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Human Resource Management System Development Based on Solving The Problems of Multi-Criteria Alternatives

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Abstract*: Human resources have recently begun to reasonably become increasingly important. Today, they, along with material, intellectual, informational and financial resources, affect the efficiency of enterprises and organizations. A competent assessment of human resources, a clear understanding of how to interact with personnel and develop human resources is the basis for the effective work of both human resources departments and organizations in general. The complexity of assessing human resources and human resources necessitates the development of tools, the use of which will simplify it and ensure that you receive the clearest recommendations and assistance in the framework of managerial decision-making. A promising direction for the implementation of the indicated tools can be the development of a decision support system, within which, among other things, there will be the possibility of a multi-criteria analysis of alternatives. Due to the fact that there are no multicriteria analysis methods for alternatives designed specifically for assessing human resources, it is necessary to conduct a thorough analysis of them, the main purpose of which is to identify the most suitable base for further adaptation and development. After conducting preliminary studies, the authors chose the TOPSIS, MAUT, AHP and ELECTRE methods as the most promising for solving the task.

Keywords*: human resources, multicriteria alternatives, management decisions, TOPSIS, AHP, MAUT, ELECTRE.

I. INTRODUCTION

In the modern economy, people are at its very center. Their professional knowledge and creative qualities, their experience and abilities affect the competitive advantages of an organization, and also provide economic efficiency within the framework of market relations. All this indicates that personnel services require fundamental changes in their work in order to ensure the most effective assessment of personnel potential. One of the most promising areas of modernizing the work of personnel services is the introduction of advanced technologies in their work, among which the use of mathematical methods and models, as well as elements of information technology, can be highlighted.

Along with material, financial and other types of resources, when evaluating the effectiveness of organizations, the term "human resources" has increasingly been used. Under human resources management understand effective management, within which the knowledge, skills and abilities of the staff are transformed into the means of the organization, in its "personnel potential". This type of resource is of high value in the market and allows organizations to achieve significant competitive advantages.

Currently, staff and competent management can be considered one of the key parameters for the successful operation of the enterprise. Modern scientists agree that personnel should be carefully selected, invested in their development and strongly motivated for further growth and development.

However, speaking about human resources, it should be remembered that this type of resources is practically impossible to assess objectively, and the sphere of personnel management is uncertain and difficult to predict. Each employee is a unique “object” of management, and difficulties arise both in finding competent employees and in the process of their further activities in the field of organizing their work behavior and motivation.

The productivity of employees is determined by a large number of various factors. These include employee loyalty, level of competence, psychological and physical stability, ability to work in a team, etc. Employee productivity directly affects his contribution to the overall efficiency of the enterprise. His desire to work, the ability to solve certain problems, the willingness to carry out his activities in certain conditions - these are the few parameters that need to be assessed in the process of making competent management decisions in the labor collective.

The main difficulty lies in the fact that the employee is both an object and a subject; This situation creates even greater uncertainty and entails the occurrence of a large number of random events in the process of personnel management.

The primary task of personnel management is its selection, in connection with which this work will consider approaches to assessing candidates when applying for a job.

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One of the areas in which research should be carried out to develop effective tools for personnel management in the face of uncertainty is the use and adaptation of existing ones, as well as the construction of new mathematical models. With their help, the uncertainty in the framework of this process can be largely leveled.

In modern corporate information systems, elements of decision support systems or even complete systems of this class are often used. With their help, you can carry out planning, regulate the activities of the organization, develop and make effective management decisions, including in personnel management tasks.

II. MATERIALS AND METHODS

When solving personnel management tasks, first of all, it is necessary to use subjective models. Another condition in this case is the construction of preference models instead of constructing environmental models. This is due, first of all, to the fact that in the framework of solving human resources management tasks, it is optimal to use decision support systems as one of the main tools, which are often based on models of the classes described above.

Define the main stages of decision making:

1) search for solutions;

2) the creation of new options;

3) the choice of the preferred alternative or groups of alternatives.

Most tasks come down to comparing the available alternatives and choosing the most preferable one.

III. RESULT AND DISCUSSION

It is customary to distinguish two main groups of decision-making tasks.

In the event that at the first stage it is necessary to determine the decisive rules based on the preferences of the decision maker, and then choose the best alternative along with ordering all available and assigning them to a certain class of solution, it can be assigned to the first group.

In a situation where, according to the formed decision rules, alternatives are sorted by quality, and then distributed according to available classes, the task can be attributed to the second group.

In the event that the tasks of the first group have a very large number of alternatives, they become close to the tasks of the second group.

The heterogeneity of a large amount of data, multicriteria, the possibility of having a multi-level hierarchical structure of criteria, the possibility that criteria can be both quantitative and qualitative, it is often impossible to unambiguously define criteria - all this allows attributing multicriteria analysis to a rather complex type of tasks. All these features determine the need for solving the decision-making problem in a fuzzy environment.

Complicating the situation is the fact that the experts involved in the assessment may have different levels of competence in the decision-making process. And although experts with approximately the same level of competence are usually attracted, in practice it is rather difficult to implement such an approach.

Consider four approaches to building models in multicriteria analysis of alternatives [4].

TOPSIS This method is based on a concept whose main meaning is that the best alternative should have the shortest distance (which is the Euclidean distance) from the ideal solution. Using this method allows you to effectively solve the problems of multi-criteria optimization and multi-criteria analysis. Despite the complexity, this method is quite effective; it uses the language of fuzzy mathematics, fuzzy numbers, linguistic variables [2].

Let there be a matrix of values according to some criteria. In this matrix, for each criterion, it is necessary to calculate the normalization vector by the formula:

$$\overline{X_{ij}} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^{n} X_{ij}^2}} \qquad (1)$$

where i are the values; j - criteria; X_{ij} is an element of the matrix.

Next, each element of the matrix must be divided into a normalization vector. As a result, a normalized matrix will be obtained, and each value in this matrix will be a normalized performance value.

At the next stage, the obtained values are multiplied by weighting coefficients (for each particular criterion for evaluating the alternative). The matrix obtained as a result of this step is called the weighted normalized decision matrix.

The next step in the TOPSIS method is to find the perfect best solution and the worst solution.

It is also necessary to determine the Euclidean distance from the worst to the best solution:

$$S_j^+ = \left[\sum_{j=1}^{m} (V_{ij} + V_j^+)^2\right]^{0,5}. \qquad (2)$$

$$S_j^- = \left[\sum_{j=1}^{m} (V_{ij} + V_j^-)^2\right]^{0,5} \qquad (3)$$

At the last stage of the method, the performance rating is calculated:

$$P_i = \frac{S_i^-}{S_i^+ + S_i^+} \qquad (4)$$

The ranking of alternatives by the value of the performance assessment allows us to further identify the most preferable one.

MAUT is a multi-criteria utility theory. To solve problems within the framework of this method, an axiomatic justification is necessary. The results obtained using MAUT are used to evaluate the available alternatives; the method is designed to solve problems of supporting decision-making of the second group [1].

Among the main stages of the method, it is possible to single out directly the development of a list of criteria by which alternatives will be evaluated in the future, the utility function will be built, the conditions checked, the dependencies between the obtained estimates will be determined. The final step is to choose the best alternative by evaluating the weights received.

The main objective of the approach is to identify axioms that a utility function should satisfy; this allows for mathematical proof.

In the MAUT method, axioms can be general and specific. Axioms of a general nature are:

1) axioms in which relations between alternatives are established $U(A) > U(B) > U(C)$

2) axioms of transitivity;

3) axioms in which the utility function is continuous.

Specific axioms can be defined as axioms of independence. These include independence by difference, independence by preference, independence by utility.

The utility function obtained in the framework of this method is a multicriteria function, which is a logical result. This happens when all the axioms from the first group and some of the second are satisfied. However, it should be noted that the resulting function will be multicriteria only if all the axioms of the first group and at least some of the second are fulfilled.

In order to illustrate such a result of the MAUT method, we can consider the theorem of R. Kinney, in the framework of which it is believed that when fulfilling the axiom of preference and independence in utility, the utility function can be considered additive (5) or multiplicative (6):

$$U(x) = \sum_{i=1}^{N} w_i U_i(x) \ by \sum_{i=1}^{N} w_i = 1 \qquad (5)$$

$$1 + kU(x) = \prod_{i=1}^{N} [1 + kw_i U_i(x)] \ by \sum_{i=1}^{N} w_i \neq 1, \qquad (6)$$

where U, U_i are utility functions that vary in the range from 0 to 1; w_i is the coefficient of importance (weight) of the criteria for $0 < w_i < 1$; coefficient $k > -1$.

This method is very time-consuming, but if the function is composed correctly, then with its help you can evaluate any alternatives (even those that have appeared again).

AHP or analytic hierarchy method. It is one of the most popular and frequently used methods. It is mainly used to solve the problems of multicriteria analysis of alternatives of the second group [5].

The main stages of AHP:

1) the creation of a multi-level hierarchical structure that takes into account alternatives, the criteria by which they are evaluated, and the goals of the analysis;

2) violated comparison of elements of each level;

3) calculation of weights for elements of each level;

4) choosing the best alternative.

In pairwise comparisons, a verbal scale can be used in which a quantitative assessment corresponds to each definition.

If A_j is the criterion, and w_j is the importance coefficient, then the formula for calculating the matrix element is as follows:

$$a_{ij} = \frac{w_i}{w_j} \qquad (7)$$

The experts make a pairwise comparison of the criteria, in the process of which their importance is determined. This makes it possible to determine the weight of the criteria. If there are n criteria, then the experts carry out n (n-1) / 2 comparisons.

In the process of building the matrix should evaluate its consistency. For this purpose, its own weight and eigenvalue are determined. The comparisons carried out under real conditions have led to the conclusion that the maximum eigenvalue will differ from the corresponding eigenvalue for an ideal matrix. In turn, this allows us to conclude that the real matrix is inconsistent and to judge the level of confidence in the results obtained.

To check consistency, the eigenvalues of the matrix are compared with the eigenvalues of a randomly filled matrix. In practical application, the approximate value of the main eigenvector can be obtained by summing all the values of the matrix row:

$$a_i = \sum_{j=1}^{n} \alpha_{ij} \qquad (8)$$

It is necessary that the sum of all α_i be equal to one. As a result of the actions performed, the eigenvector w is calculated.

The synthesis of the resulting balance should be carried out according to the following formula:

$$S_j = \sum_{i=1}^{N} w_i V_{ji}, \qquad (9)$$

where S_j is the quality indicator of the j-th alternative; w_i is the weight of the i-th criterion; V_{ji} - the importance of the j-th alternative according to the i-th criterion.

ELECTRE - a relationship of excellence in quality. The main idea of the method is "exclusion and choice reflecting reality", that is, refusal to use the theory of utility in pairwise comparison [3].

It is used to solve problems in which multicriteria alternatives are predefined, that is, to solve the problems of the first group.

Main steps:

indices of agreement and disagreement are calculated;

levels of agreement and disagreement are determined;

Prevailing alternatives from multiple alternatives are excluded;

introducing more "weak" levels of agreement and disagreement;

the formation of the last nucleus, the sequence of nuclei allows you to order alternatives in quality.

Consider one of the calculation examples. Each of their N criteria is assigned an integer p characterizing the importance of the criterion. And the theory is put forward that alternative A is superior to alternative B. The set I, which consists of N criteria, is divided into three subsets: I^+ - a subset of the criteria by which A exceeds B; I^- is a subset of the criteria by which B exceeds A; $I^=$ is a subset of the criteria by which A and B are equivalent.

At the next stage, an agreement index with a hypothesis is formulated, according to which A exceeds B. Note that in other methods of the ELECTRE family, indices of strong and weak superiority are used.

Consent index can be calculated based on weights criteria. Within the ELECTRE1 method, it is defined as follows:

$$c_{AB} = \sum_{i \in I^+, I^-} w_i / \sum_{i=I}^{N} w_i. \qquad (10)$$

The disagreement index with the hypothesis according to which A exceeds B is determined on the basis of the most "contradictory" criterion: the criterion by which B exceeds A. to the greatest degree.

In order to take into account the possible difference in the length of the criteria scales, the difference in the estimates of alternatives A and B is related to the length of the largest scale:

$$d_{AB} = \max_{i \in I^-} \frac{l_B^i - l_A^i}{L_i}, \qquad (10)$$

where l_A^i, l_B^i - estimates of alternatives A and B by criterion i; L_i is the scale length of the i-th criterion.

We denote the properties of the consent index:

1) $0 \le c_{AB} \le 1$;

2) $c_{AB} = 1$ if the subset I^{+-} is empty;

3) c_{AB} retains its value when replacing one criterion with several, provided that the weight of the first is equal to the total weight of the others.

The properties of the disagreement index are:

1) $0 \le d_{AB} \le 1$;

2) d_{AB} retains its value when introducing a more detailed scale by criterion i while maintaining its length.

Consent and disagreement indices are used to construct index matrices for given alternatives.

Obviously, each of the above methods has its advantages and disadvantages. However, at the beginning of the study, the authors had a clear goal: to identify a method or methods, the further adaptation of which will ensure their effective use in assessing human resources in enterprises.

IV. CONCLUSION

The MAUT method works with axioms of various nature. Based on the very meaning of the term "axiom", it is easy to conclude that it is almost impossible to put forward any postulates when assessing personnel potential. In this regard, the use of the multicriteria utility theory (MAUT) even in an adapted form is practically impossible in solving problems whose main purpose is the assessment of human resources.

The ELECTRE method, in general, is similar to MAUT, although, by definition, it is almost the exact opposite (implies a complete rejection of the use of the theory of utility when comparing alternatives). However, the use of this method involves hypotheses, which, again, when solving problems of assessing personnel potential, becomes an practically inapplicable approach.

The TOPSIS method, in spite of its complexity, is the most suitable for solving human resource assessment tasks. When using the method, it becomes possible to maximize the objectivity of staff assessment. The presence of importance factors of groups of criteria and particular criteria makes it possible to configure the method for solving specific practical problems (for example, when evaluating a candidate for a particular position). Another advantage of the method is that it involves the involvement of several experts. In addition, when evaluating alternatives in this case, expert competency may be evaluated, which further increases the reliability of the results.

The AHP method, also with little adaptation, can be quite successfully used to evaluate personnel. Within its framework, it is possible to create a hierarchical multi-level structure with goals, alternatives and criteria, which subsequently allows us to calculate weights for all elements and choose the best alternative.

It is also worth noting that the TOPSIS and AHP methods can be successfully applied in areas requiring an assessment of human resources together with a general assessment of the effectiveness of a particular industry [6, 7, 8, 9].

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