Rational Use of Russia's Own Workforce from the Perspective of Environmental Economics

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Abstract. The paper is devoted to assessing the possibilities of using labor resources in the Russian economy, when considering it as a closed ecosystem. Due to the sanctions, which will significantly limit the possibility of using foreign labor, the issue of rational and economical use of labor resources becomes relevant. The basis for the reproduction of the number of employed is the permanent population of the country. As factors influencing the dynamics of the process, control actions are chosen in the form of employment levels of the population. The processes of aging of the labor force in Russia are predicted as a result of the pension reform due to an increase in the average age of the employed by about one year. The forecast estimate of the economy's additional annual demand for personnel shows, on average, a one-third decrease in the volume of annual demand for personnel. The simulation modeling of the forecast number of the employed population in Russia made it possible to assess the potential volume of labor resources that the country can count on in the future. This will help to make scientifically based management decisions to improve the efficiency of the use of available labor resources.

Keywords: Environmental economics · Labor resources · Workforce · Employment forecast · Pension reform · Coronavirus pandemic

1 Introduction

The Russian economy, unlike the economies of other countries, is now facing new separate challenges. Unlike the coronavirus pandemic, which has hit countries around the world to varying degrees, the Russian economy is being further impacted by the effects of the 2018 pension reform and economic sanctions from a large number of the world's most advanced economies.

The sanctions factor will significantly limit the possibility of using foreign labor or foreign labor migrants. In this regard, the issue of rational and economical use of

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labor resources on the basis of its own population becomes relevant. Therefore, it is important to predict the number of such an active component of the labor force as those employed in the economy of the Russian Federation. Since understanding the processes of reproduction of the labor force is extremely important for its effective regulation.

The objective need to study the reproduction of the labor force is caused by a number of reasons. The labor force is an important factor of production, the rational use of which ensures not only an increase in the level of production and its economic efficiency, but also the qualitative development of the entire social system. Effective regulation of labor force reproduction processes will ensure the achievement of stable economic growth.

The labor force includes both the employed and the unemployed. From this position, forecasting the reproduction of the number of employed in the Russian economy based on the demographic forecast of the resident population is relevant in the framework of solving the problem of economical expenditure of resources.

Publications [1–4] are among the main works of domestic scientists in the field of studying the labor market, analyzing of labor flows, modeling the dynamics of employment, and forecasting the total and current demand for personnel. In the works [5, 6] the modeling of population dynamics employed, unemployed and economically active population by agent-oriented approach were made. In the article [7] gives a predictive assessment of the prospective need of the Russian economy in the labor force. Demographic forecasts are based on population dynamics models [8, 9].

The fact that a decrease in the birth rate and an increase in life expectancy leads to an increase in the proportion of elderly and old people in the population is proved in demographic studies [10].

At the same time, it is shown that the aging process also affects both the employed and the economically active population of Russia. The problem of increasing the employment of people of retirement and pre-retirement age in the context of demographic aging of the population and a shortage of labor resources is considered in the work [11]. The aging workforce in Russia as a result of both the general aging of the population and the increase in the level of economic activity of older people is evidenced by the study [12].

In foreign countries, the problem of the aging of the employed population is also being actively studied. According to the OECD, [13] indicates that over the past decades, the economic activity of older people in many developed countries has increased. This is reflected in the U-shaped dynamics of the economic activity of older people [14].

The problems arising in the economy and social sphere due to the consequences of raising the retirement age are studied in detail in [15, 16]. The advantages and disadvantages of raising the retirement age from different points of view are shown in articles [17, 18].

Within the framework of this study, it should be taken into account that the modeling of the annual change in the number of employees should be carried out for annual, rather than five-year age categories, since according to the current program (Pensionnaya reforma. Glavnoe // RBK [Pension reform. Main. RBC] URL: https://www.rbc.ru/politics/14/06/2018/5b22380d9a79474a4b883165 accessed 12.03.2022), the retirement age in the transition period until 2028 will increase every two years, and not once every five years.

In a previous study [19], the author and co-authors considered a deterministic version of the calculation of the forecast number of employees, taking into account new challenges, and assessed the indicators of the annual inflow and outflow of the employees.

This study differs from the previous ones in that it will carry out a predictive assessment of the average age of the employed, and will also predict the size of the annual additional need for the economy in personnel [20]. In addition, within the framework of these studies, a stochastic model will be used for the first time, and simulation will be carried out, which will allow obtaining more reliable calculation results.

2 Materials and Methods

The information base of the study is the open data of state and federal statistics of the Russian Federation (Demograficheskij prognoz do 2035 goda // Federal'naya sluzhba gosudarstvennoj statistiki [Demographic forecast until 2035. Federal state statistics service] URL: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/population/demography/#), (Trud i zanyatost' v Rossii. 2017 // Federal'naya sluzhba gosudarstvennoj statistiki [Labor and employment in Russia. 2017. Federal state statistics service] URL: www.gks.ru/free_doc/doc_2017/trud_2017.pdf).

The demographic forecast of the population of Russia until 2035 for both sexes in the context of one-year age categories from 0 to 100 years served as the basis for constructing a forecast of the number of employed.

Numerical values of employment levels in the context of five-year sex and age categories served as key factors influencing the number of employed population. Employment levels can be defined as "the ratio of the employed population of a certain age group to the total population of the corresponding age group, calculated as a percentage".

The number of employed by age groups for 2010–2020 is determined separately for men and women based on data on the structure of employed by age groups and the total number of employed. Based on these data, employment rates for both sexes are calculated. Figure 1 shows a retrospective of the level of employment of the entire population of Russia from 1992 to 2016, as well as separately for men and women from 2014 to 2016. The differentiation of employment levels by sex is clearly visible. Thus, on average for the period 2014–2016, the employment rate for women is 61.7%, and for men – 73.7%. It should also be noted that, since 1998, the level of employment of the population has been steadily growing, and in 2014 it reaches the peak value of 1992.

Due to the stabilization and decline in employment levels in the crisis years of 2008–2010 (Fig. 1), it can also be assumed that further growth in employment will stop even in the current crisis. Based on this, an assumption is made that the employment forecast will stabilize at the level of 2014–2016. Thus, the forecast employment levels for all age categories are set constant over the entire forecast period until 2030.

Another assumption of the model is the interpolation of the values of employment levels of five-year sex and age categories according to the values of one-year levels. Figure 2 shows the averaged values of employment rates for men and women of working age from 15 to 72 from 2014 to 2016 in the context of one-year age categories. Such an assumption is inevitable, since an attempt to restore the actual age employment of the population runs into a lack of additional information.

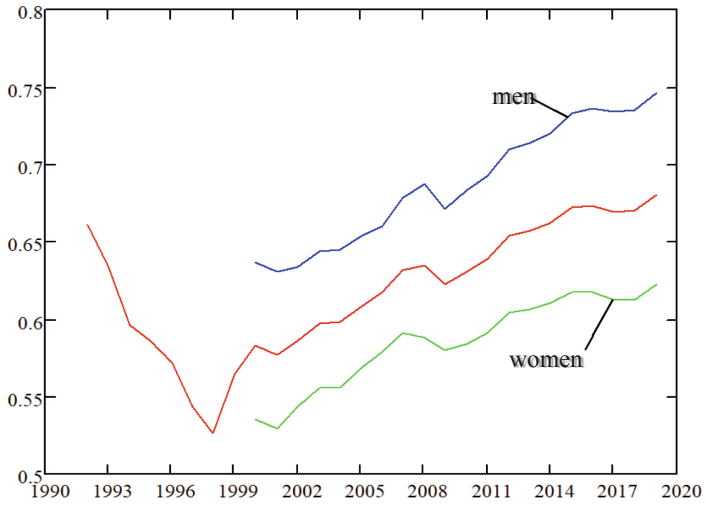

Fig. 1. Actual employment levels in the Russian Federation.

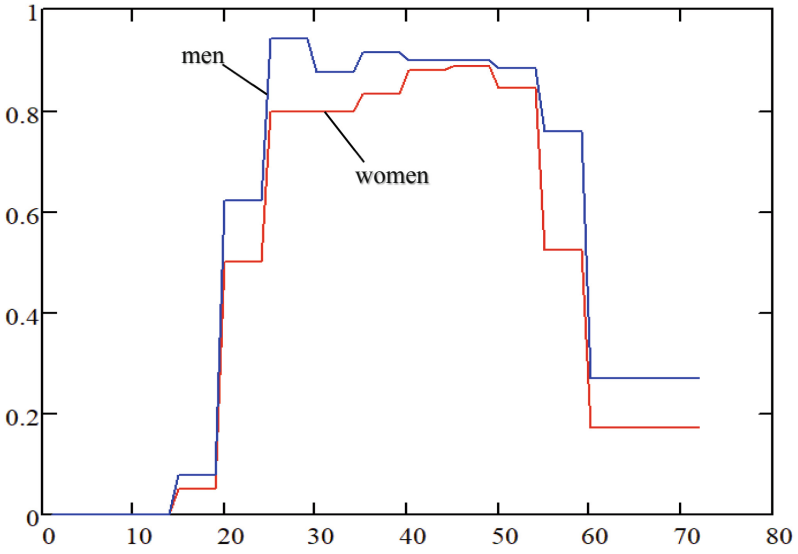

Fig. 2. The age profile of employment in Russia at working age, average from 2010 to 2019.

When analyzing the employment of people of retirement age, it should be noted that when they retire before the start of the pension reform, employment levels for men and women change differently. The main retirement age for men in Russia was 60 years, and the transition from the category “55–59” to the category “60–64” corresponded to a decrease in the employment rate from 75.2% to 27.2%, i.e., almost 3 times. For women,

upon retirement, when moving from the category "50–54" to "55–59", the employment rate decreased from 85.5% to 52.4%, which amounted to only about 40%.

The enactment of the pension reform will affect the employment rate of the earlier "retirement" age categories. Let's assume that it stays the same. That is, the employment rate for men in the 60–64 category will be the same as for the 55–59 category, while for women in the 55–59 category it will remain at the level of 50–54.

According to the schedule for raising the retirement age and the assumption made, we will make changes to the previously constant forecast employment levels for the corresponding ages. Figure 3 shows the new levels of employment that will characterize the elderly population under the program for a phased increase in the retirement age. The retirement age values will increase five times with a frequency of two years from 2020 to 2028.

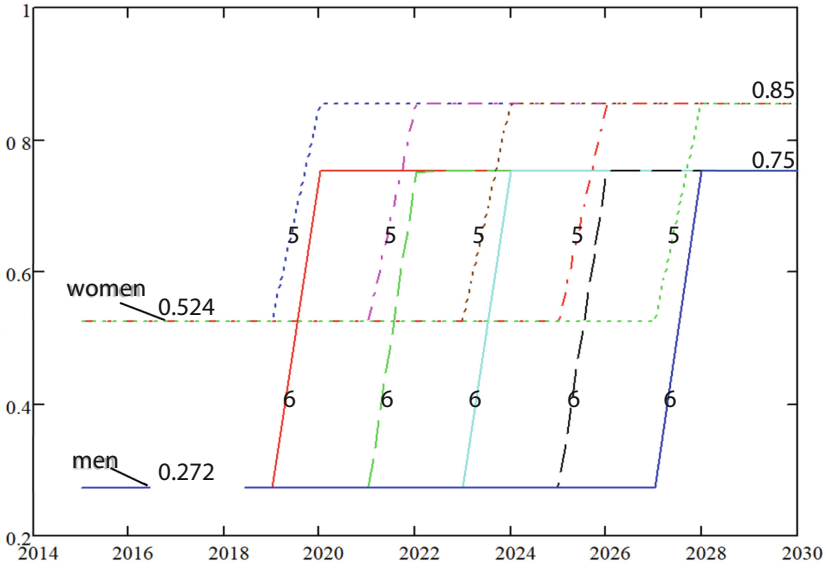

Fig. 3. Forecast employment levels of the retirement age population.

So, for example, from 2020, men will retire only from the age of 61, and women from 56 years. In other words, this means (Fig. 3) that the employment rates of 60-year-old men and 55-year-old women after 2020 will no longer be "retirement", but will increase to the employment levels of the previous "working" age cohorts of "55–59" and "50–54", respectively.

Let us introduce the following notation:

$p_{m,a,t}$ – number of men of age a in t-th year;

$p_{f,a,t}$ – number of women of age a in t-th year;

$c_{m,a,t}$ – employment rate of men of age a in t-th year;

$c_{f,a,t}$ – employment rate of women of age a in t-th year;

The forecasting period is given by the interval $t \in [t_0, t_f]$, where $t_0 = 2021$, $t_f = 2030$. The range of changes in the age of employees is limited to the population of working age: $a \in [a_b, a_e]$, where $a_b = 15$ years, $a_e = 72$ years. Index $g \in \{m, f\}$ sets the gender: m – male, f – female.

Thus, as a result of multiplying one-year forecast levels of employment by the forecast values of the population of the corresponding age and gender, a forecast of population employment is formed for one-year age and sex categories:

$$L_{g,a,t} = c_{g,a,t} \cdot p_{g,a,t}, g \in \{m, f\}, a \in [a_b, a_e], t \in [t_0, t_f]. \quad (1)$$

The final forecasts of the employed population in Russia for both sexes were obtained by summing the forecasts for individual ages (1)

$$L_{g,t} = \sum_a L_{g,a,t}, g \in \{m, f\}, a \in [a_b, a_e], t \in [t_0, t_f] \quad (2)$$

The predictive estimate of the average age of those employed in the economy is calculated by the formula

$$a_t^m = \sum_a \frac{L_{f,a,t} + L_{m,a,t}}{L_{f,t} + L_{m,t}} \cdot a, a \in [a_b, a_e], t \in [t_0, t_f] \quad (3)$$

To determine the coefficients of inflow and outflow of employees, it is necessary to establish the volumes of inflow and outflow of people employed in the economy from the corresponding age-specific equations of the balance of movement of labor resources

$$L_{g,a+1,t+1} = L_{g,a,t} + \Delta L_{g,a,t}, g \in \{m, f\}, a \in [a_b, a_e - 1], t \in [t_0, t_f - 1], \quad (4)$$

$$\Delta L_{g,a,t} = L_{g,a,t}^{in} - L_{g,a,t}^{out}, g \in \{m, f\}, a \in [a_b, a_e], t \in [t_0, t_f], \quad (5)$$

whence from (3) and (4) the annual increments or differences are expressed:

$$\Delta L_{g,a,t} = L_{g,a+1,t+1} - L_{g,a,t}, g \in \{m, f\}, a \in [a_b, a_e - 1], t \in [t_0, t_f - 1]. \quad (6)$$

To determine the volume of inflow of the entire employed population, it is proposed to sum all positive differences from (6), and for the volume of outflow – all negative ones:

$$L_t^{in} = \sum_g \sum_a \Delta L_{g,a,t} | \Delta L_{g,a,t} > 0, g \in \{m, f\}, a \in [a_b, a_e - 1], t \in [t_0, t_f - 1], \quad (7)$$

$$L_t^{out} = \sum_g \sum_a \Delta L_{g,a,t} | \Delta L_{g,a,t} < 0, g \in \{m, f\}, a \in [a_b, a_e - 1], t \in [t_0, t_f - 1], \quad (8)$$

whence the coefficients of inflow k_L^{in} and outflow k_L^{out} of employed are determined taking into account (2) in the form

$$k_L^{in} = \frac{L_t^{in}}{\sum_g L_{g,t}}, k_L^{out} = \frac{L_t^{out}}{\sum_g L_{g,t}}, t \in [t_0, t_f - 1]. \quad (9)$$

The value of the annual additional need for personnel depends on the outflow rate of employees (9) and the number of employed people in Russia (2) $\Delta D_{g,t}$ – the amount of labor force that is necessary to compensate for the loss of employment due to natural outflow:

$$\Delta D_{g,t} = k_L^{out} L_{g,t}, t \in [t_0, t_f - 1]. \quad (10)$$

3 Results and Discussion

3.1 Deterministic Modeling

The final forecasts of the number of the employed population in Russia for both sexes are shown in Fig. 4.

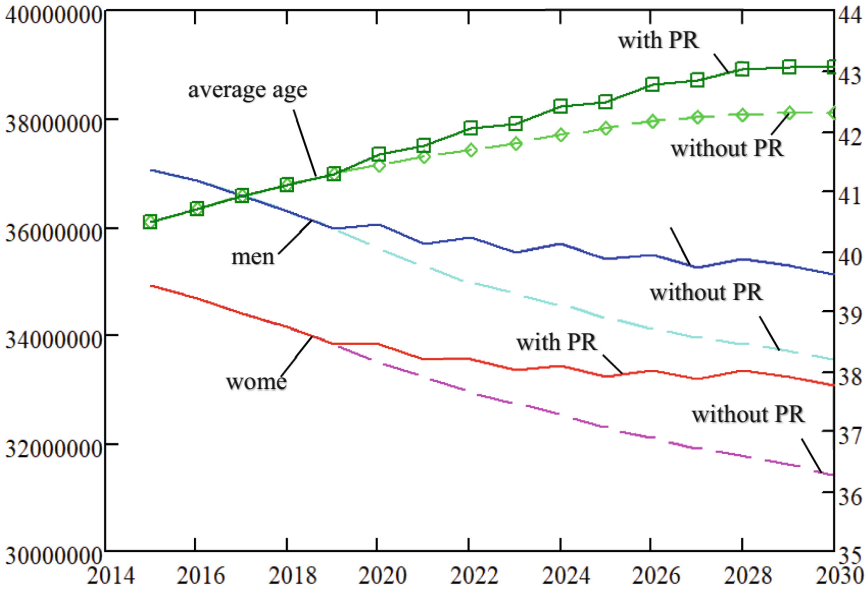

Fig. 4. The forecasted employed population of Russia until 2030, people.

Figure 4 shows projections based on two scenarios for changes in employment levels: with and without the 2018 pension reform (PR). Without taking into account the pension reform, the total number of employed men and women, starting from 2019, would have fallen at the same pace at a rate of about 440 thousand people a year, and would have decreased by 4.8 million people by 2030. After the adoption of the pension reform, the average rate of decrease in the number of employed will fall significantly and will amount to about 150,000 people a year. With this scenario, the number of employed by 2030, compared with 2019, will decrease by only 1.6 million people. Thus, thanks

to the pension reform, the country's economy will receive a bonus in the form of an "additional" 3.2 million workers by 2030, which can be characterized as strengthening the country's extensive development strategy.

The forecasting results also showed (Fig. 4) that the average age of the employed population in Russia will grow under both forecast options, but, in the case of pension reform, the average age by 2030 will become almost a year longer and reach 43 years. Thus, Russia's employed population is accelerating its aging.

The "jump" in the predicted dynamics of the number of employed, taking into account the PR, is well explained by analyzing the inflow and outflow of employees.

The economic interpretation of the outflow rate is that it is used to determine the annual additional staffing requirement "for replacement", which is equated to the annual outflow of the employed population. The reason for the outflow is natural retirement, the main components of which are: retirement for old age, disability and death. To maintain the number of employed people at last year's level (blue curve in Fig. 5), it is necessary to compensate for the need or outflow in full. The demographic characteristics of the employed population in Russia are such that the inflow of the number of employed (red curve in Fig. 5) is consistently less than the outflow in the case of the scenario without pension reform. In the case of the implementation of the PR, the additional staffing needs (dark blue bars in Fig. 5) in the odd years of the transition period will be less than the influx of staff, which will lead to an increase in the number of people employed in the economy in these years.

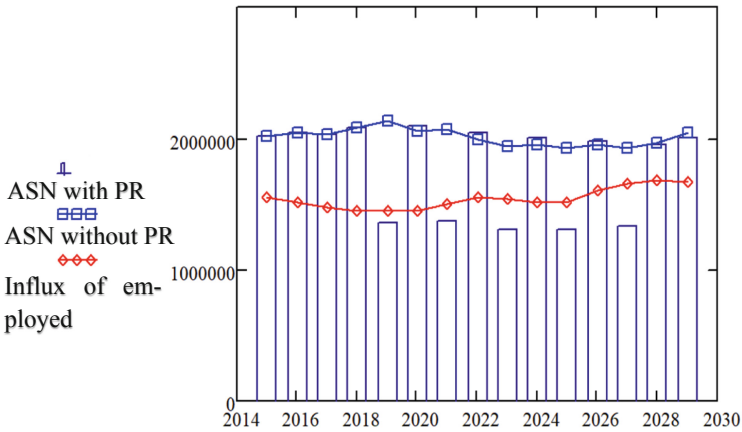

Fig. 5. Forecast of additional staffing needs (ASN) "for replacement" in the case with PR and without PR, people.

3.2 Stochastic Modeling

The input parameters for the stochastic model will be employment levels for one-year gender and age categories.

The prediction of these levels as random variables is based on the study of the dispersion of their retrospective values, as well as on determining the type of distribution law.

Figure 2 shows employment profiles for ten five-year age and sex groups. At the same time, it follows from Fig. 1 that the levels of employment have a pronounced tendency to linear growth, both for men and women, from the crisis year of 1998 to the present day.

To eliminate non-stationarity, employment rates from 2000 to 2019 were fitted using linear regression. Further, the resulting trend was excluded from the levels so that the residuals had a zero mean. For each gender, a set of 200 deviations was formed (10 categories of 20 values). The histogram of the distribution of residuals for men and women is shown in Fig. 6.

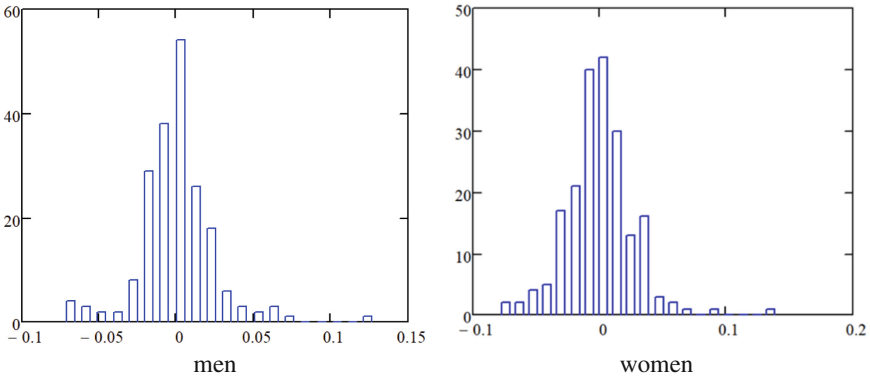

Fig. 6. Histogram of the distribution of employment levels deviations from the average in the retrospective period from 2000 to 2019.

The distribution density of residuals by species is similar to the normal distribution law, however, Pearson's test with a significance level of 5% rejected this hypothesis. However, for ten women's and 10 men's employment levels, mean and variance were found. Thus, the distribution parameters were set for 20 random variables.

For simulation modeling, an assumption was made to use the normal distribution law due to the type of deviations in Fig. 6.

Figure 7 shows the results of simulation modeling of the dynamics of changes in the forecast number of people employed in the economy from 2020 to 2030 for 10,000 implementations. The left graph shows random implementations of the process, and the right graph shows a histogram of the distribution of the number of employees at the end of the forecast period (2030).

Based on the results of simulation modeling, the minimum St_min, maximum St_max and average St_avg of the forecast of the number of employed by the stochastic model were calculated (Fig. 8).

According to the results of stochastic modeling, the average population forecast (red line) coincides with the results of the calculation by the deterministic model (blue

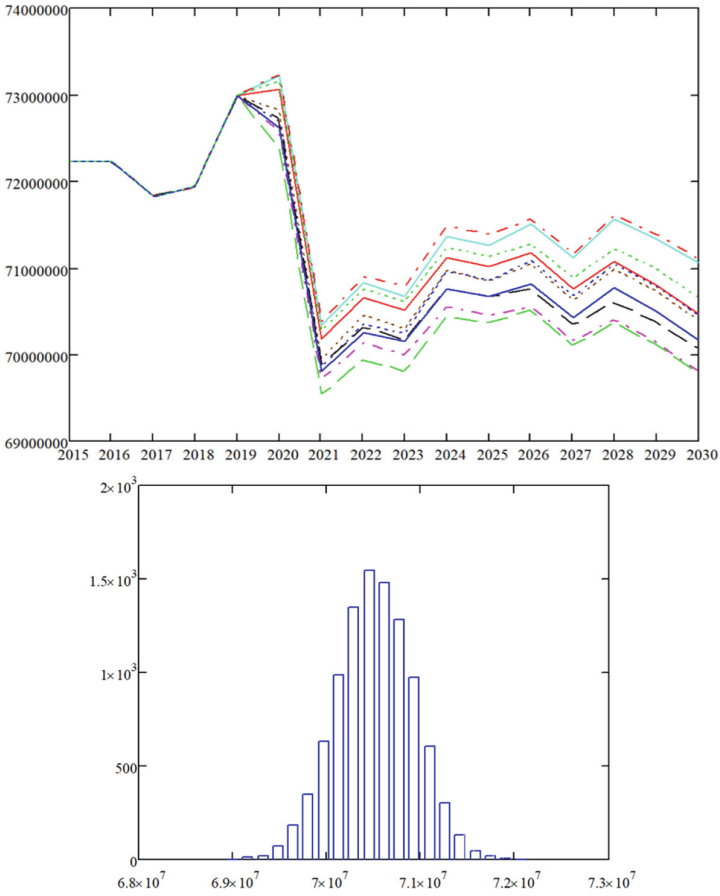

Fig. 7. Results of simulation of the dynamics of changes in the forecast number of employees.

line). The maximum deviations from the average in each direction do not exceed 1.1 million people in 2021 and 1.5 million people by 2030. Therefore, the maximum decline in employment will not break through the threshold of 69 million people. Even in the worst case (green curve), this will still give 2 million more employed people by 2030 than without the 2018 PR (brown line). In the best case (blue line), the projected number of employed may reach 72 million people. But the most likely scenario is fluctuations in the forecast number of people employed in the Russian economy in the range from 70 to 71 million people.

4 Conclusion

The Russian economy, in the context of growing sanctions, will have to switch to the economy of nature management, not only in the figurative sense of rational and economical saving of resources, but also in the literal sense of self-sufficiency with everything necessary, becoming an increasingly closed ecosystem.

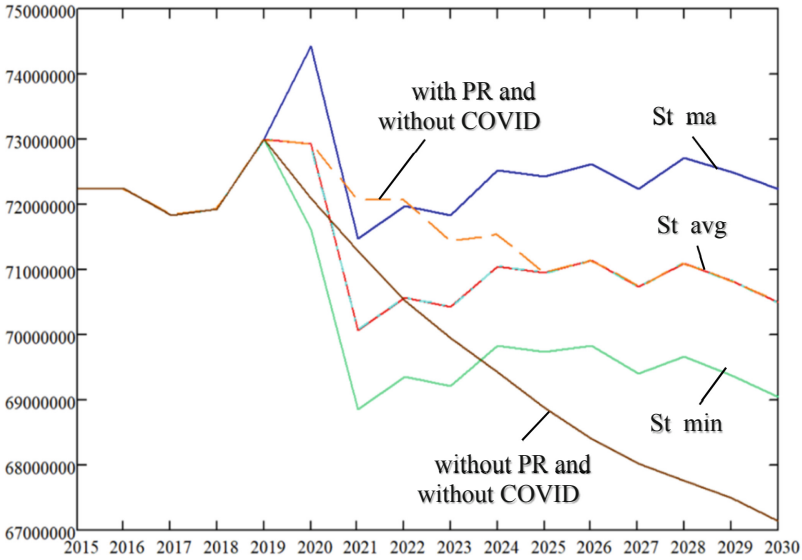

Fig. 8. Results of stochastic and deterministic modeling of the forecast number of employed in the Russian economy until 2030.

With the implementation of the pension reform of 2018 in Russia, the additional staffing requirement for the labor force will have an oscillatory "jump-like" nature. In the period from 2019 to 2028, the annual additional need for personnel will decrease, relative to the pre-reform level of 2 million people, by about 17.5% and will reach, on average, 1650 thousand people a year.

A decrease in demand for personnel (labor force) by 350,000 people annually will become a challenge for young graduates of the professional education system who are counting on jobs that have been vacated from pensioners. This will lead to an aging workforce. Thus, the average age of those employed in the economy will increase by almost a year from 42 to 43 years. The instability caused by the imbalance of supply and demand in the labor market can lead to an increase in youth unemployment and an increase in social tension.

Simulation modeling, taking into account the factor of the coronavirus pandemic, showed a temporary decrease in the number of employed from 72 to 70 million people by 2021. By 2024, the number of employed will grow back and stabilize at about 71 million people until 2028 and then will again slightly decrease by 2030 to 70.5 million people.

The obtained predictive estimates of the number of labor supply, based on the resident population of Russia, will help to make scientifically based management decisions to improve the efficiency of using the available labor resources in an aggressive external environment.

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