

The process of managing a higher institution in determining the number of postgraduates who are planned for admission is the object of this study.

The problem that was addressed is the inability to reasonably predict the need for the number of postgraduates to offset the negative consequences of staff turnover in a higher education institution.

An improved method of forecasting the trend of the time series of indicators that form the need for specialists of higher qualification has been proposed.

Special feature of the proposed method is the ability to reasonably determine the number of full-time positions of higher qualification specialists; those dismissed; postgraduates who successfully defended their thesis over a certain period. Due to this feature of this method, it is possible to form reasonable initial data for predicting the negative consequences of staff turnover in a higher education institution.

The scope of practical use of this method for determining the projected indicators is the stage of planning the educational process in a higher education institution.

A comprehensive methodology for determining the number of postgraduates who are planned for admission to postgraduate studies in specialties is proposed.

Applying the suggested procedure can make it possible to obtain the projected data with sufficient accuracy and prevent excessive recruitment, or under-recruitment of postgraduates, which will affect the expenditure of finances and the quality of higher education organization. The projected inaccuracy of the existing approach to determining the number of postgraduates compared to the proposed one is about 35 %.

The peculiarity of the methodology is the ability to justify the number of postgraduates that need to be recruited to graduate school, taking into consideration regional and sectoral contexts. Additionally, a special feature of this procedure is its versatility for any specialty and any institution of higher education.

The scope and conditions for the practical use of this set of techniques for determining the projected indicators is the process of managing a higher education institution when determining the need for postgraduates

Keywords: postgraduate training, staff turnover, higher education institution, specialists of higher qualification

IMPROVING THE METHODOLOGICAL APPROACH TO DETERMINING THE NUMBER OF POSTPOSTGRADUATES PLANNED FOR ADMISSION

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1. Introduction

The rapid evolution of society, globalization, and the affordability of education make significant adjustments to

the development of higher education. Adaptation of higher education to modern challenges is one of the main tasks faced by both teachers and managers of higher education institutions (HEIs).

One of the main issues in modern higher education is staff turnover. After all, staff turnover affects the management of personnel potential [1], personnel policy [2], economic security of the higher education system [3], the budget for higher education [4], and most importantly, the quality of such education. In particular, an important element of ensuring the quality of higher education is the motivation of scientific and scientific-pedagogical workers (S&SPW) [5]. Important factors that affect the motivation and, accordingly, the turnover of S&SPW are also the social significance of scientific and pedagogical activities (S&PA) [6] and satisfaction with their work [7].

Thus, studying all aspects of staff turnover in higher education institutions is important. Moreover, the problem of staff turnover is inherent in most higher education institutions in many countries, which once again confirms the importance of studying these issues. That is, investigating staff turnover is not a local task and applies to all types of higher education institutions and all specialties.

One of the main sources of replenishment of S&SPW in higher education institutions are postgraduates. In particular, taking into consideration the trends in reforming doctoral training in the European higher education space [8], it should be noted that the universalization of the training of Doctors of Philosophy contributes to increasing their academic mobility. In general, academic mobility contributes to improving the quality of higher education but this also leads to an increase in staff turnover. After all, existing approaches to building a career trajectory of postgraduates undergo a certain transformation.

Thus, in terms of the problem of staff turnover, the question arises – how many postgraduates are needed in order to offset the impact of this turnover on the educational process. It is clear that the more postgraduates the better, but it is necessary to take into consideration that postgraduate training requires an additional budget. This is especially true of those HEIs that are subsidized. Therefore, it is precisely the accurate forecast of the required number of postgraduates that can provide the required number of S&SPW and the appropriate quality of higher education.

Moreover, it is the inability to accurately determine the required number of postgraduates to offset the negative impact of staff turnover that can lead to a crisis in higher education both in a particular region and in the world. After all, a smaller number of postgraduates will lead to a decrease in the quality of training while a greater number, although it will create competition, can lead to overspending of resources spent on the training of unclaimed postgraduates.

Taking into consideration the transformation of approaches to postgraduate studies and the increasing role of academic mobility in the world, studying the projected need for postgraduates is of exceptional relevance for all specialties.

2. Literature review and problem statement

Study [9], based on the analysis of personnel management in higher education in the UK, proposed an approach to determining the projected value of staff turnover. Thus, monitoring the dynamics of staff turnover can determine where recruitment and retention policies and practices require focus. However, in the cited study, the set is considered in a generalized way, without determining the specificity of training in graduate school.

Article [10] highlights the approach to determining the strategy for selecting postgraduates, based on a retrospective

analysis of postgraduates with the highest and lowest rating in the last 20 years at the University of California, San Francisco. However, the cited article does not investigate the relationship between the number of postgraduates and staff turnover at higher education institutions.

Work [11] covers approaches in different countries to the process of assessing the effectiveness of training postgraduates in the ratio of financial resources – the quality of training. The cited work offers indicators for measuring the effectiveness of higher education institutions that go beyond the number of entrants, graduate courses and constantly popular reputational ratings. However, there are no practical approaches to determining the dependence of the number of postgraduates and the quality of their training.

Paper [12] considers the theoretical aspects of personnel policy and personnel planning of personnel. However, the approach to determining the need, including postgraduates, does not take into consideration factors such as the success of graduation from graduate school, the attractiveness of S&PA. In addition, the approach does not involve taking into consideration the trend of indicators.

Article [13] analyzes the content of the preparation of Doctors of Philosophy in the Hellenic Republic. The main types of doctoral programs implemented by Greek universities (traditional programs, programs with an extended period of study, distance doctoral programs) have been determined. The requirements for applicants for doctoral programs are characterized; the analysis of the stages of preparation of Doctors of Philosophy was carried out and organizational conditions for ensuring the quality of research in the universities of the Hellenic Republic were determined. However, the cited article does not specify how the need for the number of postgraduates is formed.

Study [14] analyzes the problems of employment of postgraduate graduates (doctoral studies) in European universities. The problem of organization of a balanced order for the training of Doctors of Philosophy, due to the need to model the careers of scientific and scientific-pedagogical workers, has been updated. However, the cited study does not outline the methodology for the formation of such an order for the training of Doctors of Philosophy.

Paper [15] focuses on the analysis of problems with the organization of higher education in Ecuador as part of modern higher education reforms. The key point of the cited study is to describe the problem of recruiting and retaining teachers in an environment where both financial and human resources are limited. However, the cited study does not consider solving the problem by recruiting postgraduates (doctoral studies).

Article [16] deals with the effectiveness of marketing strategies for recruiting new postgraduates. It was determined that recruitment strategies in higher education institutions can be divided into three main categories, namely; inactive recruiting strategy, passive recruiting strategy, and active recruitment strategy. The cited study shows that inactive recruitment strategies, such as the university's reputation, and passive recruitment strategies such as advertising have a significant connection to hiring talented postgraduates. However, the cited article does not investigate the situation when demand exceeds the need. In addition, the mechanisms for determining such a need are not justified.

Paper [17] explores the issues of recruitment for higher education institutions. The research was based on higher education institutions in Great Britain. The study investigated the recruitment at an institutional level where most

HEIs have at least some central processes. However, the ratio of the real need for personnel to postgraduates (doctoral studies) has not been determined.

Study [18] devised a procedure for predicting staff turnover at the organization and department level to reduce the time for hiring employees. To determine the optimal models for effective forecasting of employee turnover based on 11 years of monthly data of a large US organization, various methods of modeling time series were used. However, the proposed models do not take into consideration the specifics of higher education institutions, in particular, the training of specialists of higher qualification in postgraduate studies (doctoral studies).

Paper [19] substantiates the structure of factors that influence the choice of educational institution by foreign students. To determine the importance of identifiable factors based on data collected from students of two different types of educational institutions (university and scientific institution), the survey approach was used. However, the cited study does not address industry factors that significantly influence the choice of HEI.

The review of the literature was carried out in view of studies related to staff turnover. This is due to the fact that the selection procedures for postgraduate studies in different regions, and even higher education institutions, are somehow different, and the problem of staff turnover is inherent in all HEIs. Moreover, one of the main factors in preventing the negative impact of such turnover is the preparation of S&SPW in graduate school.

However, despite the above, the analysis of the given sources and their results allows them to be used to summarize the creation of authentic methodology.

Thus, the analysis of available studies reveals an unresolved issue related to determining the impact exerted on the turnover of higher-skilled personnel at higher education institutions by the number of postgraduates. In other words, the problem is the inability to reasonably predict the need for the number of postgraduates to offset the negative consequences of staff turnover at a higher education institution. That is, there are no mechanisms for determining the need for the number of postgraduates that need to be recruited to prevent the negative impact of staff turnover.

3. The aim and objectives of the study

The purpose of this study is to improve the methodological approach to determining the number of postgraduates who are planned for admission to higher education institutions to prevent the negative impact of the turnover of higher qualification personnel on the quality of the educational process.

To accomplish the aim, the following tasks have been set:

- to improve the method of forecasting the trend of the time series of indicators that form the need for specialists of higher qualification;

- to devise a comprehensive procedure for determining the number of postgraduates who are planning to enter graduate school based on specialties.

4. The study materials and methods

The object of this research is the process of managing a higher education institution when determining the number of postgraduates who are planned for admission.

The main hypothesis of our study assumes that in order to offset the negative consequences of staff turnover at a higher education institution, it is necessary to substantiate the projected need for the number of postgraduates.

The assumptions adopted in this study are the ratio of higher qualification specialists at higher education institutions to the total number of S&SPW will remain within 10 % of the differences between the years in respect of which the research will be conducted.

The simplifications adopted in the current study include the absence of negative factors of force majeure circumstances (war, natural or man-made disasters, etc.).

To determine the need for postgraduates at higher education institutions, forecasting methods are used, in particular, the method of trend extrapolation.

The essence of the method is to determine the main trend of change (trend) based on a dynamic series of statistical data. This trend spreads within the forecasting period. For the correct application of this method, it is necessary to adhere to the empirical rule, according to which the forecasting period, or the period of advance of the forecast, should not exceed the third part of the length of the forecast base. Thus, for example, for a forecast over 3 years, it is desirable to have statistics not less than for 9 years [20].

The terms of application of the method: in the time series there is a statistically significant trend; the process under study is inertial; factors that determine the development of the process remain unchanged. Depending on the peculiarities of changing the levels of a series of dynamics, extrapolation methods can be simple and complex. Simple methods of extrapolation (in particular, the average level of a series of dynamics and the average growth rate of a series) are based on the assumption of the immutability in the future of certain characteristics of the series. Extrapolation on the average level of a series of dynamics is used if the series does not have a statistically significant trend (trend) of development [21].

The use of the method if a series does not have a statistically significant trend (trend) of development is possible due to extrapolation on the average level of a series of dynamics. In this case, the levels of the series fluctuate around the average value; accordingly, the forecast can be defined as the arithmetic mean of all levels of the series.

In the case when a series of the projected indicator has a steady tendency to increase or decrease, and fluctuations around this trend are insignificant, then its extrapolation can be carried out at an average rate of change [21].

$$N_{m+1} = N_m E, \quad (1)$$

where N_{m+1} is the forecast level of the series (the predicted value of the numerical series of the sample); m is the number of levels of series (sampling years); N_m is the last level of the series under investigation (last year); E is the trend coefficient (trend) or the average rate of change in the levels of a series.

In general, the trend coefficient is determined from the formula [22]:

$$E = \sqrt[m-1]{\frac{N_m}{N_1}}, \quad (2)$$

where N_1 is the value for the first year of the numerical sample series.

To apply the method of extrapolation of the trend under the research conditions, the following approach to deter-

mining the trend factor (trend) is proposed. The essence of determining the trend factor (trend) is to determine the ratio of the sum of the values of the projected value to the product of the number of years of the forecast and the value of the projected value for the first year of the forecast. The general estimated dependence to determine the trend is as follows:

$$E = \frac{\sum_{i=1}^m N_i}{mN_1}, \quad (3)$$

where N_i is the projected value for a certain year.

To improve the accuracy of the trend and take into consideration fluctuations in the change in the projected value, the approach of averaging trend values over several periods is applied. As a rule, these periods are within the period of the main sample. Such a calculation can be carried out for 3, 5, and 10 years to improve the accuracy of determining the trend. It is clear that it is possible to use only one of these trends but it may not take into consideration peak values for a certain period, so it is proposed to refine this value using the following formula:

$$E_{(3,5,10)} = \frac{E_{(3)} + E_{(5)} + E_{(10)}}{3}. \quad (4)$$

The use of this method will make it possible to determine the trend quite simply, at the same time with sufficient accuracy. The restriction on the use of this method is the inexpediency of its use for numerical series, which have a large difference in values in neighboring sample clusters. Another limitation is that this method can only be used with the choice of a base year (the first year in a statistical sample). This requires additional analysis of the statistical series to select such a year.

For the experiment, in this study we used statistical data and survey data from 30 respondents at the Ivan Chernyakhovsky National Defense University of Ukraine (NUOU).

Microsoft Excel 2010 (Microsoft Corp., USA) was used for calculations, as well as the software «Determining the need for adjuncts in the implementation of admission», developed within the framework of the research work «Adagio» (NUOU, Ukraine).

5. Results of devising a procedure for determining the need for postgraduates at higher education institutions

5.1. Improving the method of forecasting the trend of the time series of indicators that form the need for specialists of higher qualification

During the study, it was found that the main indicators that affect the need for specialists of higher qualification are associated with quantitative characteristics. In particular, this applies to the number of full-time positions of specialists of higher qualification, the number of dismissed specialists for a certain period, the number of graduates of postgraduate studies.

An important indicator for our study is the number of years for which the forecast is made. As a rule, we are talking about higher education institutions in which the period of preparation in graduate school is 3–4 years, so this is the most acceptable forecast period.

The next input indicator is the number of full-time positions of specialists of higher qualification. Moreover, it is

necessary to take into consideration the number of full-time positions in certain specialties for which training is carried out in this HEI.

Another input indicator is the number of applicants who are in graduate school.

Regarding the indicators that need to be calculated to predict the HEI need for higher-skilled applicants, it should be noted that these indicators should be simple and have an understandable physical content. Additionally, these indicators should take into consideration trends in changes in the influence of factors and be modified depending on the need.

Based on the essential filling of the need for applicants of higher qualification, the main indicator will be the number of applicants of the third educational and scientific level who are planned to enter graduate school in a certain year. The specified number will be formed in accordance with the projected number of vacant positions of higher qualification specialists.

It is clear that the number of vacant positions will be formed in accordance with the actual staff. However, it may vary depending on many, sometimes unpredictable factors, for example, such as socio-political cataclysms, economic development of the country, etc. Nevertheless, it is necessary to take into consideration possible changes in the actual staff because this is one of the main indicators. Therefore, it is proposed to determine this indicator taking into consideration the trend of its change, which can indirectly be determined by analyzing changes in the actual staff for previous years.

The next important element in the formation of the need for applicants for higher qualification is the number of S&SPW, which will be dismissed at the time of graduation of applicants. This indicator is also proposed to be determined taking into consideration the tendency to dismiss. This indicator proposes to take into consideration the number of dismissed for health reasons, at the end of the contract, and by age. Moreover, if dismissal for health reasons and age occurs due to insurmountable factors, then dismissal at the end of the contract must necessarily take into consideration the attractiveness of scientific and scientific and pedagogical activities.

Another important element of the formation of the need is the projected number of postgraduates who will complete their studies in previous years. On the one hand, this is a fairly simple indicator. On the other hand, this indicator should take into consideration the success of the thesis defense because, as evidenced by the analysis of the functioning of postgraduate studies in various universities, the success of defense, as a rule, is not 100 %. Thus, the number of applicants who are trained in graduate school is almost always greater than the specialists of higher qualification who defended their thesis.

In general, the application of these indicators, in particular, such as the projected number of full-time positions, those dismissed, graduates will determine the need for the number of postgraduates who are planning to enter graduate school in a certain year. Structurally, the totality of these indicators is shown in Fig. 1.

All these indicators are time series, so to predict their values, it is advisable to use methods for predicting numerical series. At the same time, given the physical meaning of these indicators, it is advisable to extrapolate the trend of these numerical series.

To substantiate the feasibility of using the method of forecasting the trend of the time series of indicators that form the need for specialists of higher qualification, the characteristics of such series were investigated.

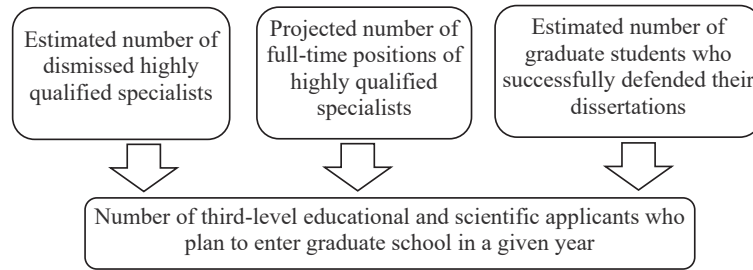


Fig. 1. Structural set of indicators that determine the need for specialists of higher qualification for a certain period

In particular, it was found that in the time series of each of the indicators there is a statistically significant trend. After all, when comparing two sample averages from each numerical series, the value of the level of statistical significance not higher than 0.05 was obtained. This confirms the statistical significance of the trend of numerical series of indicator values.

Next, the investigated processes of changing the values of indicators that form the need for specialists of higher qualification are inertial. This is due to the fact that the patterns of formation of these processes, which existed in the past, will remain in the future.

That is, the use of methods of extrapolation of trends to improve the method of forecasting the trend of the time series of indicators that form the need for specialists of higher qualification is appropriate.

Based on the fact that in order to predict the trend of the time series of indicators that form the need for specialists of higher qualification, one needs to consider several heterogeneous indicators, the method was divided into several sections.

This study adopts the following sequence of description of sections: description of the source data, description of the execution of steps, description of the conditions of compliance with the results obtained, and graphical representation in the form of a flowchart.

To begin with, it is proposed to consider a section for determining the projected number of full-time positions of higher qualification specialists for a certain period. The initial data for such a calculation is the number of full-time positions of specialists of the highest qualification for the last 5 (10) years. It is clear that the sample for 10 years will be more accurate but for some universities that began or resumed their functioning less than 10 years ago, one can use 5 years. This sample satisfies the conditions of accuracy according to the inequality [21–23]:

$$P_{conf} \leq \frac{Z-1}{Z+1}, \quad (5)$$

where P_{conf} is a confidence probability; Z is the sample (number of experiments).

Thus, for 10, it's going to be $P_{conf} \leq 0.82$, and for 5, it's $P_{conf} \leq 0.67$.

The first stage is to determine the average value of the number of full-time positions of highly qualified specialists for 5, 10 years. The estimation dependence to determine this value is as follows:

$$\bar{N}_{state} = \frac{\sum_{i=1}^m N_{state,i}}{m}, \quad (6)$$

where $N_{state,i}$ is the number of full-time positions of specialists of higher qualification for a certain year; m is the number of years for which the sample is taken, as a rule, 5, 10 years.

The next step is to determine the trend of change in full-time positions over 3, 5, 10 years. The generalized estimation dependence, according to (3), is as follows:

$$E_{state(3),(5),(10)} = \frac{\sum_{i=1}^m N_{state,i}}{mN_{state,1}}, \quad (7)$$

where $N_{state,i}$ is the number of full-time positions of highly qualified specialists for a certain year; $N_{state,1}$ is the number of full-time positions of highly qualified specialists for the first year of the numerical series.

According to (4), the average value of the trend should be determined as follows:

$$E_{state(3,5,10)} = \frac{E_{state(3)} + E_{state(5)} + E_{state(10)}}{3}. \quad (8)$$

The next step is to calculate the projected number of full-time positions of highly qualified specialists for a certain period. The estimation dependence for determining this value, taking into consideration (6) and (8), is as follows:

$$N_{state(3,5,10)} = \bar{N}_{state} E_{state(3,5,10)}. \quad (9)$$

The general view of the structural and logical scheme of the section for determining the projected number of full-time positions of specialists of higher qualification for a certain period is shown in Fig. 2.

It is clear that the projected full-time positions may differ in some way from the normative (established) number. Therefore, it is necessary to check the compliance with the specified condition. That is, the next step is a section of checking conditions. If the projected number of full-time positions of highly qualified specialists is greater than the normative (established) number, then it is necessary to make proposals for revision of staff requirements, or to develop proposals for changing the staff. If the projected quantity is less than or equal to the normative (established) value, then the projected value is used as an input value for the following procedures.

It should be noted that this predicted value is influenced by a certain set of factors that can significantly correct it. However, given the scope of this study, it is proposed to take into consideration only general factors at the third generalizing stage of our study.

The next section proposes to consider the for determining the projected number of dismissed specialists of higher qualification for a certain period.

The input data for this section is the number of highly qualified specialists dismissed under various provisions for each year. This section also proposes to use periods of study for 5 or 10 years according to the justification that was given in the previous methodology.

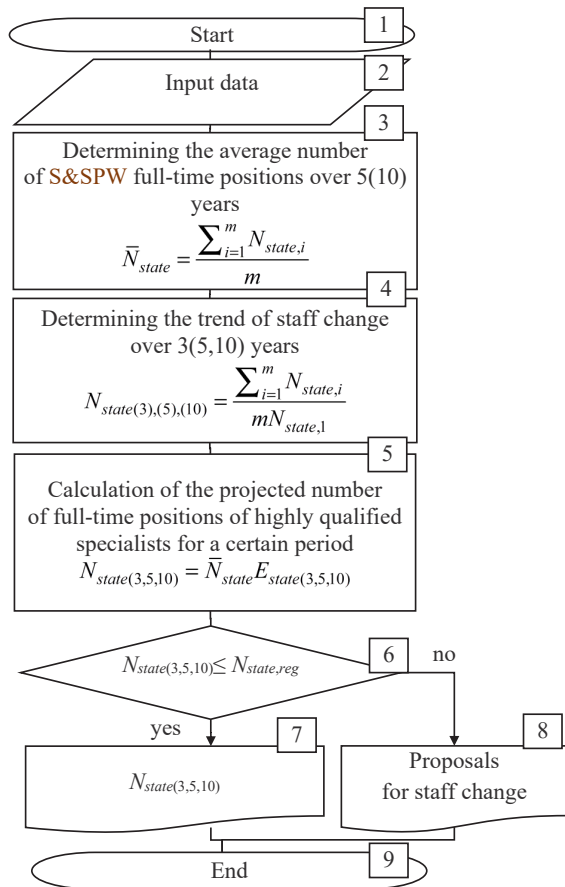


Fig. 2. Structural-logical scheme for determining the projected number of full-time positions of highly qualified specialists for a certain period

At the first stage, it is proposed to determine the average value of the number of dismissed for 5 (10) years for health reasons, age, and end of the contract. Estimation dependences, respectively, will take the following form:

$$\left\{ \begin{aligned} \bar{N}_{dis,h} &= \frac{\sum_{i=1}^m N_{dis,h,i}}{m}, \\ \bar{N}_{dis,a} &= \frac{\sum_{i=1}^m N_{dis,a,i}}{m}, \\ \bar{N}_{dis,c} &= \frac{\sum_{i=1}^m N_{dis,c,i}}{m}, \end{aligned} \right. \quad (10)$$

where $N_{dis,h,i}$ is the number of highly qualified specialists dismissed for health reasons for a certain year; $N_{dis,a,i}$ is the number of highly qualified specialists dismissed by age for a certain year; $N_{dis,c,i}$ is the number of highly qualified specialists dismissed at the end of the contract for a certain year.

In the second step, it is proposed to determine the trends in the change in the number of dismissed specialists of higher qualification according to the following estimation dependences:

$$\left\{ \begin{aligned} E_h &= \frac{\sum_{i=1}^m N_{dis,h,i}}{mN_{dis,h,1}}, \\ E_a &= \frac{\sum_{i=1}^m N_{dis,a,i}}{mN_{dis,a,1}}, \\ E_c &= \frac{\sum_{i=1}^m N_{dis,c,i}}{mN_{dis,c,1}}. \end{aligned} \right. \quad (11)$$

where $N_{dis,h,i}$ is the number of specialists of the highest qualification dismissed for health reasons for a certain year; $N_{dis,h,1}$ is the number of specialists of the highest qualification dismissed for health reasons for the first year of the numerical sample; $N_{dis,a,i}$ is the number of highly qualified specialists dismissed by age for a certain year; $N_{dis,a,1}$ is the number of highly qualified specialists dismissed by age for the first year of the numerical sample; $N_{dis,c,i}$ is the number of highly qualified specialists dismissed at the end of the contract for a certain year; $N_{dis,c,1}$ is the number of highly qualified specialists dismissed at the end of the contract for the first year of the numerical sample.

In general, to clarify the value of the magnitude of the trend in those dismissed, it is possible to apply the approach used in the previous procedure. The essence of the approach is to take into consideration the trend over 3, 5, and 10 years.

The next step is to determine the projected number of dismissals under a certain provision over 1 year.

Thus, the estimation dependences will take the following form:

$$\left\{ \begin{aligned} N_{p,dis,h} &= \bar{N}_{dis,h} E_h, \\ N_{p,dis,a} &= \bar{N}_{dis,a} E_a, \\ N_{p,dis,c} &= \bar{N}_{dis,c} E_c. \end{aligned} \right. \quad (12)$$

The next step is to calculate the total projected number of dismissed after a certain number of years. The total estimated dependence is as follows:

$$N_{p,dis} = n(N_{p,dis,h} + N_{p,dis,a} + N_{p,dis,c}), \quad (13)$$

where n is the number of years for which forecasting is carried out. It is also necessary to check the condition whether the projected number of dismissed exceeds the critical levels of dismissed at HEI. Therefore, the following section is to check the condition:

$$N_{p,dis} < N_{dis,crit}, \quad (14)$$

where $N_{dis,crit}$ is the critical number of dismissed for HEI.

If the condition is met, then the projected number of dismissed specialists of higher qualification for a certain period is accepted as an input value for the following procedures.

The general view of the structural-logical scheme for determining the total projected number of dismissed after 5 (10) years is shown in Fig. 3.

The next to consider is the section for determining the projected number of postgraduates for a certain period who have successfully defended their thesis.

Input data is the number of postgraduates who have been in graduate school for the last 5 (10) years; the number of successful defenses of postgraduates by years; the number of dismissed adjuncts by year.

At the first step, it is proposed to determine the number of postgraduates in graduate school by years. Moreover, it should be noted that if this is the period when postgraduates of the 4th year of training have completed postgraduate studies, they must be taken into consideration as S&SPW otherwise as postgraduates. Therefore, the formula can have either four components or three.

$$N_{asp} = \sum_{i=1}^{3(4)} N_{asp,i}, \quad (15)$$

where $N_{asp,i}$ is the number of postgraduates for a certain year of training.

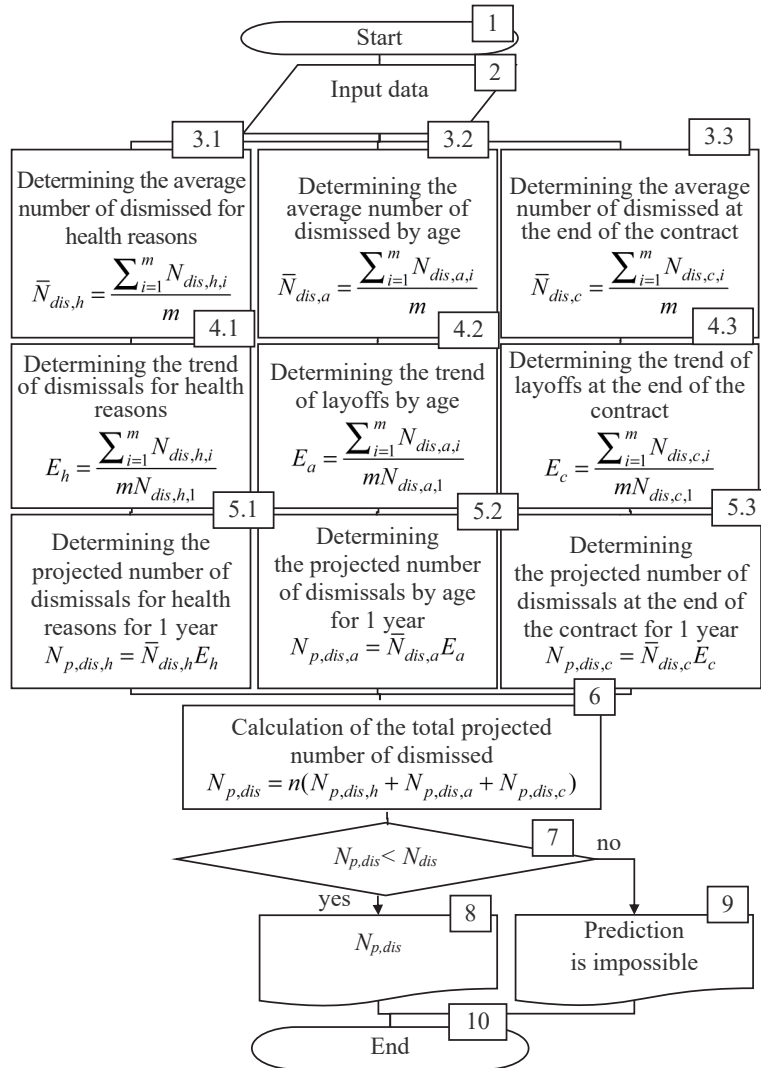


Fig. 3. Structural-logical scheme for determining the total projected number of dismissed after 5 (10) years

At the next step, it is proposed to determine the success rate of the thesis defense according to the appropriate formula:

$$E_{asp,def} = \frac{\sum_{i=1}^m N_{asp,def,i}}{\sum_{i=1}^m N_{asp,i}}, \quad (16)$$

where $N_{asp,def,i}$ is the number of postgraduates who were in graduate school and successfully defended their thesis in a certain year; $N_{asp,i}$ is the number of postgraduates who went to graduate school in a certain year.

At the next step, it is proposed to take into consideration the number of applicants expelled from graduate school. It is proposed to do this by determining a certain coefficient, in particular using the following estimation dependence:

$$E_{asp,dis} = \frac{\sum_{i=1}^m N_{asp,dis,i}}{\sum_{i=1}^m N_{asp,i}}, \quad (17)$$

where $N_{asp,dis,i}$ is the number of postgraduates who were expelled from graduate school in a certain year.

At the next step, it is proposed to calculate the projected number of postgraduates who will successfully defend their thesis using the formula:

$$N_{p,asp} = N_{asp} E_{asp,def} (1 - E_{asp,dis}). \quad (18)$$

This section also proposes to take into consideration the quality of higher education in a certain educational and scientific program (E&SP). To do this, it is proposed to check the condition whether the projected number of postgraduates who have successfully defended their thesis is less than 70 %. If this is the case, then it is necessary to revise or change the educational and scientific program, to carry out appropriate organizational measures. If the number is more than 70 %, then this value is proposed as an input in the complex procedure of determining the number of applicants of the third educational and scientific level who plan to enter graduate school based on specialties.

The general view of the structural-logical scheme for determining the projected number of postgraduates who successfully defended the dissertation is shown in Fig. 4.

Thus, the improved method of forecasting the trend of the time series of indicators that form the need for specialists of higher qualification makes it possible to determine the values of the main indicators that characterize the projected need for specialists of higher qualification. In particular, this method concerns determining the projected number of full-time positions of higher qualification specialists; the projected number of dismissed specialists of the highest qualification; the projected number of postgraduates who successfully defended their thesis. To summarize the data obtained, it is

necessary to devise a comprehensive procedure that would take into consideration the whole set of indicators and coefficients regarding the need for higher qualification specialists.

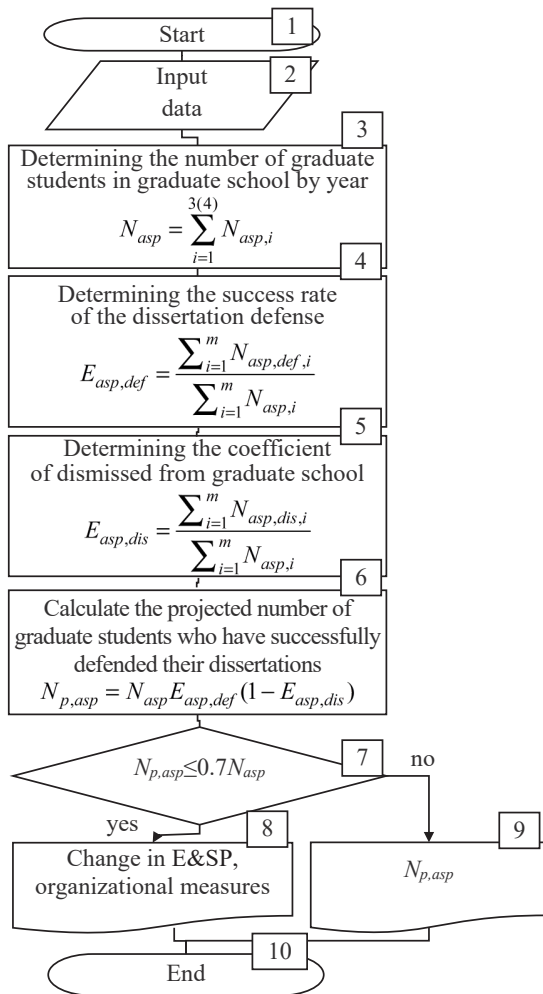


Fig. 4. Structural-logical scheme for determining the projected number of postgraduates who successfully defended their thesis

5. 2. Development of a comprehensive methodology for determining the number of postgraduates who are planning to enter graduate school based on specialties

At the second stage of our study, a comprehensive procedure for determining the number of postgraduates who are planned for admission to graduate school based on specialties is proposed.

The input data for this methodology is the projected number of dismissed specialists of higher qualification; the projected number of full-time positions of higher qualification specialists; the projected number of postgraduates who successfully defended their thesis. Additionally, the input data of this procedure are the coefficients defined in earlier studies [24], in particular, the attractiveness coefficient of S&PA; the coefficient of influence of conditions in a certain higher education institution, the coefficient of influence of the development of the industry.

The main elements of the comprehensive methodology should include partial procedures that were discussed earlier. It is also proposed to include procedures for determining the values of the impact factor of the development of the indus-

try (specialty); the coefficient of S&PA influence; the coefficient of influence of S&PA conditions in a certain HEI [24]. Calculations at the initial stage are carried out in accordance with these procedures.

Next, it is proposed to calculate the number of applicants of the third educational and scientific level who are planned for admission to graduate school according to the following formula:

$$N_{general} = N_{state(3,5,10)} K_s - N_w + (N_{p,dis} - N_{p,asp}) K_a K_{con}, \quad (19)$$

where K_s is the coefficient of development of the industry (specialty) [24]; N_w is the number of actual S&PA; K_a is the coefficient of attractiveness of scientific and scientific-pedagogical activities in a particular country (region) [24]; K_{con} is the coefficient of conditions of scientific and scientific-pedagogical activity in a certain HEI [24].

To determine the number of applicants for a certain specialty, it is proposed to determine the coefficient of specialty. This coefficient is proposed to determine according to the following estimation dependence:

$$K_{spec} = \frac{N_{state,i}}{N_{state}}, \quad (20)$$

where $N_{state,i}$ is the number of full-time positions of higher specialists in a particular specialty; N_{state} is the total number of full-time positions of higher specialists at HEI.

The following steps are related to determining the number of applicants for a certain specialty using the estimation dependence:

$$N_{spec} = N_{general} K_{spec}. \quad (21)$$

Such calculations are performed for each specialty separately. At the final step of the comprehensive methodology, it is necessary to check the compliance with the condition of not exceeding the established (if there is a norm) ($N_{spec,r}$) number of applicants in a certain specialty. If such a condition is met, then an order is formed for the number of applicants in graduate school. If the condition is not met, suggestions for correcting the need are provided.

The general view of the structural-logical scheme of the procedure for determining the number of applicants of the third educational and scientific level are planned for admission to graduate school based on specialties is shown in Fig. 5.

Thus, the proposed comprehensive methodology for determining the number of applicants takes into consideration both the indicators of the process of recruiting positions and the factors that affect this process.

To check the comprehensive procedure for the adequacy and accuracy of the results obtained, it is proposed to consider an example. It should be noted that the data for the calculations are obtained from statistical data on NUOU and from the questionnaires of 30 respondents (scientific, scientific and pedagogical staff at NUOU). The initial data for calculations are given in Table 1.

To determine the projected number of full-time positions of highly qualified specialists and the projected number of such specialists dismissed, a sample was taken from 2011 to 2020. Summary data with the calculation of the trend for 3, 5, and 10 years, as well as the projected data on these indicators, are given in Table 2.

To determine the projected number of postgraduates who successfully defended the thesis, a sample of entrants was taken (years of planned graduation from 2021 to 2024). To determine the coefficients of success of defense, a sample was

taken from 2017 to 2020. Summary data with the results of calculating the projected number of postgraduates (taking into consideration the specialty) who successfully defended the dissertation are given in Table 3.

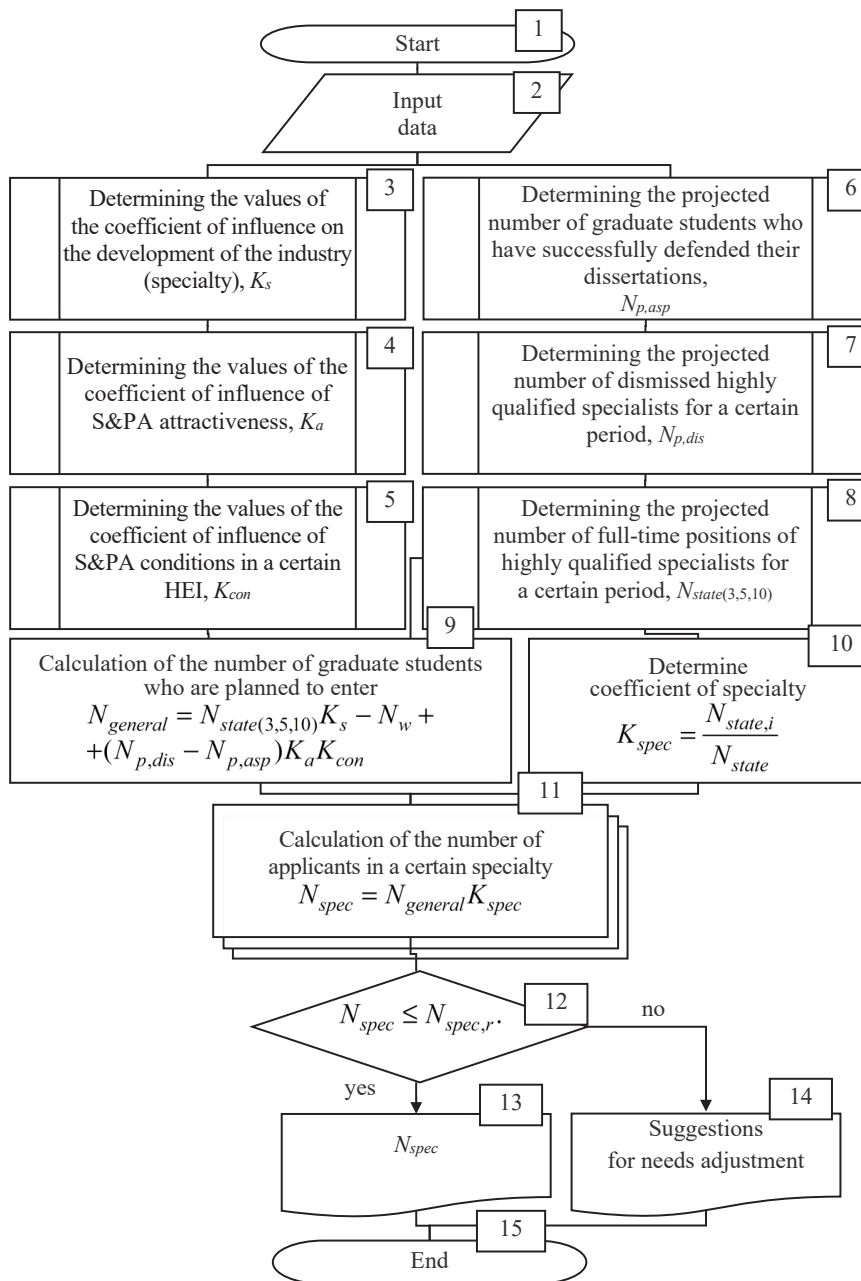


Fig. 5. Structural-logical scheme for determining the number of applicants of the third educational and scientific level who are planned for admission to graduate school based on specialties

Table 1

Table of inputs for calculations

Indicator	Designation	Value
Number of S&SPW according to the list (highly qualified specialists)	N_w	100
Forecast period	n	3
Coefficient of S&PA attractiveness in a particular country (region)	K_a	0.95
Coefficient of S&PA conditions in a certain HEI	K_{con}	1
Coefficient of development of the industry (specialty)	K_s	0.99

Table 2

Table of data on the calculation of the projected number of full-time positions of specialists of higher qualification and the projected number of such specialists dismissed

Base year	S&SPW full-time positions		Number of dismissed		
	general	specialists of the highest qualification	health reasons	contract termination	age
2011	225	123	1	4	1
2012	220	154	2	3	2
2013	257	170	3	6	3
2014	301	200	4	3	4
2015	324	211	5	2	5
2016	154	101	3	4	1
2017	208	102	2	2	1
2018	208	112	5	6	3
2019	210	116	3	3	2
2020	333	156	3	1	1
Mean value	244	145	3.1	3	2.3
Trend 10	1.09	1.00	1.33	0.95	1.13
Trend 5	1.15	1.19	1.80	0.88	1.80
Trend 3	1.06	1.13	1.63	1.29	1.63
Predicted number	267	144	16	13	10

Table 3

Table of data on the calculation of the projected number of postgraduates who successfully defended their dissertation

Graduation year	Expected number of graduates	Graduation year	Number of graduate students admitted	Number of those who defended	Number of dismissed
2021	19	2017	5	5	0
2022	17	2018	15	13	1
2023	15	2019	20	19	1
2024	20	2020	25	23	0
Total	71	Coefficients		0.917	0.033
Total		63			

In accordance with the structural-logical scheme (Fig. 5), the number of applicants of the third educational and scientific level who are planned for admission to graduate school according to the estimated dependence (19) was determined. According to formulas (20), (21), the coefficient of specialty and, accordingly, the need for specialists of higher qualification based on specialties were determined. The results of determining the number of postgraduates who are planned to enter graduate school based on specialties are given in Table 4.

Thus, the results of our analysis of the data in Table 4 indicate that with the given input data, the distribution will occur commensurate with the regular number of S&SPW. Thus, in order to offset the negative impact of staff turnover in a given HEI, it is necessary, first of all, to provide training for postgraduates in specialty 253 (8 applicants). In general, the results in Table 4 indicate the possibility of applying the proposed methodology in the process of planning the educational process at HEIs.

Table 4

Table of results from determining the number of postgraduates who are planned for admission to postgraduate studies based on specialties

Estimated number of graduate students planned to enter	Specialty		Specialty coefficient	The need for highly qualified specialists in the specialty
	Cipher	S&SPW quantity		
20	253	41	0.41	8
	254	12	0.12	2
	255	18	0.18	4
	122	6	0.06	1
	011	7	0.07	2
	053	6	0.06	1
	263	5	0.05	1
	081	5	0.05	1

Verification of the adequacy of the methodology was carried out by conducting calculations to determine the need for postgraduates according to one of the current procedures [25–28]. Its essence is to determine the need through the coefficient of intensity of personnel turnover. Moreover, this coefficient can be defined as the ratio of the number of movements of external and internal movements of personnel to the average number of personnel for the corresponding period [27, 28].

To verify the accuracy of the data obtained using the proposed methodology, calculations were carried out for the same conditions, in particular with a constant trend in the development of indicators. The results of our calculations are given in Table 5.

Table 5

Table of results from determining the number of postgraduates who are planning to enter graduate school based on specialties, with a constant trend in the development of indicators

Calculation condition	Specialties								Total
	253	254	255	122	11	53	263	81	
According to the existing procedure, persons	6	1	2	2	1	1	1	1	15
According to the suggested procedure, persons	6	2	2	2	1	1	1	1	16
Discrepancy of results, %	0	50	0	0	0	0	0	0	6.25

Analysis of the results of calculations (Table 5) reveals certain discrepancies in the data but such a discrepancy does not exceed 10 %, which indicates sufficient accuracy of the proposed methodology. After all, the discrepancy is within the statistical error.

To check the adequacy and sensitivity of the suggested procedure, conditions were proposed with a growing trend in the development of indicators. The results of our calculations are given in Table 6.

Table 6

Table of results from determining the number of postgraduates who are planning to enter graduate school based on specialties, with a growing trend in the development of indicators

Calculation condition	Specialties								Total
	253	254	255	122	11	53	263	81	
According to the existing procedure, persons	5	1	2	1	1	1	1	1	13
According to the suggested procedure, persons	8	2	4	1	2	1	1	1	20
Discrepancy of results, %	38	50	50	0	50	0	0	0	35

Analysis of the results of calculations according to different procedures (Table 6) indicates significant discrepancies in the data (35%). This is due to the fact that the existing methodology is not sensitive to changes in the characteristics of the trend in the development of indicators. Additionally, the discrepancy is due to not taking into consideration in the existing methodology of such factors as the attractiveness of S&PA in a particular country (region), the conditions of S&PA activities in a certain HEI, the development of the industry (specialty).

To facilitate the perception of the results obtained, the data were summarized in a bar chart with a quantitative and percentage comparison of the data obtained according to the existing and proposed methodology.

The results of the analysis of the obtained and generalized data (Fig. 6) indicate the accuracy of the proposed methodology (Table 5, Fig. 6), as well as its adequacy and sensitivity (Table 6, Fig. 6). This is confirmed by the fact that the proposed procedure under stationary conditions does not

allow for errors that would exceed the statistical error, and when conditions change, it reacts to them.

Thus, the use of the proposed comprehensive methodology for determining the number of postgraduates who are planned for admission to graduate school based on specialties can make it possible to obtain the projected data with sufficient accuracy. Additionally, the suggested procedure can prevent excessive recruitment or under recruitment of postgraduates within 35%, which will affect the expenditure of finances and the quality of the organization of higher education.

6. Discussion of results of devising a methodology for determining the need for postgraduates at higher education institutions

An improved method of forecasting the trend of the time series of projected indicators that form the need for specialists of higher qualification has been proposed. The essence of this method is to determine the projected number of full-time positions of specialists of higher qualification (Fig. 2), those dismissed (Fig. 3), graduates of postgraduate studies who successfully defended their thesis (Fig. 4) by extrapolation of the trend.

The proposed method is based on the forecasting method, in particular the method of trend extrapolation (3), (4). Forecasting is carried out for a period of 3–4 years based on a statistical sample for the last 10 years, which will ensure a confidence probability at the level of 0.82 (5). Unlike existing approaches to determining such projected data, this method takes into consideration factors that significantly affect these data and may change over time. In general, the method includes sections for determining the projected number of full-time positions of highly qualified specialists (Fig. 2), those dismissed (Fig. 3), as well as graduates of postgraduate studies who successfully defended their thesis (Fig. 4).

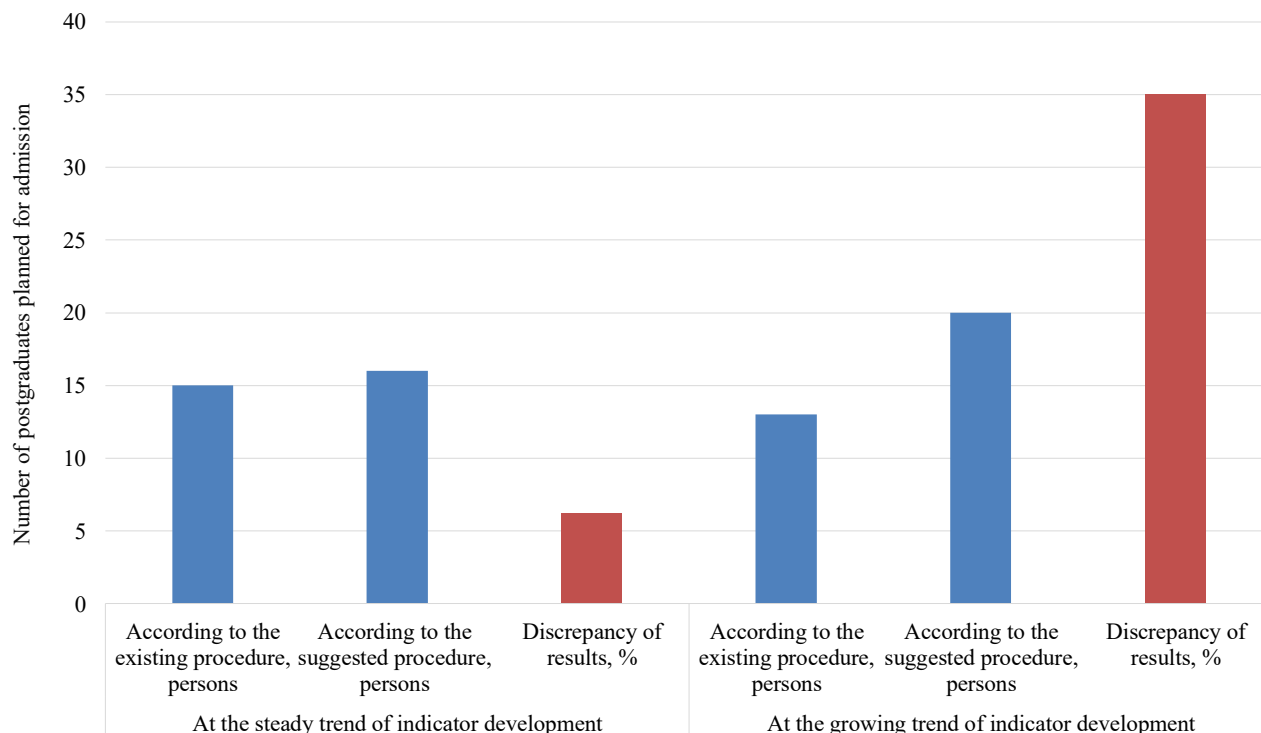


Fig. 6. Histogram of the results of forecasting the need for postgraduates according to the existing and proposed methodology for a steady and growing trend in the development of indicators

Thus, the section for determining the projected number of full-time positions of highly qualified specialists takes into consideration the normative (established) number of full-time positions in a certain HEI (section 6, Fig. 2). This makes it possible to take into consideration the economic, personnel opportunities of HEIs and industry features of the development of education.

In the section for determining the projected number of those dismissed, different dynamics of dismissal by age, at the end of the contract, for health reasons (10) to (12) are taken into consideration. This makes it possible to improve the accuracy of the forecast on the number of dismissed and to devise more detailed recommendations to prevent the negative impact of these events.

Regarding the section for determining the projected number of postgraduates, it should be noted that this section takes into consideration the success of defense (16) and the number of those dismissed (17). This will ensure an increase in the accuracy of the forecast and will determine the success of the educational and scientific program (section 7, Fig. 4).

Our improved method makes it possible to form reasonable initial data for the forecast of the negative consequences of staff turnover in a higher education institution, which makes it possible to justify the forecast of the need for the number of postgraduates. Thus, this method closes the problem specified in chapter 2 in terms of the formation of reasonable source data.

The problem part is resolved by determining the projected number of full-time positions of specialists of higher qualification (Fig. 2), the number of dismissed (Fig. 3), the number of postgraduates who successfully defended their thesis.

The sufficiency of the formation of source data as a problem part is explained by the development of sections relative to those indicators that sufficiently take into consideration the turnover of personnel.

The peculiarity of our method is the use of the base year forecast, which makes it possible for researchers to apply their experience to improve accuracy. Additionally, special features include the ability to increase the forecast period but it should be noted that prolonging the period requires an increase in statistics. As a rule, the forecast period is three times less than the period of statistical sampling.

The advantages of our method include its sufficient simplicity, availability of statistical data, taking into consideration a sufficient number of factors that affect the process of staff turnover.

The disadvantage is a weak sensitivity to force majeure circumstances, such as war, significant man-made and natural disasters.

Restrictions on the use of our method, necessarily taken into consideration when trying to apply in practice, as well as in further theoretical studies, is the use for numerical series, which have a large difference in values in neighboring sample clusters. Another limitation is that this method can only be used with the choice of base year (the first year in a statistical sample).

The next proposal is a comprehensive methodology for determining the number of postgraduates who are scheduled to enter graduate school based on specialties. This procedure is based on the combination of a set of techniques for determining the projected indicators (Fig. 2–4) and determining the coefficients of influence on the turnover of specialists of higher qualification (sections 3–5, Fig. 5).

Our comprehensive methodology makes it possible to take into consideration in a balanced way the indicators

that form the need for specialists of higher qualification and determine the need for the number of postgraduates who are planned for admission. Thus, this comprehensive procedure closes the problem part specified in chapter 2 related to the issue of determining the need for the number of postgraduates who are planned for admission based on specialties.

Verification of the proposed methodology for accuracy (Table 5, Fig. 6), indicates that the obtained data for static conditions are within the limits of statistical error (6%). When checking for adequacy and sensitivity (Table 6, Fig. 6), it was found that the proposed methodology makes it possible to obtain results that reflect the influence of important factors, factors such as the attractiveness of S&PA in a particular country (region), the S&PA conditions in a certain HEI, the development of the industry (specialty). Additionally, this check makes it possible to prevent shortfalls or exceeding the need for the recruitment of postgraduates by about 35% (Fig. 6).

The problem part is closed by determining the need for the number of postgraduates who are planned for admission, taking into consideration their specialties.

The validity of determining such a need is explained by taking into consideration the set of projected indicators (Fig. 2–4) and defined coefficients of influence on the turnover of higher qualification specialists (sections 3–5, Fig. 5).

The peculiarity of our methodology is the ability to determine the need for the number of postgraduates who are planned for admission in certain specialties ((19), sections 9–11, Fig. 5) taking into consideration both regional and sectoral factors (Table 1). Additionally, special features of our procedure include the possibility of checking the compliance of the condition without exceeding the established ($N_{spec,r}$) number of applicants in a certain specialty (21).

The advantages of this procedure are the accuracy of obtaining projected indicators. This is due to the comprehensive consideration of the projected number of full-time positions of highly qualified specialists (Table 2), those dismissed (Table 2), as well as graduates of postgraduate studies who successfully defended their thesis (Fig. 3), and factors of staff turnover. Additionally, the advantages of our procedure include the ease of use because all indicators and factors have a clear physical meaning while the mathematical apparatus is well-known and can be programmed.

The disadvantages of this procedure include the element of subjective evaluation when determining the magnitude of the influence of certain factors. Although this is leveled by the use of appropriate methods for clarifying the projected data.

Restrictions on the application of this complex methodology and necessarily taken into consideration when trying to apply in practice, as well as in further theoretical studies, are taking into consideration only regional and sectoral contexts. Other contexts (ethnic, religious, gender, etc.) were not taken into consideration due to their small impact on the results of the study precisely in relation to the conditions adopted in our research. However, to use this procedure under other conditions, it is necessary to take into consideration those factors that may affect the results.

Thus, the use of the proposed comprehensive methodology for determining the number of postgraduates who are planned for admission to graduate school based on specialties can make it possible to obtain the projected data with sufficient accuracy. Additionally, the suggested procedure can prevent excessive recruitment or under recruitment of postgraduates within 35%, which will affect the expenditure of finances and the quality of the organization of higher education.

In general, the results obtained in this study make it possible to reasonably determine the indicators of the need for specialists of higher qualification, factors of staff turnover, and distribute the need based on specialties. This indicates the improvement of the methodological approach to determining the number of postgraduates who are planned to enter and achieve the goal of the study.

This study could be advanced by determining the coefficients of influence of those factors that can affect the result under conditions different from those in which the current study was conducted. In particular, such coefficients may reflect ethnic, religious, gender factors.

7. Conclusions

1. An improved method of forecasting the trend of the time series of indicators that form the need for specialists of higher qualification has been proposed. The essence of this method is to determine the projected number of full-time positions for highly qualified specialists, those dismissed, as well as postgraduates who successfully defended their thesis, by extrapolating the trend.

The peculiarity is the improvement based on forecasting methods, in particular, the method of trend extrapolation, which provided forecasting for a period of 3–4 years on the basis of a statistical sample for the last 10 years, with a confidence probability of up to 0.82. Due to this feature of this method, it became possible to take into consideration the dynamic change in the trend of development of indicators.

A distinctive feature of our method is the possibility of applying it to HEIs from different industries and regions. In general, this method makes it possible to reasonably determine the number of full-time positions for highly qualified specialists, the number of those dismissed, as well as the number of postgraduates who successfully defended their thesis for a certain period. The scope of this method is the stage of planning the educational process at HEIs.

2. A comprehensive methodology for determining the number of postgraduates who are planned for admission to postgraduate studies based on specialties has been proposed. The essence of the procedure is a combination of techniques for determining the projected indicators that form the need for specialists of higher qualification and methods for deter-

mining the coefficients of influence on the turnover of specialists of higher qualification.

The peculiarity of this procedure is the ability to predict the need for postgraduates, taking into consideration the need for specialties. A distinctive feature of the methodology is the consideration of the regional and sectoral context during forecasting. Thus, owing to these features, it was possible to achieve the advantage of this procedure over existing ones, in particular, to take into consideration the trend of changing indicators, taking into consideration the entire set of important factors, which led to an increase in the accuracy of the forecast.

Thus, during the calculations, the coefficient of attractiveness of S&PA in a particular country (region) was adopted at the level of 0.95, and the development rate of the industry (specialty) at the level of 0.99. It was determined within the example that the projected regular number of S&SPW in 3 years will be 144. Moreover, the projected number of dismissed will be 39 people. The projected number of postgraduates who successfully completed postgraduate studies is 63 people. The use of the procedure has made it possible to determine that the greatest need for postgraduates is for specialty 253 (8 people in total), followed by specialty 255 (4 people) and specialties 254 and 011 (2 people each).

In general, the use of the proposed methodology can make it possible to obtain the projected data with sufficient accuracy and prevent excessive recruitment, or under-recruitment of postgraduates, which will affect the expenditure of finances and the quality of higher education organization. The projected inaccuracy of the existing approach to determining the number of postgraduates compared to the proposed one is about 35 %.

The improved methodology makes it possible to justify the number of postgraduates who need to be recruited to graduate school to offset the negative impact of staff turnover, taking into consideration regional and sectoral contexts. The scope of the procedure is the planning of the staffing number of graduate schools, S&SPWs, planning the organization of the educational process. The results obtained in this study make it possible to reasonably determine the indicators that form the need for specialists of higher qualification; the coefficients of influence on the turnover of specialists of higher qualification; and distribute the need based on specialties. This set of results indicates the improvement of the methodological approach to determining the number of postgraduates who are planned for admission.

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