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Economic determinants of fertility forecasting in Russia

Abstract: The article presents the author's concept of demographic forecasting, which argues that GDP, other macroeconomic and socio-economic (level of life) processes and indices do matter. The purpose of the article is to demonstrate the possibilities of publicly available (which are part of standard mathematic and statistical programs) methods of mathematical statistics to identify economic factors of population reproduction and fertility in particular. The article justifies the possibility of forecasting the total fertility rate (TFR) on the basis of macroeconomic forecasts of the dynamics of the gross national product (GDP) and other key economic indicators.

Key words: population; demographic forecast; fertility forecast, demographic and economic factors of fertility

JEL codes: J10, J11

Fertility in the Russian Federation in the last 30 years has gone through several stages. In 2000-2010, the total number of births, the crude birth rate and other general indicators experienced periods of growth and stagnation and are now in a state of decline. Having reached the maximum value of 1,943 thousand people in the last decades in 2014, the absolute number of births began to decrease, and in 2017, when this figure decreased to 1,690 thousand people, the rate of reduction was the greatest. In January-April 2018, the decline in the birth rate continued, for the first time in recent years there was an increase in the overall mortality rate, and the negative natural growth of the population was not compensated by migration. The main object of the study in this article is the total fertility rate of the conditional generation (hereinafter — TFR), which we consider as an integral indicator of the fertility situation in the Russian Federation. According to Rosstat, the TFR began to decline in 2015, when it was 1.78 and in 2017 it decreased to 1.62.

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Among the components that make up the TFR, most significant are age-specific fertility rates in the most active age group of women of 25-29 years and in the group that is second by significance, but at the same time representative, in terms of family reproductive plans, of the 20-24 age group. In the 25-29 age group, the number of births per 1,000 women rose from 63.7 in 1999 to 112.6 in 2015, after which a decline began. In the 20-24 age group, the number of births as a whole decreased in the 1990-s - early 2000s, then in 2006-2015 it fluctuated in the range of 88-90, in 2016 it amounted to 87.2.

In 2016, mothers aged 20-24 gave birth to 18.3% of all children born in Russia, mothers aged 25-29 — to 35.3% of all children, aged 30-34 — to 27.7%. The average age of the mother at the birth of a child, which was 27.7 years in 2010, reached 28.4 years by 2016 and tended to rise steadily. In the coming years, it may exceed 29 years. According to Rosstat data, the lower point of decline in the number of women of a childbearing age now falls into the age of 20 years. After 20, namely in the category of 20-24, we observe the first, youngest, active birth group (mainly firstborn). Thus, it is possible to assume that in the next 4-5 years the decline of total fertility rates in the "younger" group will slow down. But the slowdown, and under favourable conditions — the end of the general decline in fertility, can be expected only when the wave of growth in the number of women of childbearing age reaches 29-30 years, i.e. will exceed the modal value of the maximum birth age (the highest average age of the mother at the birth of the child). Influence of marriage, divorce, migration and other issues are not discussed in this article. We set very modest objectives — to determine the dependence of the TRF on the GDP and a number of other economic factors [General Results..., 2018]. The demographic situation is of concern, especially with regard to fertility.

Let's move on to the issues of relevance of the forecast of the TFR in the given period, a summary of the conclusions from the classification of factors and the pair correlation between them and then to the calculations of the perspective TFR on the basis of regression models.

Upcoming requirements of society to demographic policy are formulated by the Decree of the President of the Russian Federation of May 7, 2018. № 204 "On national goals and strategic objectives of development of the Russian Federation for the period up to 2024", which contains the paragraph 1a: "The Government of the Russian Federation is to ensure the achievement of the following national development goals of the Russian Federation for the period up to 2024: a) ensuring sustainable natural growth of the population of the Russian Federation". The main provisions of the Decree № 204 are specified in the "Main directions of activity of the Government of the Russian Federation for the period up to 2024" (ONDP-24), which states: "To ensure natural growth of the population of the Russian Federation and increase life expectancy, it is

necessary to achieve: an increase of the birth rate and *increase in the total fertility rate to a level no less than 1.7*" [Main directions..., 2018].

The task is set at the state level, we will refrain from judging whether the government is able to solve it (about which discussion in the expert community is already underway). Let's consider this issue only from the viewpoint of our research — to what extent will the macroeconomic factors we highlighted be able to accelerate or slow down the growth of the birth rate.

Fertility factors influencing the demographic system "externally" can be divided into socio-psychological, not subject to direct statistical observation, and economic, which could be analyzed and forecasted in terms of relevant statistical indicators. The most important external socio-psychological factor is "life satisfaction" and "confidence in the future" of the population. As evidence, we will refer to the survey conducted by Rosstat "Results of the sample survey 'Family and Fertility' (2009) [http://www.gks.ru/free_doc/2010/family.htm], where "non-confidence in the future" is ranked second after "financial problems" among the factors which impede women to give birth to as many children as they wish, however, there were sufficient studies with calculations of similar wording.

As it is seen from many sociological surveys, housing is a particularly important factor among socio-economic factors of fertility. It is consistently on one of the first in significance according to the results of sociological surveys and at the same time has a statistical content - an indicator of the number of square meters of housing per capita which is regularly published by Rosstat. However, this indicator is difficult to use to predict fertility because it is not part of the official projections of the main economic and standard of living indicators.

The most important macroeconomic factor in the development of demographic processes is the GDP, both in terms of per capita and in terms of dynamics. The GDP represents both the level and dynamics of economic development, that is, the potential amount of resources for carrying out demographic policy, and the standard of living of the population. This is the interpretation of GDP per capita in the methodology for calculating the United Nations HDI index. The GDP at comparable prices (at purchasing power parity) can also be used for TFR analysis by country, and the gross regional product (GRP) may be used for TFR analysis by regions of the Russian Federation. But the main value of the GDP for this study is that it is present in all official forecasts of socio-economic development of the Russian Federation.

The Passport of the National Project "Demography" contains the rules of financing of the Federal project "Financial support for families at childbirth" for 2019-2024. [Passport of the National Project "Demography", 2018], but there are no retrospective data on this expenditure line that we could use to identify the statistical relationships of these expenditures with basic fertility rate indicators. There are no such data in the reporting documents on the implementation of the Concept of Demographic Policy of the Russian Federation for the Period up to

2025 [The Concept of Demographic Policy. 2007], which were published annually by the Ministry of Labour and Social Protection of the Russian Federation. The composition of the reporting data of Rosstat on the "Family and maternal benefits" line for 2011-2016 does not coincide with the composition of planned expenditures under the National Project "Demography".

Therefore, of all the socio-economic indicators that have in retrospect influenced fertility, in the forecasting of the TFR, we can rely only on the forecast of GDP until 2024 [Forecast of socio-economic development of the Russian Federation for the period up to 2024. 2018] and draft budget expenditures (including social and cultural events) until 2021 [Draft of the main directions of the budget... 20 18]. Only statistical indicators, including macroeconomic indicators, which have fully comparable retrospective series and, at the same time, perspective series included in the official forecasts of the Ministry of Economic Development, the Ministry of Finance or Rosstat, are indeed suitable for fertility forecasting, and these indicators should not be collinear (methodically and statistically related among themselves). Therefore, the regression equations for fertility forecasting are mainly based on the volume of the GDP, taking into account the forecasts of its evolution over the years in the future.

Here is a list of indicators used in the calculation of correlation coefficients and coefficients matrices, which, due to their large volume, had to be divided into 3 blocks.

1. *Crude birth rate in ppm (births per 1,000 of population).X1.*
2. *Total fertility rate (children per woman) X2.*
3. *Birth rate by age: children per 1000 women aged 20-24 X3*
4. *Birth rate by age: children per 1000 women aged 25-29 years X4*
5. *Birth rate by age: children per 1,000 women aged 30-34 X5*

Among the factors that can be obtained from actual statistics and which we need to check for their impact on the resulting indicators, we shall include the following:

6. *The proportion of women aged 25-29 in the total number of women of reproduction age 15-49, in shares of one X6.* This indicator shows the passage and amplitude of the "demographic wave". Of course, this is a very rough and approximate indicator of the "demographic wave".
7. *Change in GDP relative to the previous year, times X7*
8. *GDP in 1990 prices, thousand rubles per capita X8*
9. *Expenditures of the consolidated budget in 1990 prices, thousand rubles per capita X9*
10. *Expenditures of the consolidated budget for social and cultural events in 1990 prices, thousand rubles per capita X10*
11. *Consumer Prices Index in relation to the previous year, times X11*
12. *Average monthly income of the population in 1990 prices, rubles per capita X12*

13. *Share of population with income below the subsistence minimum, share of one X13*
14. *The ratio of the size of the parent capital (since 2007) and the subsistence minimum, times X14*
15. *The ratio of the amount of the benefit for the care of a child up to 1.5 years (since 2007 the benefit for the care of the first child) and the subsistence minimum, times X15*
16. *Ratio of lump sum allowance at birth of a child and subsistence minimum, times X16*
17. *Ratio of birth certificate (since 2006) and subsistence minimum X17*
18. *Unemployment rate (according to surveys) to the number of economically active population, percentage X18*
19. *Housing provision, square meters per capita X19*

Verification of statistical relationships between the X1-X19 indicators was performed in the *StaDia* 5.0 program by calculating linear correlation coefficients. According to the estimate of *StaDia* 5.0 for statistical series for 1991-2017 (26 numbers per row, exceptions: 11 *X*14 numbers, 12 *X*17 numbers), the critical value taking into account the correction for multiple comparisons was 0.690. That is, correlation coefficients exceeding this value can be considered significant. In the correlation coefficient matrix (tables 5-6) the number of significant coefficients is 77 (45%), also, a high correlation (>0.95) was observed in 12 cases and a fairly high correlation (>0.90) in another 26 cases.

The correlation coefficient matrix contains formal confirmation of many economic relationships, including those that are intuitive and generally accepted — for example, between GDP per capita and per capita budget expenditure, and those that rarely fall within the scope of expert analysis. However, we did not aim to analyze all 77 significant correlation coefficients in the 19*19 matrix and focused on the structure of statistical dependencies in which the resulting birth rate indicators *X*1-*X*5 interacted with factor indicators *X*6-*X*19.

Let us characterize the TFR from the point of view of its connection with other indicators.

We note the positive relationship of the TFR with macroeconomic indicators of GDP per capita (*X*8), budget expenditures per capita (*X*9), budget expenditures on social and cultural activities per capita (X10), monetary income per capita (*X*12) and housing in square meters per capita (*X*19). And we note a negative connection with such macroeconomic indicator as the unemployment rate (*X*18).

Furthermore, we consider the equations of regression relationships between the listed indicators and the main results of calculations for these equations. Here is an example of the development of the equation of multiple linear regression for the purposes of analysis and prediction of the TFR. As already shown, the TFR, which we will consider as a dependent variable, is correlated to a number of

independent variables. These are GDP per capita (GDPpc), budget expenditure per capita (BEpc), provision of housing in square meters per capita (PHpc).

The results of selection by means of mathematical and statistical program of linear equation coefficients produced on the basis of time series for 1991-2017 are as follows:

$$TFR = 1.235 + 0.00015 * GDPpc + 0.00011 * BEpc + 0.00299 * PHpc \quad (1)$$

where: GDPpc - GDP in 1990 prices, thousand rubles per capita; BEpc — expenditures of the consolidated budget in 1990 prices, thousand rubles per capita; HPpc - housing provision, square meters per capita.

Statistical criteria: Determination coefficient R2 = 0.854; Hypothesis of the statistical program: "The regression model is adequate to experimental data"

Equation 1 covers only a part of the factors influencing the TFR, but its verification on 2017 reporting data gives a TFR of 1,625, against the reported 1,621, which means a fairly acceptable accuracy. Further, the calculation was made on the basis of the hypothesis of maintaining the GDP growth rate at 1.5% and the GDP deflator at the level of 2017. The indicators of per capita consolidated budget expenditures and housing provision for 2018-2024 were extrapolated based on the reporting indicators for 2013-2017. The result is the possibility of reaching a TFR level equal to 1.671 by 2024, which is close enough to the standard of ONDP-2024, which is 1.7. If scenario conditions change — the annual GDP growth increases from 1.5% to 3.0-3.3% (in accordance with the approved official forecast to 2024) and the trajectory of too optimistic extrapolation of the estimation of per capita budget expenditure decreases, taking into account the uncertainty of the perspective of the impact on GDP and TFR of the increase in the retirement age, and the expected positive impact of the National Project "Demography" measures — the normative coefficient of 1.7 can be reached earlier or later, compared to the hypothesis of our model (equation) 1. The influence of the main socio-psychological factor "confidence in the future", which is not digitized and is external to regression model (1) remains indefinite (and not taken into account). *However, model (1) suggests that the growth of socio-economic indicators can slow down the decline or return the CBR to the growth trajectory.*

The problem of using such a model for forecasting is that some of the indicators needed for the calculation are not developed for the future. In particular, GDP is calculated for the long-term (currently a forecast to 2024 is approved, previously approved forecasts to 2030 are outdated and their use is inexpedient), per capita budget expenditures are usually available within 3 years of the budget plan, the population required for the calculation of per capita indicators is calculated by Rosstat in 3 variants until 2036.

Table 1. Calculation of the TFR by equation (1)

Years	Reporting data				Calculation of the TFR by equation (1)
	Total fertility rate TFR	GDP per capita	Per capita budget expenditure	Housing provision in square meters per capita	
2013	1.707	4915	3913.6	23.4	
2014	1.750	4941	3967.5	23.7	
2015	1.777	4731	3883.3	24.4	
2016	1.762	4701	3944.2	24.9	
2017	1.621	4781	3821.4	24.9	1.625
	Extrapolation				
2018		4853	3989.1	25.3	1.640
2019		4926	4026.1	25.7	1.644
2020		4999	4063.1	26.0	1.649
2021		5074	4100.1	26.4	1.654
2022		5150	4137.1	26.7	1.660
2023		5228	4174.1	27.0	1.665
2024		5306	4211.0	27.4	1.671

Some other indicators for the long-term are calculated by departments and are not combined into a single system available for use, they are not included in the forecast of the Ministry of Economic Development until 2024. For example, the housing index, which has a strong impact on fertility, both in our correlation calculations and in sample surveys, is not available in the forecast of the Ministry of Economic Development until 2024. For some indicators, which are of importance for birth rate forecasting, on the contrary, approved standards for the future are available, but there are no data series published by Rosstat for the retrospective period, on the basis of which it would be possible to build a model (this means expenditures for the national project "Demography").

As a result, the methodological limitations for applying model (1) are as follows: 1) per capita housing provision in square meters for the period up to 2024 in the approved forecast is absent (it is necessary to replace official data with extrapolation); other indicators that have high positive correlation with the TFR, can also be determined for the future only by extrapolation, which is not desirable; 2) per capita budget expenditures in the Draft Budget until 2021 [Draft of the main..., 2018:15] are presented only for the federal budget, and our retrospective calculations are based on the full consolidated budget reporting data. However, the goal of our study and this article is to find a correlation between

the prospects of fertility and the officially approved scenarios of the Ministry of Economic Development. Therefore, we decided to perform future calculations on the basis of indicators according to the approved forecast until 2024.

In the construction of model (2) we used the TFR as a dependent variable, and GDP per capita, monetary income per capita and the level of unemployment as % of the labour force as independent variables (predictors). Monetary income of the population, in addition to GDP, is determined by the institutional and sectoral structure of the economy, fiscal policy, social policy and other factors. Therefore, we consider it possible to use these indicators simultaneously as independent variables of the regression model. Unemployment is also determined by a multitude of economic, social and demographic factors other than the level or GDP dynamics.

While constructing equation (2) we took into account that all indicators used as independent variables have not only retrospective series from 1991-1992 to 2017, but are also included in the set of indicators of the forecast of the Ministry of Economic Development for the period up to 2024.

$$TRF = 0.3629 + 0.000314 * GDPpc + 0.00091 * MIpc - 0.02119 * UR\% \quad (2)$$

where: GDPpc - GDP in 1990 prices, thousand rubles per capita; MIpc - average monthly monetary income of the population in 1990 prices, rubles per capita; UR% — unemployment rate, as a percentage of the labour force

Statistical criteria: Determination coefficient R2 = 0.854; Hypothesis of the statistical program: "The regression model is adequate to experimental data."

Thus, according to model (2), based on a conservative GDP forecast version, monetary income and unemployment projections, excluding the negative impact of factors external to model (2) the total fertility rate can reach 1.805 by 2024, and on the basis of the basic version of the Ministry of Economic Development — 1.833. (Tables 2 and 3).

Table 2. The version of TFR calculation according to equation (2) Conservative forecast of the Ministry of Economic Development till 2024.

Years	Reporting data				Calculation of the TFR by equation (2)
	Total fertility rate TFR	GDP per capita	Monetary income per capita	Unemployment rate as a percentage of the labour force	
2013	1.707	4915	365	5.5	
2014	1.750	4941	351	5.2	
2015	1.777	4731	341	5.6	
2016	1.762	4701	326	5.5	

End of table 2

Years	Reporting data				Calculation of the TFR by equation (2)
	Total fertility rate TFR	GDP per capita	Monetary income per capita	Unemployment rate as a percentage of the labour force	
2017	1.621	4781	326	5.1	1.589
	Calculation based on the conservative version of the forecast to 2024				
2018		4866	337	4.8	1.605
2019		4911	339	4.9	1.617
2020		5004	345	4.8	1.642
2021		5130	351	4.8	1.676
2022		5279	358	4.7	1.716
2023		5440	365	4.7	1.760
2024		5608	374	4.7	1.805

The current downward trend in the conservative forecast is reversed in 2020, in the base forecast — in 2019. We will emphasize once again that the main driver of TFR growth within the framework of this model is the dynamics of GDP, many other indicators, including measures of demographic policy, remain beyond it's scope. Therefore, the results obtained above a level of TFR of 1.8 are unlikely in terms of qualitative expert assessment. But for us, the most important results of calculations are the conclusions that economic processes positively influence the dynamics of the birth rate and enable partial compensation of both negative impact of the demographic waves and socio-psychological processes (lack of motivation in terms of "confidence in the future") and create a macroeconomic basis for the implementation of the State budget expenditure on population policy activities.

Table 3. TFR calculation version based on equation (2) Basic forecast of the Ministry of economic development to 2024.

Years	Reporting data				Calculation of the TFR by equation (2)
	Total fertility rate TFR	GDP per capita	Monetary income per capita	Unemployment rate as a percentage of the labour force	
2013	1.707	4915	365	5.5	
2014	1.750	4941	351	5.2	
2015	1.777	4731	341	5.6	
2016	1.762	4701	326	5.5	

End of table 3

Years	Reporting data				Calculation of the TFR by equation (2)
	Total fertility rate TFR	GDP per capita	Monetary income per capita	Unemployment rate as a percentage of the labour force	
2017	1.621	4781	326	5.1	1.589
	Calculation based on the base version of the forecast to 2024				
2018		4866	337	4.8	1.605
2019		4925	340	4.8	1.621
2020		5024	346	4.7	1.647
2021		5181	354	4.7	1.689
2022		5349	362	4.6	1.734
2023		5528	371	4.6	1.783
2024		5715	380	4.6	1.833

The simplest version of the linear regression model is built by us on the basis of comparison of the TFR and the main macroeconomic indicator — the GDP. The use of GDP as an independent variable solves questions of collinearity of indicators and simplifies the procedure of forecasting the TFR, because predictions of the main macroeconomic display are always available and regularly updated, regardless of the degree of detail and timing of the development of other indicators of forecasts of the Ministry of Economic Development.

$$TFR = 0.0002 * GDPpc + 0.7913 \quad (3)$$

where: GDPpc - GDP in 1990 prices, thousand rubles per capita; $R^2 = 0.8059$; Hypothesis of statistical program: "The regression model is adequate to experimental data".

The results of model 3 calculations corresponding to the basic and conservative versions of macroeconomic forecasts of the Ministry of Economic Development are shown in table 4.

From the calculations based on model 3 it can be concluded that despite a fairly high coefficient of determination, model (3), along with advantages (ease of use) has certain disadvantages. Retrospective validation on the reporting data gives a significant overstatement of the results for 2017: 1.748 versus 1.621. However, the model shows that if GDP projections are implemented, the TFR will rise by about 0.2 points, which is a satisfactory result consistent with the approved ONDP-2024 plan. By the way, the deviation of retrospective calculations for 2017 for models (2) and (3) can be interpreted as follows: this could be the total fertility rate in the Russian Federation, if it was formed only under the influence

of economic factors, if other factors ("confidence in the future", changes in the age structure of the population in the part in which they have an impact on age-specific fertility rates) did not act in the opposite direction, on the reduction of the stated indicator.

Table 4 shows that five versions of the estimate of the total fertility rate, based on various combinations of economic factors and the forecasts of the Ministry of Economic Development, show that in the period to 2024 the downward trend of this indicator should be replaced by an upward trend. Of course, for this, there must be a radical improvement in the economic situation, which is laid down in the conservative and basic versions of the forecast approved by the Ministry of Economic Development. At the same time, socio-psychological and demographic factors external to our models, which lower the TFR, should be compensated by measures of social and demographic policy, which are recorded in ONDP-2024.

For comparison with our projections, table 4, in addition to our calculations, contains the latest version of the official demographic forecast, adjusted by Rosstat in October 2018, after the signing of the Decree of the President of the Russian Federation of May 7, 2018 № 204 "On national goals and strategic objectives of development of the Russian Federation for the period up to 2024" [Decree..., 2018: 10] and "Main directions of activity of the Government of the Russian Federation for the period up to 2024" [Main directions..., 2018: 11]. As can be seen from this comparison, despite significant differences in the projection methodology, our 2024 calculations for at least model 1 lie between the medium and high versions of Rosstat's forecast.

Table 4. Versions for the forecast of the total fertility rate for the period up to 2024 according to models 1-3 on the basis of conservative and basic versions of the forecast of the Ministry of Economic Development and 3 versions of Rosstat's forecast

	Model (1)	Model (2)		Model (3)	
		Conservative version	Basic version	Conservative version	Basic version
2018	1.640	1.605	1.605	1.765	1.765
2019	1.644	1.617	1.621	1.774	1.776
2020	1.649	1.642	1.647	1.792	1.796
2021	1.654	1.676	1.689	1.817	1.827
2022	1.660	1.716	1.734	1.847	1.861
2023	1.665	1.760	1.783	1.879	1.897
2024	1.671	1.805	1.833	1.913	1.934
		Rosstat, 2018			
		Low version	Medium version	High version	
2018		1.587	1.600	1.628	

End of table 4

	Model (1)	Model (2)		Model (3)	
2019		1.587	1.610	1.633	
2020		1.540	1.599	1.658	
2021		1.490	1.583	1.675	
2022		1.495	1.598	1.700	
2023		1.514	1.616	1.717	
2024		1.535	1.639	1.742	

Practical conclusions from our study are that strong economic growth in the long-term up to 2024 could slow down the decline in the TFR and according to some of our calculations, deploy it upwards. This will not be able to fully compensate for the negative impact on the overall birth rate of the passing demographic wave but will be able to reduce its amplitude. Conversely, continued economic stagnation could deepen the demographic wave (recession), as already happened in the 1990s.

Statements and opinions expressed in the article are those of the author and do not necessarily reflect the official position of the Population and Economics Editorial Board.

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