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Development of Method of Multifunctional Personnel Assessment Using a Topsis Method

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Abstract

The paper offers the method of multifunctional personnel assessment, with the purpose of drawing a matrix of functional capabilities of multifunctional personnel, based on which we can carry out optimal selection of personnel and allocation of functions. The developed method of multifunctional personnel assessment uses a multi-criteria expert method - a TOPSIS method.

Keywords: Multifunctional personnel, matrix of functional capacities, decision matrix, TOPSIS, decision making method.

Introduction

Personnel is the most important resource for any organization, upon the effective functioning of which clearly depends successful operation of the organization. Therefore, the proper and objective selection of personnel and division of labor is very important at a formative stage of the organization or its separate units. In general, personnel assessment is a very responsible and complex task, especially when we want to set up the units of the organization on the basis of multifunctional personnel. In this context, personnel assessment implies a complex approach that is applied to the fact that the assessment should be carried out against the different criteria in order to maintain the high standard of objectivity, and most importantly, to allow us for selecting qualified personnel.

A human operator appears to us as a multifunctional element in social-production systems, who has several specialist skills and is able to accomplish several functions of this system. To be more precise, a multifunctional human operator (multifunctional operator - **MFO**) is a specialist with a functional overabundance (a), who has the ability to accomplish one specific f function at any time t , from a set of his/her functional capacities $F_a = \{f_e / e \in [1,k]\}$, $k>1$ (Tsiramua, 2017; Tsiramua & Basheleishvili, 2015).

Unlike a single-functional human operator, the multifunctional operators allow us for completing the organizational systems of the reconfigurable structure, which able to realign the structure and continue successful functioning in the case of partial fault of any specialist. (Tsiramua, 2017; Basheleishvili, 2017).

MFO's partial fault is a case when the loses the ability to accomplish his/her mandated function, but retains the ability to accomplish other functions assigned to the system, he/she can be switched to the accomplishment of other functions. The papers (Tsiramua, 2017; Tsiramua & Basheleishvili, 2015) show that the system staffed by multifunctional personnel much more efficient than a system staffed by the single-functional specialists.

The purpose of the work is to develop the method of assessment multifunctional personnel, by which we will be able to determine the matrix of functional capacities of multifunctional personnel.

The problem of multifunctional personnel assessment

The structure of the problem of multifunctional personnel assessment is similar to the problem of multi-criterion decision, consequently, the solution to the problem is based on the method of multi-criterion analysis TOPSIS (Hwang, Yoon, 1981; Yoon, 1987).

We can formulate the problem of multifunctional personnel assessment as follows:

We have a set of functions to be accomplished $F=\{ f_1, f_2, f_3, ..., f_n \}$ and a set of personnel to be assessed $A=\{ a_1, a_2, a_3, ..., a_m \}$, whose assessment we want to make regard-

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ing the functions $f_1, f_2, f_3, \dots, f_n$. We also have a set of the assessment criteria, $C_i=\{c_{i1}, c_{i2}, c_{i2}, \dots, c_{ik}, c_{ik+1}, \dots, c_{ig}\}$ – for a stand-alone function f_i, where $i=1, n$.

The given set of the assessment criteria includes criteria of the following categories:

Reviewing CV personal data of personnel involved in the assessment, which in turn may be divided into many criteria;

Interview – may also be divided into many criteria;

Testing – may include the tests of various categories, such as: general skills tests; computer skills tests; professional skills tests; psychological tests; foreign language proficiency tests and so on.

From given categories of the assessment criteria the first and second category criteria (CV reviews and interview) are evaluated by an expert (or group of experts). $E = \{e_1, e_2, e_3, \dots, e_v\}$ - is a set of experts who assess qualifying candidates according to individual criteria. While the testing category criteria are evaluated as a result of the testing personnel involved in the evaluation of specific criteria of the given category, and points obtained in the relevant tests are considered to be an assessment.

In this context, the assessment criteria $C_i= \{c_{i1}, c_{i2}, c_{i2}, \dots, c_{ik}, c_{ik+1}, \dots, c_{ig}\}$ of a stand-alone function f_i, where $c_{i1}, c_{i2}, c_{i2}, \dots, c_{ik}$ are evaluated by an expert or expert group, while the $c_{ik+1}, \dots, c_{ig}$ criteria are measured according to the test results.

The assessment criteria of a stand-alone function to be accomplished f_i have the weights, which are determined by a vector of the weights $W_i = \{w_{i1}, w_{i2}, w_{i2}, \dots, w_{ig}\}$,

where w_{ij} $j=1,g$ is a weight of the assessment criterion c_{ij} of a stand-alone function to be accomplished f_i. The weights of the assessment criteria of each function to be accomplished f_i should satisfy the following condition:

$$\sum_{j=1}^{g} w_{ij} = 1$$

Development of an assessment method

Our goal is to develop such a method, which allows us for determining the functional capacities matrix of multifunctional personnel, and based on the personnel differential assessment, to provide optimal allocation of functions. For the purpose of assessing multifunctional personnel (A), we can draw a decision matrix (where $A = \{a_1, a_2, a_3, \dots, a_m\}$ personnel represents the alternatives, and the assessment criteria are represented by the criteria for assessing a stand-alone function f_i), and based on this decision matrix, using a TOPSIS method, we can determine final assessment of all personnel to be selected for a stand-alone function f_i.

Method of multifunctional personnel assessment includes the following steps:

Step 1. Determine the decision matrix fDM_i for each function f_i:

$$fDM_i = \begin{pmatrix} x_{11}^i & x_{12}^i & \cdots & x_{1k}^i & x_{1k+1}^i & \cdots & x_{1g}^i \\ x_{21}^i & x_{21}^i & \cdots & x_{2k}^i & x_{2k+1}^i & \cdots & x_{2g}^i \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ x_{m1}^i & x_{m2}^i & \cdots & x_{mk}^i & x_{mk+1}^i & \cdots & x_{mg}^i \end{pmatrix}$$

Where

$i = 1, .., n$

$r = 1, ..., m$

$l = 1, ...k, k+1, ...g$

$$x_{rl}^i = \begin{cases} \left(\frac{\sum_{j=1}^{v} q_{rj}^{il}}{v}\right) & if \quad 1 \le l \le k \\ t_r^{il} \quad if \quad k+1 \le l \le g \end{cases}$$

x_{rl}^i- is the assesssment (numeric value) of c_{il} criteria of the f_i function of the personnel a_r, which is equal to the average arithmetic of the scores defined by the experts in the c_{il} criteria of the f_i function of the a_r personnel if the criteria are evaluated by the experts. Otherwise, it is equal to the score received by the a_r personnel in the c_{il} criteria assessment test.

Step 2. Calculate the normalized decision matrix :

$$n_{rl}^i = \frac{x_{rl}^i}{\sqrt{\sum_{r=1}^{m} (x_{rl}^i)^2}}$$

Step 3. Calculate the weighted normalized decision matrix:

$$v_{rl}^i = w_{il} * n_{rl}^i$$

Step 4. Determine the positive ideal and negative ideal solutions:

Positive ideal solution:

$$S^{i+} = \{v_1^{i+}, v_2^{i+}, \dots, v_g^{i+}\}$$

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Where

$$v_l^{i+} = \max(v_{rl}^i)$$

$$l = 1, g$$

$$r = 1, m$$

Negative ideal solution:

$$S^{i-} = \{v_1^{i-}, v_2^{i-}, \dots, v_g^{i-}\}$$

where

$$v_l^{i-} = \min(v_{rl}^i)$$

$$l = 1, g$$

$$r = 1, m$$

Step 5: Calculate the separation measures from the positive ideal solution and the negative ideal solution:

The separation from the ideal alternative is:

$$d_r^{i+} = \sqrt{\sum_{j=1}^{n} \left(v_{rl}^i - v_j^{i+}\right)^2}$$

the separation from the negative ideal alternative is:

$$d_r^{i-} = \sqrt{\sum_{j=1}^{n} \left(v_{rl}^i - v_j^{i-}\right)^2}$$

Step 6: Calculate the relative closeness to the positive ideal solution:

$$R_r^i = \frac{d_r^{i-}}{d_r^{i-} + d_r^{i+}}$$

Where

$$0 \leq R_r^i \leq 1$$

$$i = 1, n$$

$$r=1,m$$

Step 7: Based on received results determine a matrix of functional capabilities:

$$\begin{pmatrix} p_1(f_1) & p_1(f_2) & p_1(f_3) & \cdots & p_1(f_n) \\ p_2(f_1) & p_2(f_2) & p_2(f_3) & \cdots & p_2(f_n) \\ \cdots & \cdots & \cdots & \ddots & \cdots \\ p_m(f_1) & p_m(f_2) & p_m(f_3) & \cdots & p_m(f_n) \end{pmatrix}$$

Where

$$p_r(f_i) = R_r^i$$

$$r=1, m;$$

$$i=1, n.$$

Numerical example

Consider an multifunctional personnel assessment example, that clearly illustrates the work of the proposed methodology.

For example of the assessment task we have the following: $F=\{f_1, f_2, f_3\}$ - A set of functions; $A=\{a_1, a_2, a_3, a_4, a_5\}$ - a set of personnel to be assessed; $E=\{e_1, e_2, e_3\}$ - a set of experts.

Assessment criteria and the weight of the assessment criteria for the individual function are given in Table 1.

The first three of the evaluation criteria are evaluated by the Expert Group and the remaining two criteria through pricing testing.

Experts assessment and test results are presented in the tables 2-6 according to the personnel:

Table 1. *Assessment criteria and the weight of the assessment criteria for the individual function*

f_1		f_2		f_3	
C_1	W_1	C_2	W_2	C_3	W_3
c_{11}	$w_{11} = 0.1$	c_{21}	$w_{21} = 0.2$	c_{31}	$w_{31} = 0.2$
c_{12}	$w_{12} = 0.2$	c_{22}	$w_{22} = 0.1$	c_{32}	$w_{32} = 0.2$
c_{13}	$w_{13} = 0.15$	c_{23}	$w_{23} = 0.2$	c_{33}	$w_{33} = 0.1$
c_{14}	$w_{14} = 0.25$	c_{24}	$w_{24} = 0.25$	c_{34}	$w_{34} = 0.2$
c_{15}	$w_{15} = 0.3$	c_{25}	$w_{25} = 0.25$	c_{35}	$w_{35} = 0.3$

Table 2. *a_1 Personnel expert assessment and test results*

$\boldsymbol{a_1}$	f_1					f_2					f_3				
	C_1					C_2					C_3				
	Expert			Test		Expert			Test		Expert			Test	
	c_{11}	c_{12}	c_{13}	c_{14}	c_{15}	c_{21}	c_{22}	c_{23}	c_{24}	c_{25}	c_{31}	c_{32}	c_{33}	c_{34}	c_{35}
e_1	8	8	7	10	9	7	9	6	8	9	5	4	5	8	7
e_2	9	7	5			8	8	6			5	4	6		
e_3	7	6	6			9	7	8			4	5	4		

Table 3. *a_2 Personnel expert assessment and test results*

$\boldsymbol{a_2}$	f_1					f_2					f_3				
	C_1					C_2					C_3				
	Expert			Test		Expert			Test		Expert			Test	
	c_{11}	c_{12}	c_{13}	c_{14}	c_{15}	c_{21}	c_{22}	c_{23}	c_{24}	c_{25}	c_{31}	c_{32}	c_{33}	c_{34}	c_{35}
e_1	8	7	6	7	6	7	9	7	8	8	5	6	5	7	6
e_2	6	6	5			8	8	7			5	6	6		
e_3	7	6	6			8	7	8			4	5	5		

Table 4. *a_3 Personnel expert assessment and test results*

$\boldsymbol{a_3}$	f_1					f_2					f_3				
	C_1					C_2					C_3				
	Expert			Test		Expert			Test		Expert			Test	
	c_{11}	c_{12}	c_{13}	c_{14}	c_{15}	c_{21}	c_{22}	c_{23}	c_{24}	c_{25}	c_{31}	c_{32}	c_{33}	c_{34}	c_{35}
e_1	8	8	7	8	9	7	8	6	8	9	5	4	5	9	10
e_2	9	7	5			8	7	7			5	4	6		
e_3	7	6	6			9	7	8			4	5	4		

Table 5. *a_4 Personnel expert assessment and test results*

$\boldsymbol{a_4}$	f_1					f_2					f_3				
	C_1					C_2					C_3				
	Expert			Test		Expert			Test		Expert			Test	
	c_{11}	c_{12}	c_{13}	c_{14}	c_{15}	c_{21}	c_{22}	c_{23}	c_{24}	c_{25}	c_{31}	c_{32}	c_{33}	c_{34}	c_{35}
e_1	8	8	7	7	9	8	9	6	7	6	8	8	7	7	7
e_2	8	7	5			9	9	6			8	7	6		
e_3	8	7	6			9	7	7			8	7	7		

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Table 6. *a_5 Personnel expert assessment and test results*

a_5	f_1					f_2					f_3				
	C_1					C_2					C_3				
	Expert			Test		Expert			Test		Expert			Test	
	c_{11}	c_{12}	c_{13}	c_{14}	c_{15}	c_{21}	c_{22}	c_{23}	c_{24}	c_{25}	c_{31}	c_{32}	c_{33}	c_{34}	c_{35}
e_1	8	9	7	6	8	7	7	7	9	9	5	4	5	7	8
e_2	8	8	7			8	8	7			5	4	6		
e_3	7	7	6			8	7	8			4	5	4		

Determine the matrix of the decision for each individual function *({f1, f2, f3})* tables 7-9:

Table 7. *Decision matrix for f_1*

	c_{11}	c_{12}	c_{13}	c_{14}	c_{15}
a_1	8	7	6	10	9
a_2	7	6.3	5.7	7	6
a_3	8	7	6	8	9
a_4	8	7.3	6	7	9
a_5	7.5	8	6.7	6	8

Table 8. *Decision matrix for f_2*

	c_{21}	c_{22}	c_{23}	c_{24}	c_{25}
a_1	8	8	6.7	8	9
a_2	7.7	8	7.3	8	8
a_3	8	7.3	7	8	9
a_4	8.7	8.3	6.3	7	6
a_5	7.6	7.3	7.3	9	9

Table 8. *Decision matrix for f_3*

	c_{31}	c_{32}	c_{33}	c_{34}	c_{35}
a_1	4.6	4.3	5	8	7
a_2	4.6	5.6	5.3	7	6
a_3	4.6	4.3	5	9	10
a_4	8	7.3	6.6	7	7
a_5	4.6	4.3	5	7	8

For each decision matrix, using a TOPSIS method, we can determine final assessment of all personnel to be selected for a stand-alone function *fi*.

Results for a stand-alone function are given in tables 10-12.

Table 10. *Assessment results for function f_1*

	d_i^+	d_i^-	R_i
a_1	0,014709	0,076411	0,838578
a_2	0,024756	0,014482	0,369086
a_3	0,014709	0,057636	0,796684
a_4	0,011677	0,052656	0,818498
a_5	0,003048	0,040407	0,929856

Table 11. *Assessment results for function f_2*

	d_i^+	d_i^-	R_i
a_1	0,017836	0,043552	0,709452
a_2	0,011301	0,03327	0,746451
a_3	0,010443	0,043996	0,808173
a_4	0,012955	0,013559	0,511397
a_5	0,013559	0,050822	0,789392

Table 12. *Assessment results for function f_3*

	d_i^+	d_i^-	R_i
a_1	0,093326	0,020952	0,183344
a_2	0,063669	0,022104	0,257702
a_3	0,076516	0,07335	0,489437
a_4	0,00122	0,078464	0,984685
a_5	0,07652	0,034757	0,312347

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Based on the obtained results determine the functional capacities matrix shown in Table 13.

Table 13. *Matrix of functional capacities*

	f_1	f_2	f_3
a_1	0,838578	0,709452	0,183344
a_2	0,369086	0,746451	0,257702
a_3	0,796684	0,808173	0,489437
a_4	0,818498	0,511397	0,984685
a_5	0,929856	0,789392	0,312347

Conclusion

The paper offers the method of multifunctional personnel assessment, which is based on a method of multi-criteria analysis - TOPSIS, which allows us for drawing a matrix of functional capabilities of multifunctional personnel, based on which we can carry out:

• optimal selection of personnel and allocation of functions;

• assessment of the personnel multifunctionality and reliability;

• optimal reshuffling of personnel in the case of partial fault.

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