DYNAMICS MODELING AND THE STUDY OF BIRTH RATE DETERMINANTS IN RUSSIAN REGIONS

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ABSTRACT

Birth rate dynamics are affected by several groups of factors. Their impact in Russia is markedly differentiated across regions. The purpose of our study is to use cluster analysis to reveal groups of Russian regions with similar birth rate dynamics over the past 30 years of post-Soviet Russia and to define the determinants of these dynamics in region clusters. We used hierarchical cluster analysis to model Russian birth rate dynamics and segment regions with comparable determinants in this dynamic. We used the Total Fertility Rate and its indices for all regions over three important periods in the demographic history of Russia. The analysis revealed 5 clusters of regions with similar birth rate dynamics. The results of our analysis made it possible to identify the regions most and least sensitive to the impact of various groups of factors. Such modelling allows us to develop demographic policy (and to plan budgets for their implementation) in various types of regions in the most efficient way.

INTRODUCTION

Birth rate is one of the key indicators of social, economic, and political situations. Researchers study the dynamics and determinants of birth rates in different countries using various modelling methods. Correlation and regression analyzes are the main methods. They are used for dynamic (matching of time series) and stationary (studying correlations in separate territories or different population groups) data.

Demographers believe that, in general, birth rate dynamics are affected by the following groups of factors: economic, socio-cultural, religious, political.

The impact of economic factors on birth rates is estimated differently (Balbo, Billari and Mills 2013; Shubat and Bagirova 2018). Some researchers believe that the improvement of the economic situation and the economic conditions of life in a country contributes to an increase in birth rates (Martin 2004). Others, however, claim that economic growth leads to an increase in the financial, time and labor costs connected with having children, which results in a reduction of children in families (Becker, Murphy and Tamura 1990).

Researchers are more unanimous with regard to the influence of socio-cultural factors on birth rates. These factors include the spread of “social norms for the number of children” (ideas about a “normal” number of children for a family), the level of “a need for children”, youth’s ideas about the “optimal” age for having children, advantages of a family lifestyle, etc. (Arkhangelsky 2012; Antonov et al. 2016).

From a historical perspective, religious factors were connected to birth rates in a more comprehensible way. Religious doctrine forms its own social norms, which determine the number of children in a family. In traditional societies, religious norms tend to require the continuity of sexual and reproductive behavior; they condemn birth control measures. The reproductive behavior of deeply religious people often lacks choice: they do not question the number of children. Consequently, the larger the share of the population which is deeply religious, the higher the birth rate in a country.

The factors of internal policy which affect birth rates are public policy measures aimed at changing or maintaining the current demographic situation. Such measures can be aimed at stimulating or reducing the birth rate. For example, the use of contraception may be prohibited - in this case, the measure is aimed at increasing the birth rate. On the other hand, the spread of contraceptives is oriented at reducing the birth rate (this policy is implemented in many African countries). Public policy measures may involve a variety of resources: ideological and moral (for example, the creation and propagation of family values, etc.); economic and financial (for example, child benefits, maternity leave, etc.); medical (for example, development of a network of medical institutions for children and parents, etc.); or legal (in particular, measures aimed at optimizing the combination of maternity and employment, etc.).

The impact of these factors determines the dynamics of the international birth rate. At the same time, there is no clear idea about the extent to which these factors impact the birth rate or the possible effects arising from their joint impact. The issue of birth rate dynamics determinants in Russia remains unsolved. A comparison of the dynamics of Total Fertility Rate (TFR) in Soviet and post-Soviet Russia with the impact of the aforementioned groups of factors is given in Table 1.

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Table 1: Periods in the demographic history of Russia.

Years and features of TFR dynamics	Factors potentially related to birth rate dynamics		
	General economic factors	Socio-cultural factors	Internal political factors
1990-1999 Catastrophic decline of TFR	- economic crisis; - low standard of living	- transformation of life values after the collapse of the USSR; - discrediting of "Soviet" norms of behavior; - spread of extra-marital affairs, alcoholism	State policy of "non-interference" in demographic processes
2000-2006 Increase of TFR	economic growth	- social norms of having fewer children; - spread of the ideas about the priority of individual values among young people	The need for policies aimed at the stimulation of fertility is declared, but it is absent in reality
2007 – the present Relative stabilization of TFR	relative economic stability	- relative strengthening of traditional values; - youth's lack of concern about the possibility of economic shocks and the collapse of the established system; - people's understanding of the importance of a high birth rate for the state	Targeted state policies aimed at the stimulation of fertility

Despite the general trends, the impact of various groups of factors in Russia is markedly differentiated across regions. Different standards of living; varying socio-cultural conditions more or less associated with the religious factor; slightly different regional measures aimed at the birth rate stimulation – all of these factors lead to a potential difference in the birth rate and its dynamics across Russian regions. In addition, there is a possibility that the population has different "reactions" and "sensitivity" to the effects of certain groups of factors.

We consider cluster analysis as the most appropriate method for studying regional differences in the dynamics of the birth rate. It is rarely used in demographics for this purpose (Table 2). This may be due to the following reasons: a small number of regions within the studied country; lack of relevant competences among researchers; lack of understanding of its advantages; and the lack of a "trend" for the use of this tool in demography.

Table 2: The application of cluster analysis in demographic studies (according to Web of Science and the Russian Science Citation Index (RSCI)).

Year	Number of articles in the subject area "demography"		Number of articles in the subject area "demography" in which cluster analysis is applied		Share of articles in the subject area "demography" in which cluster analysis is applied, %	
	Web of Science	RSCI	Web of Science	RSCI	Web of Science	RSCI
2013	1412	3803	1	7	0.07	0.18
2014	1489	5630	2	10	0.13	0.18
2015	1933	7519	4	14	0.21	0.19
2016	2200	4968	4	13	0.18	0.26
2017	2118	4069	3	9	0.14	0.22
2018	1298	2433	1	8	0.08	0.33

We believe that cluster analysis makes it possible to segment regions according to specific indicators, distinguish groups with similar trends and find the potential to implement similar demographic policy measures. Understanding the factors active in Russia in certain historical periods allows us to also use cluster analysis to identify the birth rate determinants in certain groups of regions. In addition, given that the demographic processes occurring in countries and regions traditionally have a high degree of indeterminacy, there is hope that the use of another research method can reduce the existing gap between the birth rate dynamics and the understanding of its determinants. Thus, the goal of our study is to use cluster analysis to reveal groups of Russian regions with similar birth rate dynamics over the past 30 years in post-Soviet Russia and to define the determinants of this dynamic in clusters of regions.

DATA AND METHODS

1. To achieve this goal, we conducted a hierarchical cluster analysis of Russian regions. The analysis was carried out on the basis of Euclidean distance and Ward's method. These measures allowed us to obtain the clearest separation of the regions under study into homogeneous segments.

2. The basic variable in our analysis is Total Fertility Rate (TFR). On the basis of this indicator, we calculated each region's indices which characterize the change in birth rate over three important (special) periods in the demographic history of Russia:

The first index (X_1) shows the changes that occurred in the birth rate from 1990 to 1999. The second index (X_2) characterizes the changes that occurred in from 2000 to 2007. The third index (X_3) shows the change from 2007 to 2017. All three indices were used as clustering variables – groups of Russian regions with similar birth rate dynamics during specified periods of time were identified on this basis.

3. Russian regions with full sets of birth rate data were included in the study. Two republics - Chechnya and Ingushetia - were not included in the analysis due to the fact that there were no official birth rate statistics in these regions in the 1990s (both republics had military conflicts during this period). In addition, a number of regions were not included in the analysis due to changes in territorial boundaries. Processes of administrative and territorial division, related to the unification of a number of regions and the changes in the geographical boundaries of Russian subjects, occurred in the country during the studied period. The regions which were not involved in processes of administrative and territorial division were included in the studied population to ensure the comparability of the data. As a result, clustering was carried out based on the data of 79 Russian regions.

4. The profiling of the identified clusters was performed based on the interpretation of cluster centroids. We calculated the mean and median values of the clustering variables in each cluster and tested them for significant differences. We used the non-parametric median test, since some of the mean values in the identified clusters could not be considered as typical values (their Relative Standard Deviation exceeded the threshold of 33%).

RESULTS

1. The feasibility of cluster analysis of Russian regions was confirmed by the high variability of the initial data. The minimax and quartile values of clustering variables presented in Table 3 indicate that the birth rates in Russian regions were radically different. While a decline in birth rates was observed in all regions of the country from 1990 to 1999 (although the decline was different in intensity), the differences in regional birth rates in the next two periods were drastic. Some of the regions showed a significant decrease in the birth rate, while other regions demonstrated impressive growth.

Table 3: Minimax and quartile values of clustering variables.

Indicator	X_1	X_2	X_3
Minimum	-48.8	-9.0	-20.3
1st quartile	-41.7	18.5	6.0
2nd quartile	-40.1	22.9	12.0
3rd quartile	-37.1	27.6	16.4
Maximum	-6.5	44.6	37.2

2. The analysis revealed 5 clusters of regions with similar patterns in birth rate dynamics. The dendrogram of the clustering process is shown in the Appendix. The statistics of cluster centroids are presented in Table 4.

Table 4: Statistics of cluster centroids.

Cluster	Statistics	X_1	X_2	X_3
1	N	19	19	19
	Mean	-38.2	20.7	2.4
	Median	-39.1	19.4	3.7
	Std. Deviation	4.8	6.7	5.0
	Relative Std. Deviation, %	13	32	212
2	N	17	17	17
	Mean	-40.6	24.8	11.6
	Median	-40.2	25.9	11.7
	Std. Deviation	1.8	2.1	1.3
	Relative Std. Deviation, %	4	9	12
3	N	12	12	12
	Mean	-39.6	9.8	14.6
	Median	-40.0	9.2	15.1
	Std. Deviation	2.0	5.0	5.9
	Relative Std. Deviation, %	5	51	53
4	N	10	10	10
	Mean	-44.0	33.8	12.8
	Median	-43.5	32.9	13.0
	Std. Deviation	2.6	4.5	2.8
	Relative Std. Deviation, %	6	13	25
5	N	21	21	21
	Mean	-37.5	25.0	20.6
	Median	-37.2	25.0	18.2
	Std. Deviation	4.0	4.7	6.5
	Relative Std. Deviation, %	11	19	59

As follows from the data presented in Table 4, each of the identified clusters has its own specific features.

Thus, cluster 1 is characterized by the fact that its regions showed the smallest increase in the birth rate from 2007 to 2016 (X_3), the period when the birth rate grew in all clusters without exception.

The highest birth rate during this period was observed in the regions of cluster 5 – it also experienced the smallest drop in TFR between 1990 and 1999 relative to other clusters.

Cluster 3 was the only one where, after the fertility decline of the 1990s, the birth rate gradually increased in the subsequent two periods.

The birth rate in cluster 4 is the most dramatic – it has the largest decrease in TFR in the late 1990s and then the smallest increase in the early 2000s.

One feature can be noted about cluster 2: the decline and growth rates of fertility in this cluster occupied a middle position among the indicators of other clusters in all periods. Non-parametric tests for the difference of median values confirmed their significance (Table 5).

Table 5: Median test.

Indicator	X_1	X_2	X_3
N	79	79	79
Median	-40.1100	22.9500	12.1400
Chi-Square	13.242	29.566	45.450
df	4	4	4
Asymp. Sig.	0.010	0.000	0.000

3. Since the mean values of clustering variables could not be considered as effective characteristics of cluster centroids in some cases, we profiled the identified clusters based on medians. In this case, we used the graphical method (Figures 1-3) to represent standardized median values. In order to contrast changes in the birth rate that occurred in clusters at different times, we used normalization, which scales medians in the range [0,1] according to the following formula:

$$x_{Norm} = \frac{x - x_{min}}{x_{max} - x_{min}} \quad (1)$$

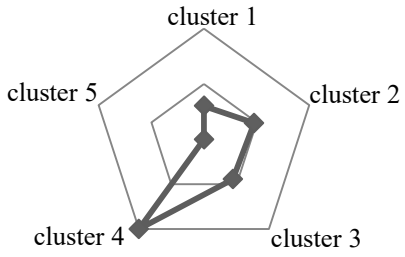

Figure 1: Differentiation of clusters by the level of the birth rate decline from 1990 to 1999

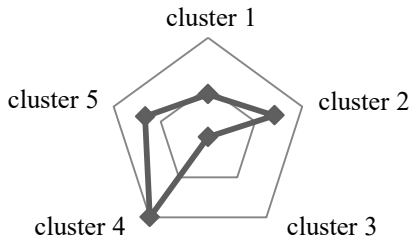

Figure 2: Differentiation of clusters by the level of the birth rate increase from 1999 to 2007

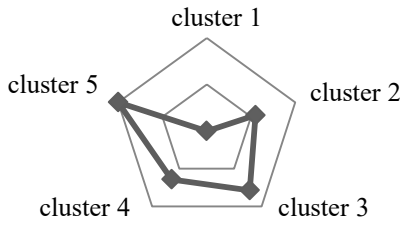

Figure 3: Differentiation of clusters by the level of the birth rate increase from 2007 to 2017

DISCUSSION

The analysis of birth rate dynamics in the clusters shows a unidirectional but varied intensity in the identified trends in the five groups of regions. The analysis allowed us not only to assess birth rate dynamics in various clusters of regions, but also to assess the impact of key birth rate determinants on this dynamic. We consider the factor of economic recession at the end of the 1990s and the factor of the state's pronatalist policy since 2007 to be such determinants.

We consider it possible to use the results of birth rate dynamics modelling to evaluate the effectiveness of state policies aimed at stimulation of the birth rate for the following reasons:

1. In 2006, unprecedented measures aimed at stimulating the birth rate were announced in Russia. Federal law introduced so-called "maternity capital" – the amount of money paid to a mother for the birth of her second child. At the time of its implementation, it amounted to 7,082 euros, while the average annual income of a Russian citizen was 5,100 euros. We consider this measure as both economic and political in character. On the one hand, it allows families to improve their living conditions (this is what the money is most often spent on). On the other hand, this measure is a kind of a signal to the population from the state communicating the priorities of state policy. The time period following the implementation of this measure can definitely be considered as the period when the demographic situation in the country changed under the influence of this measure.

2. In demography, studies aimed at identifying the impact of various state policies on the birth rate do not have a unified methodology. Different authors use different approaches. Most often, authors compare cohort and period (for hypothetical cohort) fertility data. In the late 1980s, Klupt compared actual age-specific birth rate coefficients at a time when state demographic policies were in place with hypothetical birth rate coefficients calculated by various conditions. At the same time, he used a statistical model that showed possible timing shifts – the earlier births of generations of a child-bearing age (Klupt 1988). Avdeev and Monnier used a different approach. They evaluated the effect of the 1980s demographic policy by comparing the cumulative fertility of the 1950–1960s female cohorts with the fertility of the cohort born in 1945,

which was not influenced by this policy (Avdeev and Monnier 1995).

We propose a fundamentally different methodology - identifying and describing groups of regions based on the rate of fertility growth during important periods in the country's demographic history. In this case, we used multidimensional methods of analysis. Thus, we estimate the potential impact of key determinants, which are different in specific time periods, on the birth rate dynamics in the clusters.

The results of our analysis showed that the regions of the first, second, and third clusters had the same average decline in birth rate during the economic recession. However, they came out of the demographic crisis of the end of the 1990s differently.

In the regions of the third cluster, the birth rate grew gradually – from the extremely low growth rate at the beginning of the 21st century to the high growth rate during the period of the state birth rate policies. It can be said that it took time and active state measures for the population of these regions to overcome the "memory" of the economic crisis of the late 1990s. Consequently, the economic measures that were implemented as a matter of state policy were quite effective.

In the regions of the second cluster, a different situation was observed at the beginning of the 21st century - the birth rate increased noticeably during this period. The birth rate growth continued after the commencement of state policy measures, but not so intensively. We believe this indicates that the population of these regions had a fairly high reproductive potential, the realization of which was postponed due to the economic crisis of the late 20th century in Russia. The population realized their postponed reproductive potential as soon as the economic situation stabilized. The state policy measures that began in 2007 were not as effective in these regions.

The regions of the first cluster reacted to state policies even less noticeably. These regions had an average decline in the birth rate at the end of the 20th century, which led to equally average growth in the following years and extremely low growth during the state program aimed at stimulating the birth rate. Apparently, other groups of factors had an impact in these regions – for example, socio-cultural and religious factors. They allowed an increase in the birth rate immediately after the economic crisis and reduced the response to the later implemented state demographic policy.

In contrast to the previous clusters, the fourth cluster of regions reacted to the economic crisis of the late 1990s with a sharp decline in the birth rate. In the early 2000s, this cluster experienced the most noticeable positive trend in the birth rate dynamics, which was smoothed out in subsequent years. Therefore, the regions of this cluster are most sensitive to the impact of the economic factor, both negative and positive. It can be predicted that the birth rate in these regions is most susceptible to drastic changes due to irregularities in the economic situation.

The fifth cluster of regions is interesting because the decline in the birth rate during the economic crisis was the least noticeable; equally, the highest increase in the birth rate occurred during the period of the demographic policies. Hence, this cluster was the most sensitive to measures aimed at the stimulation of the birth rate. It may also mean that the state measures proved to be the most effective in the regions of this cluster.

The results of our analysis also allowed us to arrange clusters of regions based on two grounds: in descending order of the impact of the general economic factor on the birth rate (Figure 4) and in descending order of the impact of state demographic measures on the birth rate (Figure 5).

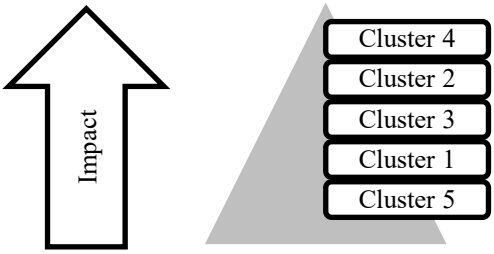

Figure 4: The ranking of clusters according to the impact of the economic factor on the birth rate

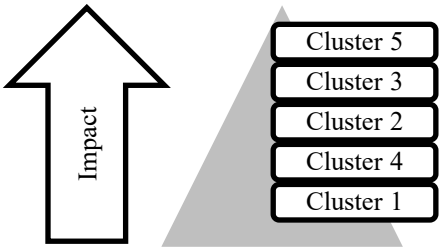

Figure 5: The ranking of clusters according to the impact of state demographic policy on the birth rate

It can be noted that the sensitivity of the birth rate to the economic context and to the impact of demographic policy is directly opposite to each other. For example, clusters 4 and 5 turned out to be the least sensitive to the action of one factor, but the most sensitive to the effect of the other.

CONCLUSIONS

The analysis led us to the following conclusions.

Firstly, using the variables' indices rather than variables themselves during the clustering process allows us to gain better knowledge of the demographic situation in the region than studying the stationary values of the variables. We consider that the identification of groups of regions which are similar in terms of the development trends of demographic processes is more reasonable than the revealing of

groups according to the achieved level of a particular demographic indicator.

Secondly, the results of cluster analysis, compared with key determinants which objectively operated in different periods of Russia's demographic history, made it possible to identify the regions most and least sensitive to the impact of various groups of factors. This would be impossible if cluster and correlation analysis were applied separately.

Thirdly, the results of the study have a potential for a practical application because they allow us to develop demographic policy and to plan budgets for its implementation in various types of regions in the most efficient way.

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Appendix: Dendrogram of the clustering process