Model of Demographic Processes Management in Russia on the Basis of Statistical Factors of Fertility

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Abstract. Statistical study of the level and dynamics of the birth rate of the population occupies an important place in the analysis of the socio-economic development of society. The task is to study the influence of certain factors on the level of fertility in the Russian Federation, by building a statistical model based on the example of the subjects of the Russian Federation for 2016. On the basis of the general system of indicators, a private one is formed, which, in our opinion, most objectively reflects the variation of the feature and, taking into account the analysis made for the existence of multicollinearity, a model based on the method of least squares has been developed. The analysis was carried out by estimating the coefficients and selecting the significant factors. The significance of the model as a whole is verified using the Fisher criterion. Thus, the analysis of the relationship between the birth rate, revealed the factors that most influenced it and formed a model in accordance with which it will be possible to plan the development of the social sphere.

1. Introduction

The Fertile component of social relations and the structure of society was relevant in all historical epochs for all states. She was invariably given great importance in resolving issues of public administration, which predetermined the need to create a reliable information base, which is the population statistics. Fertility refers to mass phenomena and has a pronounced statistical character. In order to reveal the regularity of this phenomenon and the processes associated with it, it is necessary to generalize data on the totality. The complexity of modern fertility rates, the debatable nature of many scientific and practical problems in the field of childbearing development objectively require combining the efforts of different sciences to solve the problem of scientific comprehension of the realities of fertility, elaborating concepts of demographic development not only at the country level but also on a global scale.

The relevance of this work is because the statistical study of the level and dynamics of the birth rate of the population occupies a traditionally important place in the analysis of the demographic and, in a broader sense, the socioeconomic development of society. The increased attention of scientists and practitioners to the analysis of the birth rate is due to two objective reasons. On the one hand, fertility is considered the primary natural demographic process, without which neither mortality, nor marriage, divorce, nor migration are possible afterwards. On the other hand, the role of fertility in human society is incommensurable with any other phenomenon or process. Its importance and peculiarity can be traced in the global, economic and social aspects.
The task of this paper is to construct an optimal model for analyzing the birth rate in the Russian Federation because of data on fertility in the regions for 2017.

Because now the childbearing age includes people who were born at the time of the demographic hole, the birth rate will decrease if the state does not take measures to stimulate the birth of second and subsequent children. Therefore, this work is actual

The level of fertility and its dynamics are closely linked with the socio-economic development of society. With the formation of society, the improvement of its productive forces and, of course, directly the person himself, the development of his intellectual potential, the changing role of women in society and the family, the changing role and functions of the family, the progressive process of reducing fertility has become natural. It is possible to comprehend the causes of the evolution of fertility only by carefully studying the influence on the development of this process of a whole system of factors. At present, Doctor of Economic Sciences Karmanov M.V. identifies several groups of factors that determine the level of fertility and its change in one direction or another:[3]

1) natural-biological factors:
   - heredity,
   - ecological situation, physical environment. Here you can highlight the climate
   - biological rhythms, etc.
2) socio-economic factors:
   - Living standards of the population. The level of welfare of the population and the birth rate in the country are related by the inverse correlation dependence, that is, paradoxically, but in families with higher incomes, the birth rates in all age groups are lower than in families with lower incomes. Many authors explain this by the consequence of higher cultural and economic demands for women with high incomes, their large employment.
   - the level of satisfaction of the material and cultural needs of the population. As the previous factor has a reverse effect on the birth rate. The higher the degree of satisfaction of any needs in society, the greater the opportunities for a woman to realize herself in some other sphere besides the birth and upbringing of children.
   - religious traditions that determine the reproductive behavior of the population. Many religions prohibit the application of measures to regulate the number of children in the family, thereby contributing to high fertility rates.
   - development of the health care system.
   - providing the population with children’s institutions.
   - the social status of women, employment in social production.
   - legislation that determines the country's demographic policy.
   - wars and other factors.
3) Demographic (structural) factors: sexual, age, marriage, territorial, national, etc. population composition. The main objective demographic factor of fertility is the composition of the population by sex and age. The higher the proportion of women of the most fertile age, in the female population and in the entire population as a whole, the higher the birth rate, respectively. However, children are born mainly in marriage, and the number of women who are married or the number of potential suitors determines wishing to join it.[4]

This system of indicators, although it is the most complete, but on its basis it is impossible to make a full evaluation of this phenomenon. Since not all features have a numerical rating and are published. Therefore, because of a common system of indicators, we have formed a private system, where:

- X1 - Share of household consumption expenditures on food purchases %
- X2 - Ratio of marriages and divorces, per 1000 divorces
- X3 - Unemployment rate, %
- X4 - GRP per capita, rubles
- X5 - Share of household consumption expenditures on the purchase of alcoholic beverages
- X6 - The total area of residential premises, an average of one inhabitant, square meters
X7 - Coverage of the population by television and radio broadcasting in 2016, % of the total population, have the opportunity to receive TV
X8 - Total mortality rates per 1000 population
X9 - Number of own cars per 1000 population, at the end of the year

The factor of fertility is a factor. On the basis of these indicators, a matrix of pairwise correlation coefficients was constructed (Table 1).

Table 1. Matrix of Pairwise Coefficients of Correlation.

|     | y    | x1    | x2    | x3    | x4    | x5    | x6    | x7    | x8    | x9    |
|-----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| y   | 1,00 |       |       |       |       |       |       |       |       |       |
| x1  | -0,21| 1,00  |       |       |       |       |       |       |       |       |
| x2  | -0,54| -0,27 | 1,00  |       |       |       |       |       |       |       |
| x3  | 0,52 | 0,21  | -0,55 | 1,00  |       |       |       |       |       |       |
| x4  | 0,30 | -0,15 | 0,27  | -0,16 | 1,00  |       |       |       |       |       |
| x5  | -0,22| -0,26 | 0,42  | -0,49 | 0,21  | 1,00  |       |       |       |       |
| x6  | -0,66| 0,10  | 0,59  | -0,58 | -0,06 | 0,15  | 1,00  |       |       |       |
| x7  | -0,21| -0,19 | -0,03 | -0,12 | -0,59 | -0,05 | 0,16  | 1,00  |       |       |
| x8  | -0,61| 0,06  | 0,39  | -0,50 | -0,23 | 0,31  | 0,60  | 0,03  | 1,00  |       |
| x9  | -0,39| -0,16 | 0,49  | -0,39 | 0,00  | 0,25  | 0,55  | 0,33  | 0,25  | 1,00  |

Because multicollinearity is absent (namely, all correlation coefficients between factors less than | 0.7 |) and the signs have a significant effect on the resultant characteristic, the regression analysis will be carried out for all factors.

Table 2. OLS, observations of 1-85. Dependent variable: y.

| Coefficient | Standard Error | t-statistics | P-value |
|-------------|----------------|--------------|---------|
| const       | 21,5910        | 4,06989      | 5,305   | <0,0001 *** |
| x1          | -0,0406144     | 0,00893253   | -4,547  | <0,0001 *** |
| x2          | -0,00969375    | 0,00193830   | -5,001  | <0,0001 *** |
| x3          | 0,167468       | 0,0579867    | 2,888   | 0,0051 ***  |
| x4          | 1,29181e-06    | 3,36080e-07  | 3,844   | 0,0003 ***  |
| x5          | -0,00459231    | 0,303420     | -0,01514| 0,9880     |
| x6          | -0,0368626     | 0,0715088    | -0,5155 | 0,6077     |
| x7          | -0,00506159    | 0,0354425    | -0,1428 | 0,8868     |
| x8          | -0,116840      | 0,0738298    | -1,583  | 0,1177     |
| x9          | -0,00111678    | 0,00281498   | -0,3967 | 0,6927     |

The model as a whole is significant, since the P-value is less than 5%. The variables x1, x2, x3, x4 are significant with a probability of 99%, and the variables x5, x6, x7, x8, x9 are not significant. Eliminate this method of "top-down". The resulting model is as follows (Table 3).
### Table 3. OLS, observations 1-85. Dependent variable: y.

| Coefficient | Standard Error | t-statistics | P-value |
|-------------|----------------|--------------|---------|
| const       | 24,7831        | 1,12091      | 22,11   | <0,0001 *** |
| x1          | -0,0336468     | 0,00878495   | -3,830  | 0,0003 ***  |
| x2          | -0,0113222     | 0,00195982   | -5,777  | <0,0001 *** |
| x3          | 1,34938e-06    | 2,45801e-07  | 5,490   | <0,0001 *** |
| x4          | -0,178244      | 0,0577333    | -3,087  | 0,0028 ***  |
| x5          | 24,7831        | 1,12091      | 22,11   | <0,0001 *** |
| x6          | -0,0336468     | 0,00878495   | -3,830  | 0,0003 ***  |
| x7          | -0,0113222     | 0,00195982   | -5,777  | <0,0001 *** |
| x8          | 1,34938e-06    | 2,45801e-07  | 5,490   | <0,0001 *** |
| x9          | -0,178244      | 0,0577333    | -3,087  | 0,0028 ***  |

Average dependent variables 13,04353

| Average dependent variables | Standard deviation of dependent 2,329441 variables |
|-----------------------------|-----------------------------------------------|
| 157,4784                    | 1,403026                                      |
| 0,654508                    | 0,637233                                      |
| 37,88842                    | 9,37e-18                                      |
| -146,8169                   | 303,6337                                      |
| 315,8470                    | 308,5462                                      |

Thus, the model describes a 65.5% variation in the birth rate due to the data indicative of a 34.5% variation due to unaccounted traits.

In order to assess the quality of the model, several tests are necessary. Let's check the presence of heteroscedasticity in the model with the help of tests by White and Breusch-Pagan, in order to make sure that the estimates of this model are consistent, effective and not biased (Table 4).

### Table 4. White's test for Heteroscedasticity of OLS, observations 1-85. Dependent variable: uhat ^ 2.

| Coefficient | Standard Error | t-statistics | P-value |
|-------------|----------------|--------------|---------|
| const       | 57,429         | 10,57        | 5,433   | 7,59e-07 *** |
| x1          | -0,0767431     | 0,195643     | -0,3923 | 0,6961       |
| x2          | -0,0204524     | 0,02031      | -1,007  | 0,3174       |
| x4          | 3,16E-05       | 9,35E-06     | 3,379   | 0,0012***    |
| x6          | -4,11768       | 0,996149     | -4,134  | 0,976e-05*** |
| sq_x1       | -8,04E-05      | 0,00215502   | -0,03731| 0,9703       |
| X2_X3       | 0,0005533438   | 0,000253144  | 2,186   | 0,0321 **    |
| X2_X4       | 1,37E-07       | 6,00E-08     | 2,285   | 0,0253 **    |
| X2_X5       | -0,0137411     | 0,00725446   | -0,0137411 | 0,0623 *   |
| sq_x2       | 4,12E-05       | 3,38E-05     | 1,221   | 0,2261       |
| X3_X4       | -3,00E-08      | 1,97E-08     | -1,528  | 0,131        |
| X3_X5       | -0,00132578    | 0,00178568   | -0,7425 | 0,4603       |
| sq_x4       | 1,16E-13       | 8,87E-13     | 0,131   | 0,8961       |
| X4_X5       | -5,10E-07      | 3,59E-07     | -1,419  | 0,1603       |
| sq_x6       | 0,103326       | 0,0291433    | 3,545   | 0,0007       |
Unsent R square = 0.540585
Test statistics: TR^2 = 45,949,754,
P-value = P (Chi-square (14)> 45.949754) = 0.000029
After analyzing the remnants from the model, we can say that heteroscedasticity is not found. The estimated probability of making an error is 0.000029 (Table 5)

Table 5. White test for heteroscedasticity (squares only) OLS, we used observations 1-85. Dependent variable: uhat^2.

| Coefficient | Standard Error | t-statistics | P-value |
|-------------|----------------|--------------|---------|
| const       | 55,9135        | 11,1847      | 4,999   | 3,60e-06 *** |
| x1          | 0,168307       | 0,0739955    | 2,275   | 0,0258 **    |
| x2          | 0,016444       | 0,0164182    | 1,002   | 0,3197       |
| x4          | -1,71393e-07   | 1,45E-06     | -0,1180 | 0,9064       |
| x6          | -4,38952       | 1,03104      | -4,257  | 5,85e-05 *** |
| sq_x1       | -0,00439155    | 0,00164414   | -2,671  | 0,0092 ***   |
| sq_x2       | -1,59743e-0    | 1,43E-05     | -1,117  | 0,2676       |
| sq_x4       | 0              | 3,20E-13     | 0,1709  | 0,8648       |
| sq_x6       | 0,0813762      | 0,0205028    | 3,969   | 0,0002***    |

Uncorrected R-square = 0.378573
Test statistics: TR^2 = 32,178693,
P-value = P (Chi-square (8)> 32.178693) = 0.000087
On the basis of White's test for squares of residues, we can also say that there is no heteroscedasticity (p-value = 0.000087) (Table 5)

Table 6. Brusch-Pagan test for heteroscedasticity OLS, we used observations 1-85. Dependent variable: Scaled uhat^2.

| Coefficient | Standard Error | t-statistics | P-value |
|-------------|----------------|--------------|---------|
| const       | 6,89933        | 1,32983      | 5,188   | 1,57e-06 *** |
| x1          | -0,00594385    | 0,0104224    | -0,5703 | 0,5701       |
| x2          | -0,00410309    | 0,00232511   | -1,765  | 0,0814 *     |
| x4          | 1,56E-07       | 2,92E-07     | 0,5334  | 0,5953       |
| x6          | -0,129357      | 0,0684941    | -1,889  | 0,0626 *     |

The sum of squares explained is = 57.8519
Test statistics: LM = 28,925,948,
P-value = P (Chi-square (4)> 28.925948) = 0.000008
Because of Table 6, it can be said that the estimates of the obtained model are effective, since according to the results of the Breusch-Pagan test, the model lacks heteroscedasticity.
Table 7. Brusch-Pagan test for heteroscedasticity OLS, we used observations 1-85. Dependent variable: Scaled uhat \(^2\) (robust version of Koenker) 2.

| Coefficient | Standard Error | t-statistics | P-value |
|-------------|----------------|--------------|---------|
| const       | 10.9296        | 2.46376      | 4.436   | 2.89e-05 *** |
| x1          | -0.0110121     | 0.0193094    | -0.5703 | 0.5701      |
| x2          | -0.00760174    | 0.0043077    | -1.765  | 0.0814 *    |
| x4          | 2.88E-07       | 5.40E-07     | 0.5334  | 0.5953      |
| x6          | -0.239657      | 0.126898     | -1.889  | 0.0626 *    |

The sum of squares explained is 198,574
Test statistics: LM = 17.593246,
P-value = P (Chi-square (4) > 17.593246) = 0.001482

Analyzing the Bruesh Pagan test (robust version of Cohenker), we see an analogous variant that p = value is less than the test statistic and is 0.001482.

Based on the results of the study of the remnants of the model for heteroscedasticity with the help of the test of White and Breusz Pagan, one can say that in this model heteroscedasticity is not found, the model estimates are unbiased, effective and well off.

Based on the results of various forecasts, the model is formulated:
\[
y = 10.9 - 0.011*x1 - 0.0076*x2 + 0.0000003*x4 - 0.24*x6, \tag{1}
\]
Where X1- Share of household consumption expenditures on food purchases %,
X2- Ratio of marriages and divorces, per 1000 divorces,
X4 - GRP per capita, rubles,
X6- The total area of residential premises, an average of one inhabitant, square meters.

Based on the developed model, we obtained a private system of indicators of the dependence of the birth rate. And as a result of the results obtained, it can be said that the birth rate depends on such factors as: the share of household consumption expenditures on food purchases, the ratio of marriages and divorces, the GRP per capita, and the total area of living quarters, an average per capita. With a 95% probability, it can be argued that with an increase in the share of consumer spending by households on food purchases by 1%, the birth rate on average decreases by 0.011 births per 1000 population. With an increase in the ratio of marriages and divorces by 1 divorce per 1000 marriages, the birth rate will decrease by 0.008 per 1000 people born. With an increase in GRP per capita by 1 ruble, the birth rate will increase by 0.0000003 births per 1000 population. With an increase in the total area of residential premises per 1 person per 1 square meter, the birth rate will decrease by 0.24 born per 1000 population. This model explains describes 65.5% of the variation in the birth rate due to data at sign in the 34.5% variation due to unrecorded characteristics.

2. Conclusion

Thus, the proposed statistical model has its own specificity and is modified. Based on only officially published data, it can be said that the model adequately reveals all aspects of the phenomenon being studied and has applied significance, and on the basis of which it will be possible to plan the development of the social sphere.

3. Reference

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