УДК 65.012.32

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MODELING THE TASK OF MANAGEMENT BY NUMBER OF DYNAMICS AND PROFESSIONAL-QUALIFICATION STRUCTURE OF PERSONNEL

Abstract. The article substantiates the application of methods of economic-mathematical modeling for solving the problem of dynamics of the number and professional qualification structure of personnel in order to create an initiative, rationally operating collective, whose efforts are aimed at the effective functioning and development of the enterprise. With the help of these methods, it is likely to predict possible models of enterprise development. The peculiarities of their application are studied: the main advantage of these methods is the possibility of their use in enterprises with unstable organizational structure and in the unstable external environment, the disadvantage is the complexity of the study of all possible situations of organization development and the creation of a model that is adequate to the existing conditions.

A pairwise linear regression model was developed to solve the problem of quantification of the needs of employees of all categories of staff and an optimization model for personnel management, namely, the definition of an optimal plan for retraining, advanced training, hiring and dismissal of personnel based on the criterion of minimizing total expenditures for all categories of staff by the nature of the functions performed for data of a particular enterprise. As a result of the implementation of the constructed models, the economic interpretation of the modeling results obtained and the recommendations for the change in the number and professional qualification structure of the personnel of a particular enterprise, as well as the formation of its personnel reserve, that is, the formation of such a group of workers who are potentially capable of managing activities, meet the necessary requirements, have been selected and targeted training to improve their skills.

Advantages of creating a personnel reserve group are to ensure continuity in management, increase the level of readiness of employees for changes in the organization, their motivation and loyalty, which leads to a decrease in personnel turnover and overall personnel stabilization. In addition, it can significantly save financial and time resources in recruiting, training and adapting key employees and responding in a timely manner to the company to change the external and internal environment, which is also very important.

Keywords: economic and mathematical methods and models, optimization model, pair linear regression model, personnel management.

JEL Classification: M12, M5

Formulas: 13; fig.: 1; tabl.: 1; bibl.: 11.

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МОДЕЛЮВАННЯ ЗАДАЧІ УПРАВЛІННЯ ДИНАМІКОЮ КІЛЬКОСТІ ТА ПРОФЕСІЙНО-КВАЛІФІКАЦІЙНОЇ СТРУКТУРИ ПЕРСОНАЛУ

Анотація. Обґрунтовано застосування методів економіко-математичного моделювання для розв'язання задачі управління динамікою кількості та професійно-кваліфікаційної структури персоналу задля створення ініціативного, раціонально діючого колективу, зусилля якого спрямовані на ефективне функціонування та розвиток підприємства. За допомогою цих методів імовірно спрогнозувати можливі моделі розвитку підприємства. Вивчено особливості їх застосування: основною перевагою цих методів є можливість їх використання на підприємствах із нестабільною організаційною структурою і за нестабільного зовнішнього середовища, недоліком – складність дослідження усіх можливих ситуацій розвитку організації та створення моделі, адекватної наявним умовам.

Також розроблено парну лінійну регресійну модель для вирішення задачі визначення кількісної потреби працівників усіх категорій персоналу та оптимізаційну модель управління персоналом, а саме — визначення оптимального плану перепідготовки, підвищення кваліфікації, найму і звільнення персоналу за критерієм мінімізації сумарних витрат для всіх категорій персоналу за характером виконуваних функцій за даними конкретного підприємства. За результатами реалізації побудованих моделей здійснено економічну інтерпретацію отриманих результатів моделювання і розроблено рекомендації щодо зміни чисельності та професійно-кваліфікаційної структури персоналу конкретного підприємства, а також формування його кадрового резерву, тобто формування такої групи працівників, що потенційно здатні до керівної діяльності, відповідають необхідним вимогам, пройшли відбір та цільову підготовку з метою підвищення кваліфікації.

Перевагами створення групи кадрового резерву є забезпечення наступності в управлінні, підвищення рівня готовності працівників до змін в організації, їх мотивації та лояльності, що призводить до зниження плинності персоналу і загальної кадрової стабілізації. До того ж це дозволяє значно заощадити фінансові та часові ресурси при доборі, навчанні та адаптації ключових працівників і своєчасно реагувати підприємству на зміни зовнішнього і внутрішнього середовища, що також є дуже важливим.

Ключові слова: економіко-математичні методи та моделі, оптимізаційна модель, парна лінійна регресійна модель, управління персоналом.

Формул: 13; рис.: 1; табл.: 1; бібл.: 11.

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МОДЕЛИРОВАНИЕ ЗАДАЧИ УПРАВЛЕНИЯ ДИНАМИКОЙ КОЛИЧЕСТВА И ПРОФЕССИОНАЛЬНО-КВАЛИФИКАЦИОННОЙ СТРУКТУРЫ ПЕРСОНАЛА

Аннотация. Обосновано применение методов экономико-математического моделирования для решения задач управления динамикой количества и профессионально-квалификационной структуры персонала с целью создания инициативного, рационально действующего коллектива, усилия которого направлены на эффективное функционирование и развитие предприятия. С помощью этих методов вероятно спрогнозировать возможные модели развития предприятия. Изучены особенности их применения: основным преимуществом этих методов является возможность их использования на предприятиях с нестабильной организационной структурой и при нестабильной внешней среде, недостатком — сложность исследования всех возможных ситуаций развития организации и создания модели, адекватной существующим условиям.

Также разработаны парная линейная регрессионная модель для решения задачи определения количественной потребности работников всех категорий персонала и оптимизационные модели управления персоналом, а именно — определения оптимального плана переподготовки, повышения квалификации, найма и увольнения персонала по критерию минимизации суммарных затрат для всех категорий персонала по характеру выполняемых функций по данным конкретного предприятия. По результатам реализации построенных моделей осуществлена экономическая интерпретация полученных результатов моделирования и разработаны рекомендации по изменению численности и профессионально-квалификационной структуры персонала конкретного предприятия и формирования его кадрового резерва, то есть формирование такой группы работников, которые потенциально способны к руководящей деятельности, соответствуют необходимым требованиям, прошли отбор и целевую подготовку с целью повышения квалификации.

Преимуществами создания группы кадрового резерва являются: обеспечение преемственности в управлении, повышение уровня готовности работников к изменениям в организации, их мотивации и лояльности, что приводит к снижению текучести персонала и общей кадровой стабилизации. К тому же это позволяет значительно сэкономить финансовые и временные ресурсы при подборе, обучении и адаптации ключевых работников и своевременно реагировать предприятию на изменения внешней и внутренней среды, что также является очень важным.

Ключевые слова: экономико-математические методы и модели, оптимизационная модель, парная линейная регрессионная модель, управление персоналом.

Формул: 13; рис.: 1; табл.: 1; библ.: 11.

Introduction. In modern conditions, personnel management is especially important as the training of competent, qualified personnel capable of productive labor, its rational placement and development is a key to the success of the enterprise in the process of its activities. In addition, none of the enterprise systems can operate effectively without skilled and motivated employees. Today, when the methods and forms of personnel policy have undergone significant changes, have come to a new level, it can be argued that the staff was considered as one of the most important, if not the most important, resource of any enterprise. However, the current stage of development of the field of personnel management is not without problems. This necessitates the development of approaches

that would ensure their solution. Economic and mathematical modeling is one of the most effective methods for solving these problems.

Thus, it is topical to consider the main problems of personnel management and the issues of applying economic and mathematical modeling as one of the methods of their solution.

Analysis of research and task statement. The most important theoretical and practical aspects, the methodology of personnel management are highlighted in the works of such foreign and domestic scientists as I. Ansoff [1], B.M. Genkin, O.A. Grishnova [2], A.M. Kolot [3], A.Ya. Kibanov, R. Marr [4], O.V. Maslova, M.V. Semikina, G. Schmidt [4] and others. In particular, the issue of managing personnel development was studied by such scientists as A.G. Babenko [5], L.V. Balabanova, O.A. Braverman, M.D. Vinogradsky, T.O. Vodolazhskaya [6], T. P. Zbritska, O.M. Krivoruchko [6], O.V. Sardak and others. Over the modeling of personnel management problems worked such scientists as Ye.E. Vitvitsky, A.A. Gordeyev, N.M. Daihes [7], D.V. Domashova [8], O.M. Krivoruchko, I.A. Samoilova, I.K. Pustovetov [9], A.I. Urintsov [10] and others.

However, due to the multifaceted and complexity of the problem of personnel management, today there are issues that are insufficiently researched and need to be finalized.

The object of the study in the article is the management of personnel as a system of effective management of employees and their activities.

The subject of the study is economic and mathematical models for managing the dynamics of the number and professional qualification structure of staff.

The purpose of the article is to highlight the possibilities of solving some tasks of personnel management, such as the formation of a personnel reserve of an enterprise, using economic and mathematical methods and models, and the construction of an optimization model for personnel management, namely the definition of an optimal plan for retraining, advanced training, hiring and dismissal of personnel for a criterion for minimizing the total costs for the categories of personnel by the nature of the functions performed.

Research results. In modern conditions, employees are the main resource of the company, because they are profitable, and the quality and level of goods and services depends on them. Therefore, adjusting the work of employees is an important task of any organization.

That is, providing the firm with the necessary staff and qualifications, as well as the efficient use of hired personnel, is the main purpose of personnel management, and the tasks related to personnel planning, recruitment and hiring, assessment and distribution of employees, their rational use, development, are one of the main tasks of personnel management.

Today, as a result of the intensified competition for qualified staff, interest in the personnel reserve has returned. Enterprises are aware of the existence of a shortage of competent employees with practical experience in the labor market. In modern conditions, the material motivation of employees is no longer the main argument for the maintenance of professionals. This period is characterized by the dismissal of key employees because of the impossibility of career growth and the reduction of interest in work, decrease or even loss of motivation.

It is therefore appropriate to respond in a timely manner to changes in the external and internal environment by creating a human resources reserve that can handle many human resources management problems.

To successfully solve these problems, it is expedient to use the methods of economic and mathematical modeling, through which one can predict possible models of enterprise development. Their main advantage is the possibility of application in enterprises with an unstable organizational structure and in an unstable external environment, the disadvantage is the complexity of the study of all possible situations of organization development and the creation of a model that is adequate to the existing conditions.

In the article, the economic and mathematical modeling was used to solve the problem of controlling the dynamics of the number and the professional qualification structure of the personnel on the example of the enterprise of State Enterprise (SE) "UAMC".

The main objective of the company is to provide meteorological services for civil aviation flights and air transport operators with information on the actual and expected state of weather on

the national, international, intercontinental airships on Kyiv / Boryspil, Kiev / Zhulyany, Kiev / Antonov-2 and Kyiv / Antonov-1 aerodromes, at landing aerodromes and reserve aerodromes.

SE “UAMC” is the main methodical center in the field of hydrometeorology on meteorological security of civil aviation in Ukraine, whose responsibilities include training, retraining of aviation meteorology specialists, assessing the quality of their work, testing and introducing new technologies and methods forecasting weather-hazardous for aviation.

Scheme of the organizational structure of the company is presented in Fig. 1.

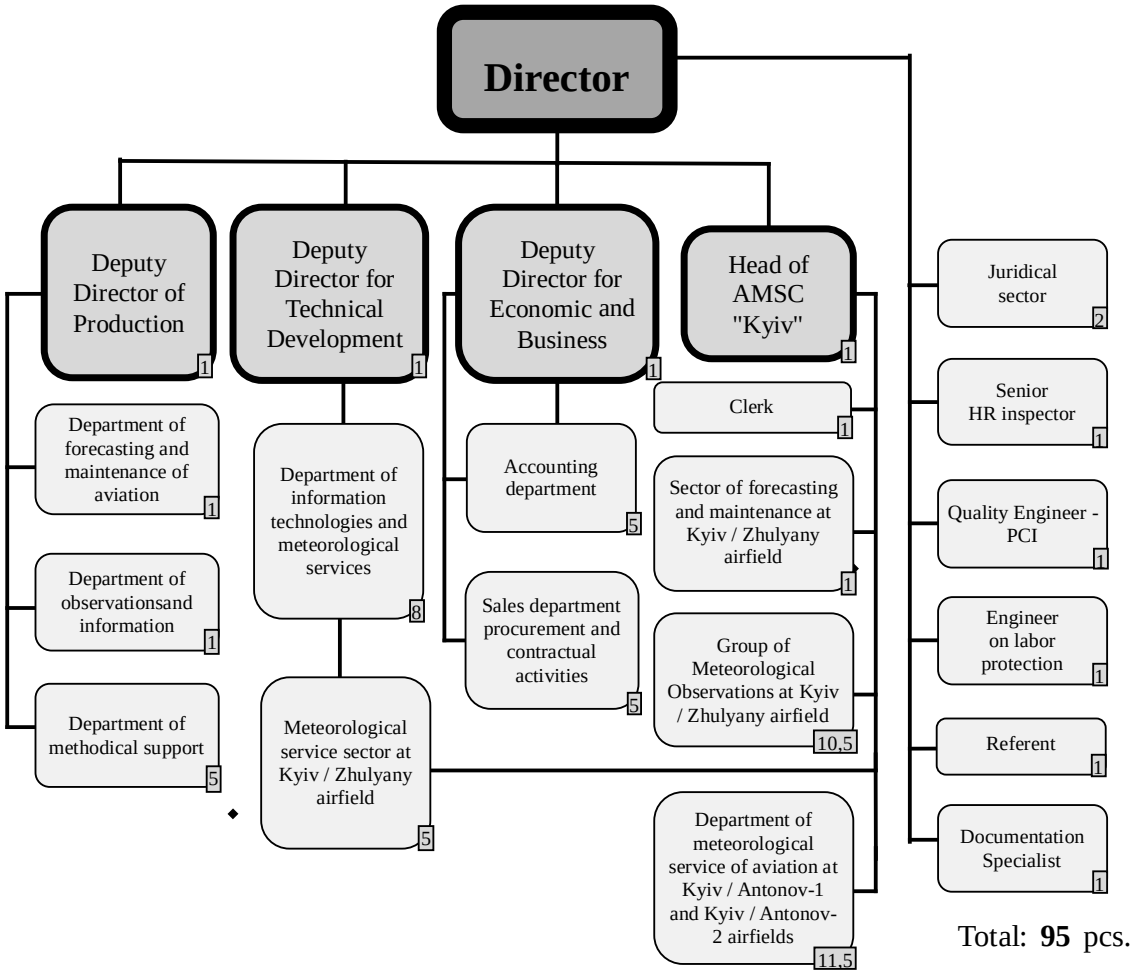

Fig. 1. Scheme of organizational structure of SE "UAMC"

Source: [11]

The staff of the enterprise is highly skilled specialists in the field of meteorology, geography, technology and modern computer systems, economics and marketing (weather forecasters, meteorologists, electronics engineers, accountants, economists, lawyers).

All necessary data was received from the official website of the company. The data was selected for the period from 2013 to 2017 [11].

First and foremost, a pairwise linear regression model was constructed to solve the problem of quantification of personnel requirements for four categories of personnel (by the nature of the functions performed — managers, specialists, employees, workers):

$$\hat{Y}_x^i = a^i + b^i x, \tag{1}$$

where i — number of staff category, $i = \overline{1,4}$;
$\hat{Y}_x^i$ — an additional number of staff of the i-th category is projected, $i = \overline{1,4}$;
x — absolute profit growth;

a^i, b^i — coefficients of the regression equation for the i-th category of staff, $i = \overline{1,4}$.

This task is to establish a connection between the absolute gain of the enterprise *x* and the number of additional personnel $Y_x^i, i = \overline{1,4}$ for all categories (by the nature of the functions performed).

As a result of the regression analysis, for the category of staff "Managers" the following regression equation was obtained:

$$\hat{Y}_x^1 = 0{,}175125 - 0{,}000267x. \quad (2)$$

The coefficient for the variable *x* is negative, therefore, influence the factor is negative, and that is, the greater the absolute increase in profit, the smaller additional of number of staff of the category "Managers".

The value of the projected need in the additional frames of this category to ensure an absolute profit increase of 5,000 thousand UAH, calculated on the basis of the performed regression analysis, will be -1.15794. That is, under these conditions, the number of staff in this category should be reduced.

As a result of the performed regression analysis for the category of staff "Specialists", such a regression equation was obtained:

$$\hat{Y}_x^2 = 2{,}436848 + 0{,}000116x. \quad (3)$$

In equation (3), the coefficient for the variable *x* is positive, that is, with the increase in the additional number of staff of the category "Specialists", the absolute increase in profit will also increase.

To ensure an absolute profit increase of 5,000 thousand UAH the value of the predicted demand in the additional frames of the category "Specialists" will be 3.016634. Consequently, it is likely to find the opportunity to achieve this increase in profits, provided that more employees of this category are attracted to work.

The result of the regression analysis for the category of staff "Employees" was the regression equation:

$$\hat{Y}_x^3 = -0{,}036126 - 0{,}000188x. \quad (4)$$

Equation (4) demonstrates the negative effect of the factor, because the coefficient for the *x* variable is negative. Consequently, the larger the absolute increase in profits, the smaller will be the additional number of staff of the category "Employees".

In this case, with the help of the obtained regression equation, the value of the predicted demand in the additional frames of the category "Employees" is calculated, which will allow an absolute profit increase of 5,000 thousand UAH, will be —0.97384, i.e. it is recommended to reduce the value of the number of employees of this categories.

For the category of staff "Workers", this regression equation was obtained:

$$\hat{Y}_x^4 = 3{,}093607 + 0{,}000431x. \quad (5)$$

The coefficient for the variable x is positive, that is, with an increase in the additional number of staff of the category "Workers" absolute gain will also increase.

For the category of staff, "Workers" calculated the value of the forecast demand for additional frames of this category, which is equal to 5.248523, will allow to provide an absolute profit increase of 5,000 thousand UAH. That is, this can be achieved by increasing the number of employees in the category "Workers".

Next, an optimization model was developed for determining the optimal plan for retraining, qualification improvement, hiring and dismissal of staff on the criterion of minimizing total

expenses for four categories of personnel (by the nature of the performed functions) for the SE "UAMC".

The target function that minimizes the total costs of retraining, upgrading, hiring and dismissal of the staff is as follows:

$$\sum_{i=1}^{m}\sum_{j=1}^{n} y_{ij}C_{ij}x_{ij} + \sum_{i=1}^{m} C_i x_i + \sum_{i=1}^{m} Cz_i z_i + \sum_{i=1}^{m} Cy_i y_i \to min \quad (6)$$

The system of constraints is considered:

1) Concerning the maximum percentage of hiring and dismissal of staff by category:

$$\begin{gathered} y_i \le \alpha_i l_i, i = \overline{1,4}; \\ z_i \le \beta_i l_i, i = \overline{1,4}. \end{gathered} \quad (7)$$

2) As to the possible rejection of the planned values of the number of staff from the predicted by categories:

$$l_i - \Delta l_i \le \sum_{j=1}^{n} x_{ij} + x_i + z_i - y_i \le l_i + \Delta l_i, i = \overline{1,4}. \quad (8)$$

3) As to the inalienability of the variables:

$$\begin{gathered} x_{ij} \ge 0, i = \overline{1,4}, j = \overline{1,4}; \\ x_i \ge 0, i = \overline{1,4}; \\ z_i \ge 0, i = \overline{1,4}; \\ y_i \ge 0, i = \overline{1,4}, \end{gathered} \quad (9)$$

where i - number of staff category, $i = \overline{1,4}$;

C_{ij} - expenses for retraining of one employee *i*-th category of staff for transfer to j-th category, $i = \overline{1,4}, j = \overline{1,4}$;

C_i - expenses for increase qualifications of one employee *i*-th category, $i = \overline{1,4}$;

Cz_i - expenses of hiring an employee of the *i*-th category, $i = \overline{1,4}$;

Cy_i - expenses for the dismissal of one employee of the *i*-th category, $i = \overline{1,4}$;

$y_{ij} = \begin{cases} 1, \text{if transition from the } i-\text{th to the y } j-\text{th category is allowed} \\ 0, \text{if transition of employee is prohibited} \end{cases}$, $i = \overline{1,4}$, $j = \overline{1,4}$;

x_{ij} — the number of employees of the i-th category who have undergone retraining and transition to the j-th category, $i = \overline{1,4}, j = \overline{1,4}$;

x_i — the number of employees of the *i*-th category, who passed the advanced training, $i = \overline{1,4}$;

z_i — the number employees which of hired for work of the *i*-th category, $i = \overline{1,4}$;

y_i — the number employees which fired of the *i*-th category, $i = \overline{1,4}$;

α_i — the highest possible percentage of employees *i*-th category, which can be fired, $i = \overline{1,4}$;

β_i — the highest possible percentage of employees *i*-th category, which can be hired, $i = \overline{1,4}$;

l_i — projected need for additional frames for the *i*-th category of staff, $i = \overline{1,4}$;

Δl_i — the maximum possible absolute deviation of the actual value from the forecast for the *i*-th category of staff, $i = \overline{1,4}$.

In this model, as the cost of retraining staff, the average market value of the relevant retraining courses of the relevant category of workers is considered. Extension costs are the average market value of the required training or advanced training courses. The cost of hiring is the average

market value of a recruiting agency or private recruiter service. As expenses for the dismissal of staff, the compensation in the form of rounded average monthly salary for the corresponding category of employees is considered. All of these types of expenses are the total expenses of retraining, advanced training, hiring and dismissal of staff, the minimization of which is the purpose of the application of this model.

The results of the previous model are also used for this model, in particular, the predicted need for additional frames and the regression equation (1—5) for each category of staff are calculated.

The highest possible percentages of employees who can be fired and hired are determined by the personnel policy and personnel management strategy of the company. In our case, the value of 80% is used in both cases.

Also, the model uses the matrix of transition opportunities for employees from the *i*-th category to the *j*-th. The matrix of possibilities for transferring employees from one category to another is presented in Table 1.

Table 1

The matrix of transition opportunities for employees from the i-th category to the j-th category

			J			
			1	**2**	**3**	**4**
			Managers	**Specialists**	**Employees**	**Workers**
I	**1**	**Managers**	0	0	0	0
	2	**Specialists**	1	0	0	0
	3	**Employees**	0	1	0	0
	4	**Workers**	1	1	0	0

* Source: compiled by the authors based by data [11]

Let's look at the form of the economic and mathematical model for determining the optimal plan for retraining, advanced training, hiring and fired of staff on the criterion of minimizing total expenditures (6—9) for the category of staff "Managers" (10—13):

Target function that minimizes the total expenses of retraining, upgrading, hiring and fired of staff, has the form:

$$11{,}2x_{21} + 12{,}2x_{41} + 10{,}9x_1 + 3z_1 + 17{,}5y_1 \to min. \quad (10)$$

Constraint system:

1) Concerning the maximum percentage of hiring and fired of staff by category:

$$y_1 \geq 0{,}926352. \quad (11)$$

2) As to the possible rejection of the planned values of the number of staff from the predicted by categories:

$$-1{,}389528 \leq x_{21} + x_{41} + x_1 + z_1 - y_1 \leq -0{,}926352. \quad (12)$$

3) As to the inalienability of the variables:

$$\begin{gathered} x_{21} \geq 0; \\ x_{41} \geq 0; \\ x_1 \geq 0; \\ z_1 \geq 0; \\ y_1 \geq 0. \end{gathered} \quad (13)$$

A similar look will have appropriate models for other categories of employees of this enterprise.

The implementation of the models for determining the optimal plan for retraining, advanced training, hiring and fired of staff based on the criterion for minimizing total expenditures (6—9) for each category of employees, including "Managers" (10—13), provided the opportunity to formulate the following conclusions:

minimum total expenses for retraining, advanced training, hiring and fired of staff for the category staff of "Managers" will amount to 17.5 thousand UAH. In addition, under these conditions, it is necessary to release one employee of this category. The expected absolute gain of profit, determined by means of the above-mentioned regression equation (2) without total expenses, will amount to 4383.72 thousand UAH;

for retraining, advanced training, hiring and fired of staff for the category of staff "Specialists" the minimum total costs will be 11 thousand UAH. These conditions state that it is necessary to hire two employees and one employee of the category "Employees" must undergo retraining for transfer to this category. The expected absolute gain of profit, determined by means of the above-mentioned regression equation (3) without total expenses, will amount to 4843.76 thousand UAH;

for the staff category "Employees", the minimum total expenses for retraining, advanced training, hiring and fired of staff will amount to 15.500 UAH. Under these conditions, one employee must be fired, one worker must undergo retraining to be transition to the "Specialists" category, and one worker must undergo advanced training. The expected absolute gain of profit, which is determined by the above-mentioned regression equation (4) without total expenses, will amount to 5111.49 thousand UAH at the given conditions;

the minimum total expenses for retraining, advanced training, hiring and fired of staff for the category of "Workers" will amount to 15.75 thousand UAH. In addition, under these conditions, four workers should be hired and one employee should be promoted to further training. The expected absolute gain of profit, determined by means of the above-mentioned regression equation (5) without total expenses, will amount to 4407.44 thousand UAH;

total costs for all categories of staff will make, in the given conditions, 59.75 thousand UAH.

The result of the application of this model is the change in the number and professional qualification of the staff structure and the formation of the staff reserve of the enterprise, that is, the formation of a group of employees who are potentially capable of managing activities, meet the necessary requirements, passed selection and targeted training to enhance their skills.

Advantages of creating a personnel reserve group are to ensure continuity in management, increase the level of readiness of employees for changes in the organization, their motivation and loyalty, which leads to a decrease in staff turnover and overall personnel stabilization. In addition, the availability of a staff reserve can significantly save financial and time resources in the selection, training and adaptation of key employees, which is also very important.

Conclusions. Consequently, our research has allowed us to formulate the following conclusions.

Firstly, it was found that in modern conditions, workers are the main resource of the enterprise, because they are profitable, and the quality and level of goods and services depends on them. Therefore, adjusting the work of employees is an important task of any organization.

Secondly, the main purpose of staff management is to provide the firm with the employees of the required number and qualifications, as well as to organize the effective use of hired staff.

Thirdly, it has been found that tasks related to personnel planning, recruitment and hiring, assessment and distribution of employees, their rational use, and development are the main tasks of personnel management.

To succeed in solving these problems, it is important to use methods of economic and mathematical modeling, through which one can predict possible models of enterprise development, in particular personnel management. One of their main advantages is the possibility of application

in enterprises with an unstable organizational structure and in an unstable external environment, the disadvantage is the complexity of the study of all possible situations of organization development and the creation of a model that is adequate to the existing conditions.

In this work, a pair linear regression model was developed for solving the task of quantification of personnel requirements and an optimization model for determining the optimal plan for retraining, training, hiring and fired of staff based on the criterion for minimizing total expenses, which helps to solve one of the most important tasks of personnel management, namely creation the team, the required number, structure and qualifications, and its constant development.

The constructed models were implemented to solve the tasks of staff development on the example of the enterprise SE "UAMC". As a result of the implementation, recommendations have been developed for the change in the number and professional qualification structure of the staff of this enterprise and the formation of its personnel reserve.

Further research on the application of methods of economic and mathematical modeling of personnel management tasks will contribute to the development of new methods of personnel management to increase the efficiency of the use of labor resources of enterprises, as well as to expand the possibilities of timely response to changes in the external and internal environment through the creation of a personnel reserve, with which you can cope with a significant amount personnel management issues.

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Стаття рекомендована до друку 03.12. 2018

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The article is recommended for printing 03.12.2018