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## HUMAN CAPITAL MANAGEMENT IN ENTERPRISES AS MULTI-CRITERIAL OPTIMIZATION TASK

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**Abstract** — The task of managing the human capital of the enterprise has been considered as the task of the multi-critical optimization. For this purpose it was developed software which allows us to evaluate the efficiency of knowledge, which was formed as the result of professional training of direct managers and higher ranking managers.

**Key Terms** — Optimizing decision making, operations research, optimization criterion, multi-criteria, human capital.

In economic development, the 21st century is defined as the economics of knowledge. In this regard, human capital is the main driving force behind the development of any enterprise or company [7]. The concept of human capital involves the knowledge, skills, and personal development abilities that employees of an enterprise possess. It is these qualities of the company's employees that ensure the successful introduction of innovative technologies and contribute to the transition of the enterprise to a qualitatively new level of production. That's why integrating of knowledge management technologies directly into organizational business processes makes it possible to raise production efficiency.

One of the ways to increase the human capital of an enterprise is professional training of employees. This process involves these two stages [1; 5]. The first of stages consists directly in professional training and/or retraining. The purpose of this stage is the accumulation of human potential. And the second stage involves the implementation of acquired knowledge in practical activities. At this stage, the purpose is to capitalize the human potential, namely, to transform human potential into human capital.

The effectiveness of the training can be assessed using the same principles that are used in any assessment of knowledge. The degree of capitalization of the human potential of workers and technical personnel can be estimated from the change in the surplus value of the products they produce. However, to assess the capitalization of human potential linear managers and managers of higher rank, it is necessary to develop special complex criteria that meet the requirements of this particular enterprise.

The purpose of this work is to analyze the principles on which the complex criteria of evaluation are based. The development of such criteria will allow us to consider the problem of optimizing human capital management as a task of operations research.

As a rule, the problem of operations research contains only one criterion by which the quality of the solution is evaluated:

$$f(x) \rightarrow \max, \quad x \in X, \quad (1)$$

where the objective function  $f$  is the only decision criterion, and our objective is to find a vector  $x$  from  $X$ , at which the function reaches its maximum.

However, there are problems in which the list of basic parameters is known, but it is impossible to build quantitative connections between them, due to sufficient information. Such tasks are weakly structured and, in fact, are multi-criteria [2; 3]. In the process of solving a multi-criteria optimization problem, the choice of a solution exists by several criteria, but the methods for choosing a solution themselves remain the same as when choosing by one criterion.

The difficulty of multi-criteria optimization is that it requires the simultaneous optimization of

several criteria that can compete with each other. Thus, an improvement in one criterion can only be made to the detriment of one or more of the other criteria. This means that a decision can be made only in accordance with the preferences of the decision maker.

There are various approaches to the construction of optimization criteria for solving weakly structured problems. All these methods include the direct involvement of the decision maker, not only in formulating the optimization goal, but also in choosing the optimality criterion.

The most common methods of multi-criteria analysis include simple weighted addition and analytical hierarchical process. Both of these methods are similar in principles of the construction of an objective function and can be used in the tasks of the optimization of human capital management. Since this problem is weakly structured, we preferred the analytical hierarchical process [4]. For this purpose the paired comparison matrix was built:

$$A = \{a_{ij} \mid a_{ji} = 1/a_{ij}, a_{ij} > 0, i = \overline{1, k}, j = \overline{1, k}\}, \quad (2)$$

where  $k$  is number of criteria for optimization. Elements  $a_{ij} (i = \overline{1, k}, j = \overline{1, k})$  of the matrix  $A$  reflect the significance of the  $i$ th criterion in comparison with the  $j$ th criterion. The values of these elements are determined by experts or the decision maker and are expressed in integers in the range 1 through 9 [6]. The major advantage of analytical hierarchical process is that it makes possible to calculate the inconsistency index. This index gives opportunity to assure the decision maker that his judgments were consistent and that the final decision is made right.

After ranking of the particular criteria each of them is assigned a weighting coefficient  $w_i$  with which the  $i$ th criterion is included in the complex criterion:

$$w_i = \frac{r_i}{\sum_{i=1}^k r_i}, \quad (3)$$

where  $r_i$  is rank of  $i$ th criterion.

Further, the ranks of particular criteria are calculated using a comparison matrix:

$$w_i = \frac{r_i}{\sum_{j=1}^m r_{ij}}, \quad (4)$$

where  $m$  is the number of experts. Since this weighting coefficients reflect the relative importance of particular criteria and must satisfy the following requirements:

$$\sum_{i=1}^k w_i = 1, w_i > 0. \quad (5)$$

Complex criterion is obtained as a result of linear convolution of normalized partial criteria:

$$U = \sum_{i=1}^k w_i \cdot F_i(x), \quad (6)$$

where  $F_i(x)$  is a dimensionless criterion, which is obtained by transforming a particular criterion. Thus, instead of the mathematical model (1) we get the mathematical model (7) of the linear programming problem, for the solution of which we use the generally accepted methods of solution:

$$U = \sum_{i=1}^k w_i \cdot F_i(x) \rightarrow \max, \quad x \in X. \quad (7)$$

The use of dimensionless criteria is due to the fact that particular criteria are measured in different units, and can also be not only quantitative, but also qualitative. In addition, some of these criteria should be investigated for a maximum, while others are investigated for a minimum. If this particular criterion involves research on a maximum, for normalization of particular criteria, such a formula was used:

$$F_i(x) = \frac{y_i^{\max} - f_i(x)}{y_i^{\max} - y_i^{\min}}, \quad (8)$$

where  $y_i^{\max}$  and  $y_i^{\min}$  are the maximum and minimum values of the function  $f_i(x)$  on the set  $X$ , if they exist.

And if this particular criterion involves research on a minimum, for normalization of particular criteria, such a formula was used:

$$F_i(x) = \frac{f_i(x) - y_i^{\min}}{y_i^{\max} - y_i^{\min}}. \quad (9)$$

Instead of the indicator  $y_i^{\min}$  ( $i = \overline{1, k}$ ), you can consider the minimum acceptable value of the function  $f_i(x)$ . This should be used when evaluating knowledge and skills of top managers.

Formulas (8) and (9) were used to normalize particular criteria, if they were quantitative. When it was necessary to normalize the particular criteria that were qualitative, the ideal point method was used:

$$F_i(x) = |y_i^* - f_i(x)|, \quad (10)$$

where  $y_i^*$  is the ideal point, namely, the best value for  $i$ th criterion.

It should be noted that under research of processes which are associated with the management of employees' knowledge, imitation models are used [8; 9 and etc.]. In addition, the subject of evaluation was quantitative indicators of labor productivity.

In this paper we developed a special computer program as a calculator to evaluate the degree of capitalization of human potential acquired during the training. The baseline data that is used for its work are the key performance indicators measured before the training and after the training, as well as the values of these indicators that must be achieved.

The formation of a system of key performance indicators is carried out before the start of training. Indicators are selected in accordance with the purpose of the training. Post-training assessment is carried out on two types of key indicators. These are the indicators which are characterized the work of the production unit, governed by this manager, and the indicators which are characterized the personal contribution of the manager to the organization of work of this unit.

The program is available for customization, i.e. you have a possibility to change the scale, which is used to assess the degree of capitalization of human potential for the estimated value of the complex indicator.

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