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Forecast of the Volume of Expenses for the Payment of Old-Age Insurance Pensions in the Russian Federation until 2035

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ABSTRACT

The article is devoted to the assessment of the impact of demographic processes on the volume of expenses for the payment of old-age insurance pensions in the Russian Federation. The **purpose** of the study is to make a forecast of the volume of expenses of the Russian Social Fund budget for the payment of insurance old-age pensions for the period up to 2035, taking into account population fluctuations in 3 scenarios: optimistic, probable and pessimistic. The **relevance** of study is due is due to the influence of demographic processes on the pension system of the Russian Federation. The **results** obtained are new, they can be used in the practical activities of the state authorities of the Russian Federation, in the conduct of scientific research and in the educational process, etc. The authors used a multifactorial dynamic model in the form of a system of stochastic differential equations with parameters, and numerical calculations were carried out on a discrete approximation of this model. The authors revealed that with a pessimistic version of the population forecast, the volume of budget expenses of the Pension and Social Insurance Fund of the Russian Federation for the payment of insurance pensions (excluding early appointment) for 2023–2035 will increase by 56.67% (which in monetary terms is 4.22 trillion rub.); with a probable one — by 60.39% (which in monetary terms is 4.50 trillion rub.); with a pessimistic one — by 66.02% (which in monetary terms is 4.93 trillion rub.). It is important to note that any of the forecast, due to the population decline in the forecast period, assumes an increase in the volume of expenses for the payment of insurance pensions at rates below inflation (the latter, according to the minimum estimates of the authors of the article, will amount to 74.76%).

Keywords: pensions; pension provision; insurance pensions; government spending; pension system; budget forecasting; financial forecasting; demography

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INTRODUCTION

For the pension system of the Russian Federation, the task of forecasting the financial provision of compulsory pension insurance (further — CPI) and the consequences of government decisions taken with the aim of increasing the financial stability of pension system and guaranteed fulfilment of social obligations of the state to the elderly citizens of the country can be implemented only within the framework of a formalized model, allowing to take account of causal links between demographic factors and the volume of expenses for payment of pensions.

The CPI financial support forecast can be set for short-term (1 to 5 years), medium-term (5 to 10 years), long-term (10 to 20 years) and over-long-term (20 to 100 years) periods. At the same time, the main objective of forecasting for the short- and medium-term perspective is to determine the parameters of the pension system that ensure its development in accordance with the forecasts of socio-economic development formed by the Ministry of Economic Development of the Russian Federation.

MATERIALS AND METHODS

The pension system has been modeled and its financial condition forecast using both deterministic and stochastic models in static and dynamic scenarios with an extensive amount of experience up to this time. At the same time, the complexity and structure of such a model are determined primarily by the availability and quality of the statistical information necessary for modeling, as well as the objectives of modeling.

For forecasting the budget expenses of the state budget system, various formalized methods and models, theoretical-probability and econometric methods, methods of mass service theory, theory of games, component methods (components), expert assessment, simulation and other formalized techniques, and algorithms are used.

When it involves social insurance fund budgets, we consider that actuarial mathematics methods are the most appropriate. This is particularly so when estimating expenses in the context of compulsory pension insurance.

In the Russian Federation, methods of actuarial modeling of the CPI system were discussed in the papers of A.K. Soloviev [1, 2], D. Yu. Fedotov [3, 4]. Analysis of the pension actuarial studies in Russia, which developed in the first decade of the next century, is conducted in the paper of V.I. Arkin and A.G. Sholomitsky [5]. Large contribution to the development of methods of actuarial modeling by V.I. Rotar [6], V. Yu. Korolev et al. [7], A.V. Bataev [8], P.V. Kalashnikov [9, 10]. The objective assessment of the state and level of development of CPI actuarial calculations requires to note one of the serious studies in this direction, belonging to foreign researchers [11], which examines effective tools for measuring and dynamics of risks in pension funds, determining the results of their activities, and, in particular, finding optimal strategies for investing fund resources in conditions of inflation risk.

The paper of P. Booth et al. [12], which provides an overview of achievements in actuarial theory and its application in the modeling of pension systems on the basis of modern advances in probability and mathematical statistics, is one of the most important studies carried out abroad in applying methods of actuarial pension modeling.

In the paper [13] noted that the actuarial assessments of social security pension systems in most of the studies were conducted using traditional deterministic models, despite certain advantages of stochastic modeling methods. The author showed that stochastic models in the field of social security allow for more reliable estimates of the existing pension scheme when forecasting its state under the conditions of several interrelated stochastic factors.

It should also be noted that in recent years, issues related to the management of pension systems in various countries of the world have also been actively raised in the scientific literature in the context of contemporary socio-demographic challenges [14–19].

Any demographic forecast is adopted to be carried out in 3 stages.

The first stage — is analytical. At this stage, the analysis of the demographic situation in the country is carried out at a certain historical time interval $[0;T]$ before the beginning of the forecasted period, the assessment of the population state of the society and the results of its development for the past period is performed, the comparison of the indicators obtained with their forecasting values built at previous stages of analysis of demographic situations, and the identification of possible negative trends in the development of population situation.

In the second stage, which is called the target, the objectives of the demographic forecast are formulated, the achievement of which ensures the solution of the problems identified in the first stage and the implementation of demographic requirements of society in accordance with the goals of socio-economic development at the forecasting interval.

The third stage is calculated. At this stage, the estimated demographic indicators are substantiated: the population, its dynamics over time (growth or decrease in population), the gender and age structure of the population, etc.

The forecast of the demographic situation is developed for different periods of time. However, it is well known that with the increase of the forecasting interval, the accuracy of the forecast decreases proportionally to the growth of the function $\sqrt{T+t}$, where the time moment T is the end of the analytical phase of the construction of a demographic forecast.

Experiments on demographic forecasting show that in the absence of socio-economic development crises (unfavorable international or epidemiological circumstances, military conflicts and other social shocks), the most practical value and satisfactory accuracy are the results of forecasts based on actuarial methods developed for a period not exceeding 20 years. Similarly, the need to forecast the demographic situation in the country for significantly larger horizons is determined, in particular, by the problems of improving the public pension system and solving the tasks of strategic planning of socio-economic development.

We consider that in accordance with the adopted practice of building forecasts of socio-economic development by the Ministry of Economic Development of the Russian Federation (pessimistic, optimistic and probable) the problems of forecasting the demographic situation in the country should also be solved in the same three scenarios. At the same time, the most likely forecast is the main benchmark for the development and justification of government management decisions.

To solve the problem of demographic forecasting in this paper, we will use a multi-factor dynamic model in the form of a system of stochastic differential equations with parameters, and the numerical calculations are realized on a discrete approximation of this model.

RESULTS AND DISCUSSION

Within the framework of solving the problem of modeling population dynamics in the Russian Federation, we implement an attempt to develop a mathematical model of the dynamics of the population taking into account socio-economic factors of development of the Russian Federation, comparative features with similar processes in other countries, as well as population migration processes. The proposed mathematical model identifies the conditional "center of migration attraction" and "periphery", which traditionally serves as the demographic donor for the "center". Examples of such socio-economic formations are the relations between the Russian Federation and the countries of the EAEU, the EU and the Baltic States, EU and Ukraine, Moldova and Georgia.

Today's progress in the development of mathematical models for complex social systems [20] suggests that demographic forecasts cannot be considered in isolation, but must be aligned with the state of socio-economic development of society and take into account both quantitative demographic indicators and qualitative changes in the structure of social and economic development of a country.

The idea and methodology of building a mathematical model of the dynamics of demographic processes is based on the work on dynamic modeling of such processes by J. A. Schumpeter, H. Uzawa [21, 22], the modeling system by P. M. Romer [23] and S.P. Kapitsa [24, 25].

The model of population dynamics can be presented as a system of stochastic differential equations in the form of:

$$dx_t = \left\{ a_x x_t - d_x x_t^2 + c_x \frac{x_t y_t}{x_t^2 + \alpha^2} \right\} dt + b_x dw_t ,$$

$$dy_t = \left\{ a_y y_t - d_y y_t^2 + c_y \frac{x_t y_t}{x_t^2 + \alpha^2} \right\} dt + b_y dw_t .$$

The values of the parameters a_x and a_y are determined by the balance of instant birth and mortality in each region of the Russian Federation. Since the economic conditions of existence of different regions and nationalities in Russia, as well as their way of life can vary significantly, the values of these coefficients can also vary greatly (even have different signs and change over time). The parameters d_x and d_y characterize the limited resources in the country, determining the standard of living of the population in each region, with the presence of a corresponding foldable in each equation indicating that population growth is completely stopped over time, and the ratio of the values of the parameters a_x and a_y, on the one hand, and of the parameter d_x and d_y, on the other, determines the "bifurcation point" of the system solutions.

We have adopted a symmetrical form of writing the mathematical model equations, the coefficients a_x, a_y, d_x, d_y determine the internal dynamics of the processes of birth and death, and the coefficients c_x and c_y — determine the speed of migration between the groups considered. The coefficients b_x and b_y — determine the probability fluctuation processes of the variables x_t and y_t.

The model indicates the possibility of exceeding the rate of economic growth of a country over its population rate, as the migration of the rural population to the city creates an additional opportunity for industry to attract labor resources. The rate of urban and rural migration is determined by the values of the coefficients c_x and c_y.

For the Russian Federation, the issues of interregional migration processes and rural population migration to urban agglomerations are not only topical, but also the processes of inter-country migration within the EAEU, in which the migration of the population of Ukraine to our country currently plays a significant role, as well as the integration of 4 new regions into the Russian federation (Donetsk People's Republic, Lugansk People's Republic, Zaporozhye region, Kherson region).

We use the concept of convergence to look at the processes of inter-country migration [26]. To this end, in the mathematical model of the dynamic evolution of the population we will introduce additional factors that determine the migration processes, which take into account the level of socio-economic regional development. We call the factors s_x and s_y level of material well-being, and the factors k_x and k_y — average level of qualification (education). Obviously, the introduced factors are functions of time and, therefore, their change over time should also be modeled by some dynamic ratios.

Table 1

Forecast of Life Expectancy of the Population of the Russian Federation at Birth, Years

Year	All population			Men			Women		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
2023	69.64	69.77	69.94	64.83	64.88	65.13	74.78	75.06	75.18
2024	69.72	69.89	70.02	64.92	64.99	65.19	74.86	75.17	75.26
2025	69.75	69.86	69.94	64.87	64.93	65.02	74.82	74.91	75.06
2026	69.81	69.91	69.98	64.91	64.98	65.11	74.94	75.03	75.13
2027	69.88	69.97	70.06	65.07	65.13	65.18	75.07	75.15	75.21
2028	69.95	70.12	70.19	65.16	65.21	65.27	75.16	75.24	75.29
2029	69.99	70.17	70.25	65.20	65.26	65.33	75.22	75.29	75.34
2030	70.07	70.24	70.32	65.31	65.37	65.42	75.31	75.39	75.44
2031	70.38	70.54	70.87	66.48	67.13	67.64	76.25	76.93	77.51
2032	71.73	72.17	72.76	68.37	69.28	69.87	77.35	77.83	78.29
2033	72.19	72.35	72.91	68.77	69.57	70.04	77.78	78.27	78.74
2034	72.49	72.86	73.17	69.22	69.84	70.37	78.16	78.63	79.07
2035	73.18	73.54	73.81	69.93	70.59	71.17	78.85	79.16	79.54

Source: Calculated by the authors based on Rosstat data (taking into account the entry of 4 new regions into the Russian Federation). Rosstat: Population of the Russian Federation by gender and age. URL: https://rosstat.gov.ru/compendium/document/13284 (accessed on 10.12.2022).

Note: (1) — pessimistic forecast; (2) — probable forecast; (3) — optimistic forecast.

Table 2

Forecast of the Dynamics of Changes in the Number of Men and Women in the Russian Federation of Retirement Age Until 2035

Year	Number of women aged ⩾ 60, thousand people			Number of men aged ⩾ 65 years, thousand people		
	(1)	(2)	(3)	(1)	(2)	(3)
2023	23 041.9	23 057.6	23 062.9	8130.9	8165.3	8166.7
2024	23 054.4	23 061.1	23 054.6	8081.9	8096.0	8162.7
2025	22 965.5	23 090.5	23 048.0	8028.0	8058.4	8158.9
2026	22 841.1	23 021.2	23 045.0	7984.0	8037.9	8157.5
2027	22 754.2	23 003.9	23 045.1	7574.1	8007.4	8156.9
2028	22 625.3	23 001.0	23 039.7	7528.9	7972.3	8155.6
2029	22 484.4	22 976.3	23 033.4	7486.8	7948.5	8151.9
2030	22 445.5	22 894.8	23 026.4	7402.4	7950.7	8148.4
2031	22 440.2	22 871.8	23 021.6	7303.2	7930.1	8145.9
2032	22 421.1	22 849.4	22 908.7	7208.9	7912.5	8191.4
2033	22 336.2	22 827.9	22 907.4	7177.3	7897.8	8190.4
2034	22 204.6	22 213.3	22 904.9	7127.7	7837.9	8189.5
2035	22 202.2	22 204.3	22 902.9	7082.5	7826.2	8188.8

Source: Calculated by the authors based on Rosstat data (taking into account the entry of 4 new regions into the Russian Federation). Rosstat: Population of the Russian Federation by gender and age. URL: https://rosstat.gov.ru/compendium/document/13284 (accessed on 10.12.2022).

Note: (1) — pessimistic forecast; (2) — probable forecast; (3) — optimistic forecast.

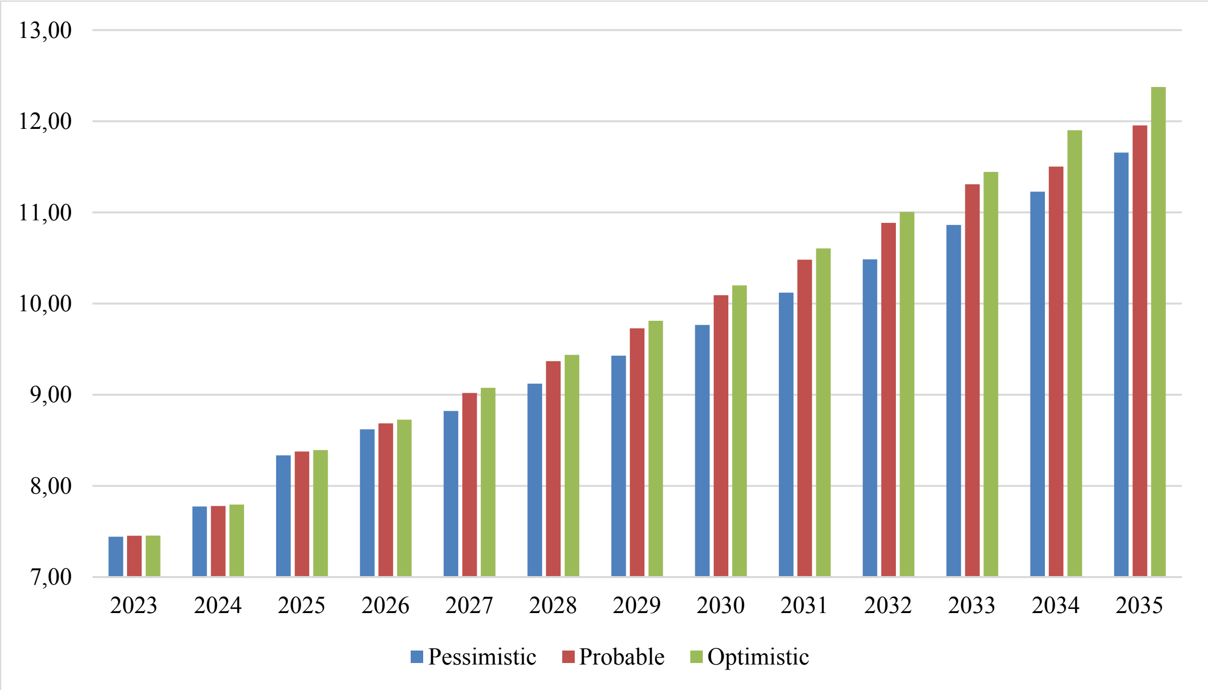

Fig. **The Volume of Financial Support for Expenses on Payment of Insurance Old-Age Pensions (Excluding Early Appointment) in 2023–2035, Trillion Rubles (According to Predictive Models)**

Source: Author's calculations.

As a result of the use of this idea, a dynamic model that determines population dynamics can be presented in the form of:

$$dx_t = \left\{ a_x x_t - d_x x_t^2 + \left[\begin{array}{l} A\dfrac{s_x(t)-s_y(t)}{s_x(t)+s_y(t)} + \\ +B\dfrac{k_x(t)-k_y(t)}{k_x(t)+k_y(t)} \end{array} \right] \dfrac{x_t y_t}{x_t^2+\alpha^2} \right\} dt + b_x dw_t,$$

$$dy_t = \left\{ a_y y_t - d_y y_t^2 + \left[\begin{array}{l} A\dfrac{s_x(t)-s_y(t)}{s_x(t)+s_y(t)} + \\ +B\dfrac{k_x(t)-k_y(t)}{k_x(t)+k_y(t)} \end{array} \right] \dfrac{x_t y_t}{x_t^2+\alpha^2} \right\} dt + b_y dw_t,$$

$$ds_x(t) = b_x s_x(t) k_x(t) \left\{ 1 - \frac{g(t)}{G} \right\} dt + b_{sx} dw_t,$$

$$ds_y(t) = b_y s_y(t) k_y(t) \left\{ 1 - \frac{g(t)}{G} \right\} dt + b_{sy} dw_t,$$

$$dk_x(t) = n_x k_x(t) \{1 - k_x(t)\} dt + b_{kx} dw_t,$$

$$dk_y(t) = n_y k_y(t) \{1 - k_y(t)\} dt + b_{ky} dw_t,$$

$$g(t) = x_t \left[m + s_x(t) \right] + y_t \left[m + s_y(t) \right].$$

In this model, the coefficients c_x and c_y, which determine the rate of population migration from one region of the country to another, are replaced by dynamic expressions that determine the level of well-being of the population and the average level of qualification for each region in the system. Namely: $s_x(t)$ — is the relative surplus per capita in the migratory center of attraction; $s_y(t)$ — is the relatively surplus in the periphery of the attracting center; $k_x(t)$ — is the average level of qualification of the population in the center of migration attraction; $k_y(t)$ — is the level of average qualification for the population at the periphery of the attractive center. The function $g(t)$ models the integral GDP of the attracting center system and its periphery, with the value m determining the minimum GDP required to meet the socio-economic development goals of the system, and the value G — is a certain fundamental limit introduced for the Mir-System [27–29].

Numerical modeling for three different combinations of parameters of the system, allowed to carry out the forecast of life expectancy of the population in the Russian Federation (*Table 1*), as well as pessimistic, probable and optimistic scenarios of forecasts of the dynamics of the change in the number of men and women in Russia pension age up to 2035 (*Table 2*).

It is important to emphasize that these models, on the one hand, do not take into account the early assignment of pensions (due to the large number of grounds and the lack of relevant data from Rosstat), but take into consideration the jumping increase in the population of the country as a result of the accession to the Russian Federation of four new regions in the autumn of 2022 and thus allow to form the most justified recommendations on the management of the system of CPI. Given the differences in life expectancy and the variability of age for old-age pension, it is necessary to forecast the population by gender.

Taking into account the results reflected in *Tables 1* and *2*, a forecast of the amount of expenditure required for the payment of insurance pensions for old age in the Russian Federation for the period up to 2035 was calculated in three variants, taking into consideration the pessimistic, probable and optimistic forecasts (for 2023–2025 the level of inflation reflected by the Ministry of Economic Development of Russia for the relevant period of time, and for subsequent years — at 4%). The results of the calculations are shown in the *Figure* according to the population forecasts.

Accordingly, in the pessimistic version of the population forecast, the amount of expenditure of the budget of the Pension and Social Insurance Fund of the Russian Federation on the payment of insurance pensions (excluding early appointment) for 2023–2035 will increase by 56.67% (which in monetary terms is 4.22 trillion rubles), with a probable — by 60.39% (whose monetary expression is 4.50 trillion rubles) and with a pessimistic — by 66.02% (4.93 trillion rubles). It is important to note that any of the scenarios of the forecast, due to the reduction of the population in the projected period, presupposes an increase in the cost of payment of insurance pensions at rates below inflation (the latter, according to the minimum estimates of the authors of the article, will be 74.76%). This makes it possible to achieve the objectives of the pension system's long-term development strategy, increase pension payments, and preserve a balance between the income and expenses of the Russian Federation's Pension and Social Insurance Fund's budget for insurance pension payments. Thus, taking into account the fact that the amount of expenses of the budget of the Pension and Social Insurance Fund of the Russian Federation on payment of insurance pensions for old age according to the forecasted calculations is below the amount of expenses given by the level of inflation, by 0.7 trillion rubles (optimistic population forecasts) — 1.34 trillion rubles (pessimistic population forecasts), this will solve both problems simultaneously.

CONCLUSION

In the process of the study on the basis of the author's forecast of the population of the Russian Federation for the period up to 2035 was determined the amount of expenses of the budget of the Pension and Social Insurance Fund of Russia on the payment of insurance pensions for old age in three scenarios: optimistic, probable and pessimistic. Calculations showed an increase of 56–67% by 2035 (4.22–4.93 trillion rubles).

The results of the calculations conducted allow, firstly, to ensure the strategic management of the budget of the Russian Social Fund taking into account the current demographic trends, which is especially important in the context of the formation of the system of actuarial calculations, provided by the Federal Law "On the Pension and Social Insurance Fund of the Russian Federation", and, secondly, plan the expenditure of the federal budget on the provision of inter-budgetary transfer for compulsory pension insurance.

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Author's declared contribution:
V.F. Sharov — statement of the problem, critical analysis of the literature, synthesis of the mathematical model, forecasting the population of the Russian Federation.
I.V. Balynin — development of the concept of the article, determination of the forecast amount of budget expenditures of the Social Fund of Russia for the payment of insurance pensions, description of the research results, formation of research conclusions.
M.L. Sedova — collection of statistical data.

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