of criteria and criteria indicators in relation to each other are taken into account, and the conflict is determined;

The competency of the experts participated in the selection, ranking and assessment of the best alternatives in the relevant field are taken into account;

Subjectivity of decision-maker in the decision-making process are reduced, more objective and transparent decisions are made.

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