The Features of the Development of HR Decision Making Support Systems

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Abstract. The article deals with theoretical and applied problems of creating systems to support personnel decision-making. The purpose of this article is to clarify the methodological principles of building models that formalize the processes of personnel decision making. The tested subject area belongs to semi-structured systems described using the quantitative and qualitative indicators. Given the nature of the subject area, the mathematical apparatus based on the application of decision theory methods and expert assessments was used for the formalization of processes under consideration. The paper considers features and limitations related to the use of the integral assessments indicators. The article also discusses the practical aspects of developing a data warehouse for storing the results of expert evaluations of personnel.

Keywords: Personnel management, methods to support managerial decisions, human resource management, decision making support systems

1 Introduction

Modern personnel management uses an approach based on the achievements of several Sciences: psychology, sociology, information technology, mathematics, etc. This approach implies a comprehensive consideration of employee's personality characteristics.

However, the application of this approach has its own features. The main difficulty in applying this approach is due to the heterogeneous nature of the characteristics of the property of employees. The majority of social and psychological indicators have qualitative, verbal description. At the same time, many other characteristics can be described by quantitative values only.

The approach proposed in the article is based on using of the expert assessments methodic. This will make it possible to build an information and analytical system for assessing personnel using indicators of a different nature [12]. However, we should consider the main ideas of management theories firstly, because the process of the assessments of the personnel depends on the management concepts used in the organization.

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2 The development of HR management theories

The principles and methods of personnel management have changed significantly since the appearance of the first theory named as "scientific management".

This theory was created at the beginning of the XX century by F. Taylor and his followers [3]. The main thiught of the "scientific management" theory "was the rationalization of labor process in the organization based on the scientific organization of work at a separate workplace" [12].

The other streams of the classical management were "administrative management" of A. Fayol and the "theory of ideal bureaucracy" of M. Weber. These scientists proposed to improve "the performance of the enterprise due to the application of the universal principles of management in the scales of the firm and the improvement of the organizational structure" [12].

Both of these theories considered the role of personnel in the organization as a mechanism for performing certain tasks. "An employee was considered as a set of knowledge and labor skills" [12] that should be used for doing the job. Classical management theories almost did not consider the social or psychological characteristics of employees.

The crisis of classical theories led to the appearance of theories of human relations and behavioral management. The founders of the behavioral management theories are M. P. Follett and E. Mayo [8]. Significant role in the development of behavioral theories had played by researches in the field of motivation, management styles, leadership [3]. The behavioral management theories "proposed to consider the personality as a combination of inborn and acquired qualities" [12].

Classical management theories and behavioral approach have made a great contribution to the development of personnel management methods. However, their significant lack was the one-sided consideration of problems of improving personnel management in the organization.

The development of HR management theories led to the appearance of such concepts as the "Z" theory of A. Ouchi, the theory of human resources, and the system and quantitative approaches.

These theories are using the comprehensive, integrated consideration of the properties of personnel when making personnel decisions. However, effective application of these approaches requires the use of information technologies and mathematical model-ing methods. It should be noted that the theories of personnel management corresponded to the level of development of social institutions and technologies in society. These reasons caused the permanent improvements of the theories of personnel management.

3 The problems of complex accounting of indicators of the HR decision support system

According to the modern HR theories, "it is necessary to consider the whole range of parameters describing the employee in making personnel decisions" [10, 12]:

- the results of the work;
- an education and qualification skills;
- social and psychological characteristics;
- personal data's.

But, this approach also contains a number of serious problems [12]:

1. How to choose the indicators for the decision-making process?
2. How to use together the indicators with different nature?
3. How to measure and describe the verbal indicators?
4. And finally, how to find good, rational solution of the problem if when there are a large number of evaluation criteria are used?

We should use methods of mathematical modeling to find the answers for all of these questions. «The above-mentioned problems of the application of the integrated approach to the decision-making process in personnel management and the features of this subject area determine the following conclusions» [1, 5, 12]:

1. We should use the expert's technologies because of the following reason: the subject area is non-deterministic and its description depends on the HR concept.
2. The criterions of assessment are different by the importance and influence on the job duties. [4, 6].
3. The staff position defines the set of assessment criterions.
4. It is impossible to make full compensation of the skills by criterion A using the skills by criterion B.
5. We should use only natural language terms to descript the criterions with the different nature and physical sense within the common set of assessment's indicators [12].

4 The model of the HR decision support system

It is preferable to build a model of staff responsibilities starting from the macro level. The organizational structure defines the official duties of the employee. In turn, job responsibilities determine the requirements for this position [10]. Business activity of an organization can be described as a set of r interrelated functions of its different divisions (1) [12].

$$F_{org} = \{F_{org_1}, F_{org_2}, F_{org_3}, \ldots, F_{org_r}\} \quad (1)$$

Let any such *s-th* division performs *k* organization's functions (F_{otd_s}), alongside with it $1 \leq k \leq r$ (2). This double inequality means that a single division cannot perform more functions than the entire organization

$$F_{otd_S} = \{F_{org_1}, F_{org_2}, F_{org_3}, \ldots, F_{org_k}\} \quad (2)$$

The performance of any *k*-th large function $F_{org\ k}$ can be divided into *m* tasks that should be executed the subdivision.

$$F_{org_k} = \{F_{1_k\ otd_S}, F_{2_k\ otd_S}, F_{3_k\ otd_S}, \ldots, F_{m_k\ otd_S}\} \quad (3)$$

Any division consists from employees. They are responsible for performing one or more tasks or in the division (4). The number of the tasks $z=|F_{P\,x}|$ for the position p_x lies in the interval $1 \leq z \leq m$. This inequality means that the position p_x can participate in the performance of one to m tasks of the subdivision.

$$F_{P\,x} = \{F_{1_k\ otd_S}, F_{2_k\ otd_S}, F_{3_k\ otd_S}, \ldots, F_{z_k\ otd_S}\} \quad (4)$$

where $F_{P\,x}$ – functional duties of position p_x.

The staff participation in the jobs of the division can be described by a matrix. The columns of this matrix are staff positions. The lines (rows) are the jobs to be done. It means that the job $F_{z\,k\,otd\,s}$ is performed with the help of one or more employees. It has shown below in the abstract example (5).

	p_1	p_2	p_3	...	p_x
$F_{1\ otd_S}$	1	0	1	...	0
...	0	1	0	...	1
$F_{Z\ otd_S}$	0	1	0	...	1
...	...	...	...	...	...
$F_{m\ otd_S}$	1	0	1	...	0

(5)

To perform task $F_{zk\,otd\,s}$ with the result $R_{z\,k\,otd\,s}$ an employee or a group of employees should possess certain skills and knowledge (6):

$$R_{z\,otd_S} = F_{z\,otd_S}(sk_1, sk_2, sk_3, \ldots, sk_n) \quad (6)$$

The formula (6) describes the set of skills that should has an employee to perform the job. A complete list of staff responsibilities and skills can be set after analyzing all work processes and their features. This list of required skills (6) will be used in the future to compile a list of personnel assessment indicators.

The expert selection stage begins after determining the indicators necessary for the staff to perform their job. First of all, it is necessary to determine the competence of the experts. This will make it possible to calculate the weight's coefficients of the experts within the model. This stage is very important for the further development of the system of personnel assessment indicators.

The weights' values of the experts can considerably influence on the results of further calculations [7, 9]. The methods used to calculate the expert's weights are very important. The results of expert weights calculations will significantly affect for all futher calculations. One of the possible methods for calculating expert weights is described by the formula (7).

$$w_{\exp j} = \frac{K_j}{\sum_{j=1}^{n} K_j}, \quad (7)$$

n – is the quantity of experts;

K_j – are the points, obtained by an expert during his/her assessment (testing, exam);

$w_{\exp j}$ – is the weight of j-th expert.

In addition, the expert group should have sufficient general competence to participate in the evaluation procedures. The level of general competence should correspond to the double inequality (8).

$$0{,}67 \le KLG \le 1, \tag{8}$$

KLG – value of the expert group's competence level.

If this value does not meet the condition (8), other experts should be invited to the group. The value of the common level of expert's group competence can be determined by the formula (9).

$$KLG = \frac{1}{n} \times \sum_{j=1}^{n} KLE_j , \tag{9}$$

n – is the number of experts;

KLE_j – is an expert's competence level.

The level of the competence of the certain expert can be obtained by the formula (10).

$$KLE = \frac{K_j}{K_{\max}}, \tag{10}$$

where KLE_j – is the expert's competence level;

K_j – is the value (points), that has been obtained by an expert during his examination;

K_{max} – is the maximum value (points) that can be received by the expert during his examination.

The result of the completion of this stage is the model of an expert commission $Exp = \{w_{exp\,1}, w_{exp\,2}, w_{exp\,3}, \ldots, w_{exp\,j}\}$. Its components $w_{exp\,1}, w_{exp\,2}, w_{exp\,3}, \ldots, w_{exp\,j}$ are the coefficients of the importance (weights) of the experts. These values should satisfy the system of conditions (11):

$$\begin{aligned} &w_{\exp_1}, w_{\exp_2}, w_{\exp_3}, \ldots, w_{\exp_m} \ge 0, \\ &w_{\exp_1} + w_{\exp_2} + w_{\exp_3} + \ldots + w_{\exp_j} = 1. \end{aligned} \tag{11}$$

The experts must agree on a list of assessment indicators if the responsibilities of the position have been defined.

Then you need to determine the relative significance of the selected evaluation indicators among themselves. The weights of the indicators are calculated in accordance with previously determined opinions of experts and their weights. The calculation of the weights of the assessment indicators will be obtained by the formula [12]. It is so called ranking method of calculating the weights of the indicators (12).

$$w_{kr_i} = \sum_{j=1}^{n} (w_{\exp_j} \times (\frac{m+1-R_{kr_{ij}}}{(\sum_{i=1}^{m} R_{kr_i})})), \quad (12)$$

$w_{kr\ j}$ – is the weight of *i*-th criterion by the summary opinion of all experts;

$R_{kr\ ij}$ – is the rank of *i*-th criterion according to the opinion of *j*-th expert;

m – is the number of assessment criteria;

n – is the number of experts.

The development of scales for measuring the values of criteria is a very important task that must be solved when creating a personnel evaluation system. The fact is that the personnel evaluation system uses together quantitative and qualitative indicators that have different data types and physical meaning. At the same time, they should be reduced to one common measurement scale. This problem is solved using ordinal scales. They allow qualitative characterization of criteria using verbal variables, i.e. expressions of natural or artificial language [1, 5].

To create an ordinal scale for each indicator (criterion) for evaluating the performance of staff, the opinion of experts is requested. The scales should correspond to the values of verbal variables on the one hand and the values that characterize the criteria for evaluating personnel, on the other hand. This takes into account the previously obtained weights of the experts.

The final function can be described with the help of functions that should be formed by the experts taking into account their weights (11, 13).

$$f(x)_{gr} = w_{\exp 1} \times f(x)_{\exp 1} + w_{\exp 2} \times f(x)_{\exp 2} + \ldots + w_{\exp n} \times f(x)_{\exp n} \quad (13)$$

$w_{exp\ j}$ – is the weight of an *j*-th expert;

$f(x)_{exp\ j}$ – is the membership function that was built by an *j*-th expert;

$f(x)_{gr}$ – is the group (summary) function that was calculated on the basis of functions, was built by all experts from the group.

The minimum limit of the value of the indicator that characterizes the position. It is determined on the basis of expert estimates, taking into account their weights within the model. The minimal limit values for the indicators can be obtained by the formula (14) [9, 12, 15].

$$w_{\exp 1} \times lm_{cr_i 1} + w_{\exp 2} \times lm_{cr_i 2} + \ldots + w_{\exp n} \times lm_{cr_i n} = lm_{cr_i \Sigma} \quad (14)$$

$w_{exp\ n}$ – is the normalized weight of an *j*-th expert (see the formula (8));

$lm_{cr\ j\ n}$ – is the minimal limit of the value of the *i*-th assessment indicator, according to the opinion of an *n*-th expert;

$lm_{cr\ j\sum}$ – is the minimal limit of the value of the *i*-th assessment indicator, according to the opinion of experts' group.

After the determination of all the necessary indicators the multi-criteria evaluation function can be built. This function can be used for following tasks:

1. Calculating the value of the global evaluation criterion (the weighted sum of points for all individual indicators). This summary indicator can be used for compari-

son only for those candidates who have passed all previous selection stages. (15) [11, 6].

$$Cr_{gl_k} = \sum_{i=1}^{m} w_{kr_i} \times \sum_{j=1}^{n} (w_{\exp_j} \times Cr_{ij}^{k}) \quad , \tag{15}$$

$Cr_{gl\,k}$– is the value of the global assessment criterion for *k*-th employee;

Cr^{k}_{ij} – is the value of the assessment criterion for *k*-th employee by *i*-th criterion, determined by *j*-th expert;

$w_{exp\,j}$ – is the weight of the *j*-th expert;

$w_{kr\,i}$ – is the weight of the *i*-th criterion.

In accordance with the restrictions on the minimum allowed values of evaluation indicators, a non-strict inequality must be met (16).

$$lm_{cr_i \sum} \le \sum_{j=1}^{n} (w_{\exp_j} \times Cr_{ij}^{k}) , \tag{16}$$

$lm_{cr\,i\,\sum}$ – is the limit value of the *i*-th indicator by the opinion of experts' group.

2. Aggregated values can be used for a group of indicators. For example, we can create aggregated values for professional, educational, social, psychological, or any other groups. This will provide more information in the HR decision-making process [12].

3. Comparison of employee's indicators with a "ideal worker". This procedure performs according to the method of ideal point (17).

$$D_k^{et} = \sqrt{\sum_{i=1}^{m} w_{kr\,i} \times (Cr_{i\max} \quad \sum_{j=1}^{n} w_{\exp j} \times Cr_{ij}^{k})^2} , \tag{17}$$

D_k^{et} – is the distance from the point, which characterizes *k*-th employee, to the point, corresponding to the ideal (standard) employee in the given position;

$Cr_{max\,i}$ – is the maximally possible value by *i*-th assessment criterion;

Cr^{k}_{ij} – is the value of the assessment criterion for *k*-th employee by *i*-th criterion, determined by *j*-th expert;

$w_{exp\,j}$ – is the weight of the *j*-th expert;

$w_{kr\,i}$ – is the weight of the *i*-th criterion.

The mathematical apparatus described in this work requires the usage of DBMS information technologies to automate computational processes. DBMS is necessary for creation the special DSS for supplying, saving and making a decisions [14].

5 The model of data storage of expert's estimates for making decision in the field HR

Let us consider the structure of the tables of data for the saving of expert's estimates for the DSS in the field HR. One of the possible ways of realization the storage for saving the expert's estimates information has shown in the figure 1.

Let's look at the structure of tables in the data storage in more detail.

The table *Group* saves the information about the groups of experts.

The table *Employee* is using for saving an information about all experts. It can be people from our organization or HR professionals from outsourcing. This table can also store data about employees or candidates being evaluated.

The table *Expert* saves information about participating people in the expert's groups. One expert can take part in several expert's groups.

The table *Stafflist* saves the information about all positions in the organization.

The table *Criterion* is intended for storing the information about all possible parameters that can characterize positions in organization. These can be quantitative or qualitative indicators.

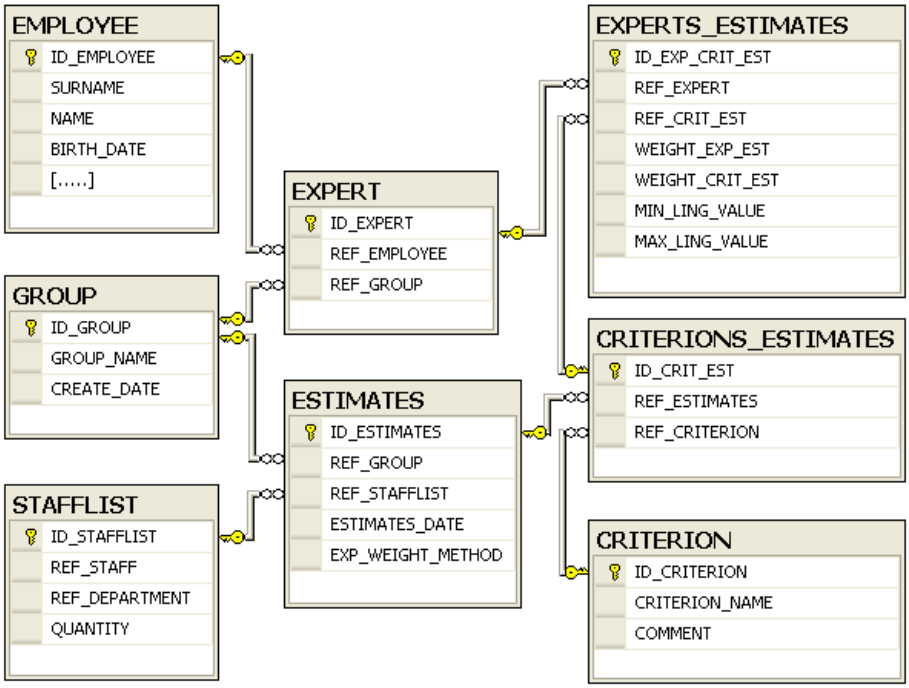

Fig. 1. The model of data storage of expert's estimates of DSS for personnel management

Experts select criteria that can characterize a particular position. This set of indicators is stored in a table *Criterions_Estimates.* It should be noted here that different expert groups may choose different indicators for the same position in the organization.

The table *Estimates* stores the data's about the position and method that will be used for calculation the weight of the indicators within the model of assessment. It is very important for all further calculations.

The table *Experts_Estimates* stores the experts opinion about weight of criteria (indicators) for the certain staff position.

6 Conclusion

The procedures described in the article should be used to form scientifically based management decisions on personnel assessment and development.

The researches in the field of personnel management should use the mix of achievements in the applied mathematics, human sciences (psychology, sociology, etc.) and information technologies [2, 13].

Social systems are semi-structured systems. Such systems contain both quantitative and qualitative indicators. This circumstance makes it difficult to describe the subject area for making an informed management decision. That is why the mathematics apparatus for the such kind of systems should be based on using expert technologies, verbal analysis of decisions, qualitative methods of decision making, multiple criteria decision analysis. This choice of mathematical apparatus can be explained by the nature of processes in the personnel management [4, 5, 9].

Mathematical formalization of the description of management processes is only an intermediate stage of improving the system of the corporate personnel management. The next step would be to design a data warehouse for DBMS to record, store and finding the decision of the problems of personnel management.

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