Fertility dynamics differentiated by birth order in Russian regions

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Russia is facing one of the most severe demographic problems – low fertility rate. At the same time, fertility dynamics differ significantly across the regions of the country. Subsequently, the birth dynamics of first, second, and subsequent orders also differ. Our study identifies the types of regions that have the same or very similar fertility trends differentiated by birth order. For this purpose, we applied hierarchical cluster analysis based on Ward's method and squared Euclidean distance.

We used official Russian statistics and calculated three regional indicators as clustering variables, including the percentage change of the total fertility rate of first, second, and third and subsequent births from 2018 to 2022. We profiled clusters based on economic indicators (gross regional product (GRP), income, and housing provision) and population indicators (women's age at first, second, and third and subsequent births), testing convergent and divergent trends in the dynamics of regional birth rates.

Cluster analysis revealed four clusters of Russian regions with similar fertility trends differentiated by birth order. Cluster 1 includes 10 Russian regions and can be considered the most depressive cluster. Cluster 2 includes 18 Russian regions and can be called the driver of Russian population dynamics. Cluster 3, with 38 regions, and Cluster 4, with 19 regions, occupy intermediate positions between the first two clusters. We found no statistically significant differences between the clusters concerning the birth rates that prevailed in 2018; thus, their starting positions did not determine the regional fertility changes in 2018–2022. The analysis revealed that the clusters did not differ in the age of women at first, second, and third and subsequent births. We also did not find statistically significant differences among clusters in terms of the dynamics of economic indicators such as gross regional product, income, and housing provision. The results did not confirm that traditionally recognized economic determinants defined order-differentiated birth dynamics. Russian regions exhibited no convergent or divergent trends in order-differentiated birth dynamics. Our results established new research areas related to the analysis of birth rate determinants, such as informational support for regional programs to increase birth rates. The approach can form the foundation for developing a segmented state information policy in the demographic sphere. It also indicates the need for continuous monitoring of the reasons behind declining birth rates differentiated by birth order and the related stereotypes concerning various socio-demographic population groups.

Keywords:
fertility,
total fertility rate,
birth order,
Russian regions,
cluster analysis

Online first publication date: 6 January 2025

Introduction

Like many countries, Russia struggles with significant demographic challenges due to a declining birth rate, and the situation has only gotten worse in recent years. Between 2015 and 2022, the country's total fertility rate (TFR) decreased by 14%, while the crude birth rate dropped by 33.1% [1].

Adding to this situation's complexity, Russia exhibits significant regional differentiation in many demographic and socioeconomic indicators. This variation is not just minor fluctuations but a stark contrast, as illustrated by the diverse characteristics presented in Table 1.

Table 1

Indicators with high variability across Russian regions

Indicators	Maximum to minimum ratio	Coefficient of variation, %	Data period
Gross regional product per capita	20.1	79	2021
Average monthly nominal wages of workers	5.1	38	2023
Crude birth rate	3.5	26	2022
Crude mortality rate	5.4	22	2022

Source: [2].

With such marked regional differences, like some other countries, Russia offers a unique laboratory, and although this has been said about the study of regional fertility differentiation in India (Chatterjee–Desai 2020), it also applies to Russia. Geographic unevenness of fertility decline has also been examined in recent years by researchers in Spain (Iglesias 2024), Italy (Alderotti 2022), Slovakia (Šprocha et al. 2022), and other countries. Notably, some researchers consider intracountry differences in fertility dynamics as justification for criticizing the widespread theory of the second demographic transition (Klupt 2008, Tardivo et al. 2021), which is most often used to describe fertility dynamics. This highlights the importance of in-depth analysis of intraregional fertility differentiation to develop a system of arguments for interpreting the results of such analysis.

The remainder of this study is structured as follows. We first describe the fertility circumstances in Russia and the state support measures aimed to improve it. We then present a scientific literature review discussing fertility determinants in contemporary Russia. We next justify the need and conduct our analysis to identify clusters of Russian regions with similar fertility dynamics and describe the resulting clusters. We then examine several variables that have traditionally been considered fertility factors, evaluating the statistical significance of their differences in the identified clusters. Finally, we draw some practical conclusions from the results of our analysis.

Birth rate trends in Russia and government policy measures

The problem of declining Russian fertility has a particular structure, the individual elements of which behave differently. In Appendix Figure A1 shows the fertility dynamics in Russia for the last 5 years, in general and by birth order. It is evident that declining fertility rates are not uniform and exhibit various trends. The TFR for all births and first-born children (TFR1) and second-born children (TFR2) is decreasing. However, the TFR for third and subsequent children (TFR3+) shows no such trend.

The findings indicate that in 2020–2021, when Russia, like other countries, was experiencing the Covid-19 pandemic, no decrease occurred in the birth rate of third and subsequent children. In these years, TFR3+ even increased slightly compared with previous years. In addition, despite the negative dynamics of TFR1 and TFR2, no catastrophic decline is evident in these years. This does not demonstrate an unambiguous negative (or positive) impact of the pandemic on Russian fertility dynamics. Notably, the absence of unambiguous effects of the pandemic on fertility was also revealed by other scientists (Pomar et al. 2022, Golovina et al. 2023).

TFRs for different birth orders have significant regional differentiation in Russia. In recent years, the regional differentiation of TFR3+ has visibly increased. In 2018, the ratio of the maximum and minimum values of TFR3+ in Russian regions was 6.48, and in 2022, it reached 8.82. A steady increase in differentiation is also observed for TFR from 2.65 to 3.15. At the same time, regional differentiation of TFR1 and TFR2 decreased slightly. Perhaps the significant differentiation of TFR3+ in Russian regions can be explained by the high variability in regional public measures to support the birth of third children. Regional authorities are responsible for the development and implementation of such support measures, whereas fertility support measures in Russia are generally established at the national level.

Maternity capital has been the most commonly employed policy measure to support fertility in Russia. Since its launch in 2007, this benefit has been paid to families for the birth of a second child (Federal Law, № 256). As of 2020, most of the maternity capital is paid after the first child's birth, and a more minor proportion is paid after the second child's birth.

Another state program is the national Demography project, which includes monthly payments for the first and third child and the possibility for parents to obtain a mortgage loan at a reduced rate at the second child's birth (Ministry of Labor and Social Protection of Russia 2018).

Therefore, the measures of state support for fertility in Russia in recent years have been differentiated by birth order. Second, they were established at national and regional levels. These circumstances could have influenced the varying fertility trends differentiated by birth order forming in different Russian regions.

Literature review

The comprehensive study of fertility and its determinants in Russia has a long history. One of the most extensive empirical studies was the project Parents and Children, Men and Women in the Family and Society, which was completed in the early 21st century under the leadership of Maleva, Sinyavskaya, and Zakharov, in which fertility factors were classified into three groups, including 1.) demographic (state of marriage or partnership, present number of children, and state of reproductive health); 2.) economic and labor (monetary income, housing, status in the labor market, and professional status); and 3.) social (education, type of settlement, attitude toward religion, values, and others) considerations (Maleva–Sinyavskaya 2007).

The study of the influence of economic determinants on fertility has led scientists to different – even opposing – conclusions. For example, Kumo–Kechetova (2023), based on microdata from the Russian Longitudinal Monitoring Survey (RLMS-HSE), determined that higher household income stimulates childbearing. At the same time, based on econometric modeling implemented on panel data from regions, Vakulenko et al. (2023) concluded that fertility is negatively correlated with income. Studies of the influence of economic factors on fertility in Russia have a very long history. For example, back in 1934, the Central Statistical Office study revealed an inverse relationship between birth rate and income (Strumilin 1963).

Much of the research on Russian fertility has been devoted to assessing the impact of maternity capital on fertility dynamics. The positive impact of this unprecedented measure on fertility was substantiated in Miljkovic–Glazyrina (2015), Slonimczyk–Yurko (2014), and several others. Validova (2021) assessed the role of tempo and quantum effects in changing Russia's fertility after maternity capital's introduction.

The assessment of the impact of certain factors on fertility rates has been widely represented in the academic discourse. For example, the extensive work of Balbo et al. (2013) can serve as a reference point for scientific research on specific determinants in specific periods and territories. This review proposes categorizing all determinants into macro, meso, and micro levels.

Considering the existing body of research on the determinants of Russian fertility, makes a contribution to this discussion by focusing not on the birth rate itself but on its dynamics. We do so because previous studies have shown that the country's regions traditionally differ in fertility level as well as dynamics (Kuchmaeva 2010, Shubat 2023).

Research questions and methodology

The purpose of our study is to identify types of regions that exhibit the same or very similar fertility dynamics differentiated by birth order. Our research questions are as follows:

- Is it possible to identify groups of Russian regions that demonstrate similar fertility dynamics differentiated by birth order?
- If such regional differentiation is found, is a satisfactory explanation using traditionally studied determinants of fertility available?
- Which determinants can and cannot explain birth order-differentiated fertility dynamics in identified types of Russian regions?

Our research methodology includes several features. First, we analyze Russia's overall and structural fertility, in terms of birth order. Second, we cover the period before the start of the state "Demography" program (Russian Government 2018) and during its implementation. Third, instead of studying fertility rates per se, we analyze fertility rate dynamics to identify regions that are similar in this respect. Finally, we use cluster analysis, which is quite a rare approach in demographic studies (Mischke 2011, Green et al. 2014, Haynes 2014, Jurun et al. 2017, Shubat et al. 2019, Kastreva–Patarchanova 2021, Newsham–Rowe 2023, Wardhana 2023, Bagirova et al. 2023).

We employ several population indicators to conduct the cluster analysis. These include TFRs differentiated by birth order across Russian regions for the period from 2018 to 2022 ([1], [3], [4])). Data for earlier periods could not be included in our analysis as differentiated birth rates data were not systematically collected for all Russian regions.

Our analysis uses the TFRs and percentage changes. Previous research by Russian authors has demonstrated that fertility rates as well as associated dynamics differ across regions (Kuchmaeva 2010, Shubat 2023). It is evident that to increase the effectiveness of state support programs it is essential to consider these kinds of regional differences and evaluate them. Therefore, we used the following three clustering variables:

– the percentage change of the TFR of first birth,
– the percentage change of the TFR of second birth, and
– the percentage change of the TFR of third and subsequent births.

These variables presented changes from 2018 to 2022.

We conducted hierarchical cluster analysis using Ward's method and squared Euclidean distance. Determining the homogeneity of objects in a multidimensional space and selecting the most appropriate metric to identify such homogeneity is the most difficult and least formalized task of multivariate classification. Aldenderfer and Blashfield (1984) presented a broad overview of the practice of using various clustering methods, the results of testing various metrics on actual data, and one simulated using the Monte Carlo method. Ward's method was shown to have several advantages. In particular, its results establish dense, hyperspherical clusters, in contrast with single link methods that tend to create long and prolate cluster chains. In addition, Ward's method provides extremely valid results when complete classification is required and the number of outliers is small. It also gives the best results in cases of overlapping clusters. These advantages suggest that Ward's method will likely produce accurate results and have the best differentiating ability for our study.

Nevertheless, we employed different clustering methods and compared the results to reveal the most natural structure of the fertility rate differences across Russian regions. In most cases, the cluster structures formed were very similar; however, Ward's method exhibited the most precise clustering.

After identifying the clusters of Russian regions, we assess the significance of their differences using parametric and nonparametric tests. We use one-way analysis of variance, the nonparametric (Kruskal–Wallis) test, and post hoc tests to confirm the significance of differences in cluster centroids; the Levene test is used to examine the homogeneity of variances; and the Shapiro–Wilk test is used to test the normal distribution hypothesis. Statistically significant cluster centroid differences are given a meaningful interpretation. The cluster centroids are described based on either average or median clustering variable values.

To extend our research, we seek explanations for the identified cluster structure and its possible determinants. For this purpose, we profile the identified clusters based on demographic and economic indicators. We use fertility rates as additional demographic indicators (i.e., TFRs differentiated by birth order). Therefore, we test the possibility of convergent or divergent trends in the dynamics of Russian fertility rates. Researchers of demographic processes have shown convergence (in some cases divergence) of fertility trends in different Russian regions (Franklin–Plane 2004), EU countries (Lanzieri 2014), and in the world (Strulik–Vollmer 2013). In Russia, convergent trends in regional fertility rates (based on the TFR not differentiated by birth order) were also not confirmed (Shubat 2019).

We also use the mean age of women at birth of first, second, and third and subsequent children as another population variable for additional cluster profiling. Open data from the Russian Federal State Statistics Service do not contain such indicators by region; therefore, the mean age of women at birth of first/second/third and subsequent children was calculated for each region using data on the number of children born to women of different ages ([5]). We also calculate and analyze the intervals between the first and second births and second and third births to test the possible influence of the age at which a woman gives birth to her first (second, third) child on fertility dynamics. In some Russian studies, the authors identified such a relationship and noted the need to consider it when developing population policy (Ediev 2006). However, other studies have given more cautious assessments of the dependence of regional fertility levels on the age of women at the birth of their first child (Arkhangel'skiy–Kalachikova 2020).

We also include indicators that have traditionally been introduced by Russian and international demographers as fertility factors (gross regional product [GRP]) per capita, median per capita income, housing provision, and employment rate) as economic determinants of the identified cluster structure (Kumo–Kechetova 2023, Maleva–Sinyavskaya 2007, Zhuravleva–Gavrilova 2017). These indicators are calculated annually by ROSSTAT for all Russian regions and are publicly available ([2]). This study analyzes the annual values of these indicators and their percentage changes from 2018 to 2021 to investigate whether the levels and rates of growth/decline of economic indicators in Russian regions affected the birth dynamics differentiated by birth order.

We profile the clusters using all the specified variables and tests to determine the significance of their differences in the clusters. We use parametric (one-way analysis of variance), nonparametric (Kruskal–Wallis), and post hoc tests. SPSS software is used to perform data analysis.

Table 2 presents the characteristics of all variables used in the analysis.

Table 2

Cluster analysis variables

Variable	Variable description	Role in the clustering process	Designation in tables with the analysis results
Percentage change of the total fertility rate differentiated by birth order	Indicates birth dynamics differentiated by birth order from 2018 to 2022; Presented in a regional context.	clustering variables	PC_TFR1 PC_TFR2 PC_TFR3+
Total fertility rate differentiated by birth order	Indicates the average number of first/second/third and subsequent children that would be born to a woman during her lifetime; Presented in a regional context; Average annual data from 2018 to 2022.	additional cluster profiling variables	TFR1 TFR2 TFR3+
The mean age of women at birth of the first/second/third child	In years; Estimated indicator as of 2022; Presented in a regional context.		Av_Age1 Av_Age2 Av_Age3+
The interval between the births of the first and second child	In years; Estimated indicator as of 2022; Presented in a regional context.		Int_1_2
The interval between the births of the second and third child	In years; Estimated indicator as of 2022; Presented in a regional context.		Int_2_3
Gross regional product per capita	In rubles; Annual data from 2018 to 2021; Presented in a regional context.		GRP_PC
Median per capita income	In rubles per month; Data from 2018 to 2021; Presented in a regional context.		income
Housing provision	In square meters; Indicates the average total area of residential premises per inhabitant; Annual data from 2018 to 2021; Presented in a regional context.		housing
Employment rate	Percentage of employed persons in the comparable total population; Annual data from 2018 to 2021; Presented in a regional context.		employment
Percentage change of GRP per capita	In percentage; Indicates the dynamics of GRP per capita from 2018 to 2021; Presented in a regional context.		PC_ GRP
Percentage change of median per capita income	In percentage; Indicates the dynamics of median per capita income in the period from 2018 to 2021; Presented in a regional context.		PC_Inc
Percentage change of housing provision	In percentage; Indicates the dynamics of housing provision for the population from 2018 to 2021; Presented in a regional context.		PC_House
Percentage change in employment rate	In percentage; Indicates the dynamics of the employment rate from 2018 to 2021; Presented in a regional context.		PC_Empl

In this section, we provide some comments explaining our use of cluster analysis to study the impact of economic factors and various pronatalist policy measures on fertility dynamics. In Russian research, comparative methods have often been used for this purpose, in which the actual level of fertility is compared with some hypothetical level, as well as correlation and regression analysis. For example, the comparative method was applied by Avdeev–Monnier (1995). The authors evaluated the effect of Soviet population policy in the 1980s in two ways. First, by comparing the cumulative fertility of female cohorts born in 1950–1960 with the 1945 cohort, which, due to the time factor, no longer felt the impact of these measures. Second, by comparing the actual fertility of cohorts with the hypothetical fertility that would have been possible if the trend in age-specific fertility rates for conditional generations had been constant. Zakharov (2006) examined the difference between the actual number of births for 1981–1990 and the hypothetical number calculated under the presumption that the 1980 age-specific fertility rates would remain unchanged. Based on this difference, Zakharov provided estimates of the additional number of births resulting from family policy measures. In the late 1980s, Klupt (1988) compared actual age-specific fertility rates during the period of state population policy measures with hypothetical rates that would have been the case under various conditions, using the proposed statistical model to estimate a possible timing shift of births to earlier years in generations that were at childbearing ages.

Correlation and regression analysis have been used often to assess the impact on fertility of pronatalist population policy measures in Russian studies (Zhuravleva–Gavrilova 2017). Two different research approaches have been used. The first approach involves comparing two time series representing fertility dynamics and any of its factors. The second approach involves analyzing cross-sectional data. Regional factors of a country have often been used to compare fertility levels; however, in conducting such an analysis, researchers may encounter spurious correlation. In addition, considerable regional differentiation in many socioeconomic and demographic indicators in Russia can lead to the nature of the correlation and its strength being very different in across groups of regions. This may subsequently lead to the statistical cancelation of multidirectional influences and fully or partially offset such a relationship at the country level.

In our opinion, cluster analysis can be used to overcome the methodological problems described; therefore, this study applies a self-constructed cluster analysis approach. In a previous study, one of the authors presented a somewhat detailed description of this methodology and possibilities of its application for investigating the impact of various factors on fertility (Shubat 2019). The basic approach is to profile the identified clusters based on economic factors of fertility or variables that characterize the measures of pronatalist policy, and then assess the differences in cluster centroids on these variables. Statistically significant differences may indicate the existence of correlation and some influence of these factors on fertility or its dynamics.

Results

The cluster analysis reveals four clusters of Russian regions with similar birth trends differentiated by birth order. We determine the number of clusters based on a dendrogram of the clustering process (see in Appendix Figure A2) and the agglomeration schedule.

The resulting clusters had a low level of intracluster variation and were sufficiently full and the minimum number of objects in a cluster was 10. The statistical significance of the differences in cluster centroids (the mean and median values of the clustering variables) is confirmed using the parametric ANOVA test (see Appendix Table A1), the nonparametric Kruskal–Wallis Test (see Appendix Table A2), and post hoc tests.

The resulting clusters can be characterized as follows:

Cluster 1, which includes 10 Russian regions, can be called the most depressive cluster. It is characterized by the following features of birth dynamics differentiated by birth order:

1) It is the only cluster in which the dynamics of third and subsequent births were negative. In some regions of the cluster, an increase in this indicator is noted, but it is minimal at less than 4%. Notably, the TFR for third and subsequent births increased by 9.1% in Russia over the same period.
2) This cluster had the most significant drop in the number of first births at more than 21%, while the average decline in Russia was 10.5%.
3) This cluster also had the most significant drop in the number of second births, decreasing by 30% versus the average 20.7% decline in Russia.

This cluster can be considered a brake of reproductive dynamics since the birth rate trends are significantly worse than the Russian average.

Cluster 2, which includes 18 Russian regions, is the opposite of the first cluster. It can be considered a driver of Russian reproductive dynamics (particularly concerning third and subsequent births). This cluster is characterized by the following features:

1) The largest increase in third and subsequent births, which amounted to 17.2%.
2) The smallest decrease in second births.
3) The smallest decrease in first births.

In general, fertility trends in the regions of this cluster are much better than the Russian average.

Cluster 3, with 38 regions, and *Cluster 4*, with 19 regions, occupy intermediate positions between the first two clusters. Regarding first birth dynamics, Cluster 3 is significantly better than Cluster 4; however, Cluster 4 shows more impressive growth in the birth dynamics of third and subsequent births. In terms of second birth dynamics, the clusters correspond to the average Russian trend.

In Appendix Figure A3 illustrates the distribution of Russian regions by the identified clusters, presenting only those regions for which we had a complete set of indicators used for our analysis on the map.
Table 3 presents the average values of variables characterizing birth dynamics differentiated by birth order in the identified clusters.

Table 3

Cluster centroids

Denomination	Mean values of clustering variables		
	PC_TFR1	PC_TFR2	PC_TFR3+
Cluster 1	−21.6	−30.4	−1.5
Cluster 2	−5.8	−13.4	17.2
Cluster 3	−8.2	−21.5	3.9
Cluster 4	−17.0	−21.6	8.8
Average for Russia	−10.5	−20.7	9.1

Further cluster profiling using variables other than those that the clustering was based on demonstrated the following results:

First, no statistically significant differences are identified between the clusters concerning the fertility rates that prevailed in 2018 (the beginning of the study period). Thus, the regional changes in fertility in 2018–2022 were not determined by their starting positions. For example, an increase in third and subsequent births is evident in regions with both low and high TFR3+.

However, statistically significant differences in the clusters' fertility rates developed in 2022. A clear pattern emerged in which TFR1 and TFR2 were the lowest in Cluster 1 (the depressive one) and TFR1 and TFR2 were the highest in Cluster 2 (the most positive one), and these indicators took an intermediate position in two other (intermediate) clusters (3 and 4) (see in Appendix Figure A4). The statistical significance of these differences was confirmed by parametric (see in Appendix Table A3) and nonparametric (see in Appendix Table A4) tests. Similar patterns are also found for TFR 3+, but statistical tests did not confirm the significance of the differences. Generally, no convergent or divergent trends in birth dynamics differentiated by birth order are evident in Russian regions.

Second, the analysis reveals that the clusters did not significantly differ concerning the age of women at first, second, and third and subsequent births. Logically, the mean age of women at the birth of their children rises with the increase in birth order, and this trend was equally evident in all clusters. The intervals between the first and second births and second and third births did not differ in the identified clusters (Table 4).

Third, the analysis did not reveal statistically significant differences between clusters in terms of economic factor dynamics such as GRP, income, and housing provision; therefore these factors cannot be considered as determinants of changes in fertility in Russian regions.

Table 4

Women's average age at the birth of children and intervals between childbirth in 2022 (in years)

Clusters	Av_Age1	Av_Age2	Av_Age3+	Int_1_2	Int_2_3
1	25.72	30.05	33.08	4.33	3.03
2	25.90	30.04	33.01	4.14	2.97
3	26.10	30.27	33.08	4.17	2.82
4	25.98	30.20	33.04	4.22	2.84

Discussion

The interpretation of the results obtained during cluster analysis and subsequent cluster profiling raises several important questions that are related to fertility support policy implementation in modern Russia and its regions.

First, our analysis did not confirm that traditionally recognized economic factors determine birth dynamics differentiated by birth order. The identified clusters of Russian regions confirm the presence of a wide variety of fertility factors. An approach that involves searching for statistically significant differences in clusters allows us to screen out certain variables and identify variables with values that differ among the clusters. For example, measures of financial support for fertility in the region could be such a factor. In particular, one-time payments for the birth of children of a particular birth order. Indeed, we note that regions that differ widely in the support measures implemented fall into the same clusters. For example, Perm Krai and Magadan Oblast fell into the second cluster; however, Perm Krai canceled payments of regional maternity capital in 2016, while the Magadan Oblast still provides relatively high payments for first, second, and third children. Therefore, the fact that regions with such diverse policies fall into the same cluster leads us to assume that the reason for these dynamics could be related to some other area.

Notably, birth dynamics differentiated by birth order may be influenced by highly unusual factors; for example, by so-called "birth tourism" – a phenomenon in which women from one Russian region give birth to children of a particular birth order in other regions where payments for children of this birth order are higher than in the home region. For example, this circumstance can be observed in two neighboring regions of Nenets Autonomous Okrug (first "negative" cluster) and Yamalo-Nenets Autonomous Okrug (second "positive" cluster), which differ in third birth trends. In the Yamalo-Nenets Autonomous Okrug, the regional payment for the birth of a third child is 500 thousand rubles, while in the Nenets Autonomous Okrug, it is 380 thousand rubles. Perhaps families living in the Nenets Autonomous Okrug prefer to give birth to a third child in the Yamalo-Nenets Autonomous Okrug to increase the household budget by an additional 120 thousand rubles.

Another potential factor, that of population religiosity, does not provide convincing grounds for consideration as an explicit determinant of fertility that affects regional differences. Russian researchers have often cited religiosity as a factor in fertility. For example, Zakharov–Churilova (2022) found higher fertility among Muslim women in the 1940–1979 cohorts. It is also often noted that those Russian regions where Islam is the predominant religion have traditionally had higher fertility levels. An earlier analysis (Shubat 2023) revealed that only three of the top 10 regions of the Russian Federation with the highest TFR3+ have Islam as their predominant religion (Chechnya, Ingushetia, and Dagestan). In the remaining seven regions of this group, other religions are predominant such as Buddhism, Orthodoxy, and traditional beliefs (for example, Aar Aiyy, a traditional Yakut faith). In addition, in some regions with strong Islamic traditions, TFR3+ may be below the average Russian level; for example, in Tatarstan. This study also did not reveal an unambiguous determination of the dynamics of TFR3+ by religious factors. TFR3+ could fall and rise in regions with very different religious traditions.

Second, our results demonstrate no regional convergence or divergence in the birth dynamics of different orders. It was not confirmed that regions with the lowest or highest TFR had differing potential for increased fertility. This also indicates that factors of fertility dynamics differ from those that quite recently (in 2018) influenced the fertility rates in Russian regions. The differences between the factors influencing birth dynamics in the recent past and current times indicate the need to continuously monitor reproductive orientations and the reasons for their changes. The cluster analysis results reveal that regions should conduct strategic sociological research to determine the reasons behind declines in births of specific orders. It is also possible that stereotypes in this regard persist in the regions and information policies can target these stereotypes in the future.

Third, the analysis shows that in clusters that differ significantly in birth order dynamics, the average age at the first, second and third birth does not differ. The absence of such differences casts doubt on the widespread discussion in Russia about the need to motivate and incentivize the population to make have children earlier to increase the birth rate (Egorsheva 2024). However, specialized studies are certainly needed to provide more convincing evidence of the significance or low potential of this factor.

Fourth, the obtained results provide valuable insights for improving regional programs aimed at increasing fertility rates. For this purpose, some pilot groups of related measures such as informational programs could be chosen for implementation. For example, solutions can be developed to target specific clusters with information policies in the demographic sphere, focusing the reproductive age population's attention to having children and birth orders that have the most negative dynamics in comparison with others (Grushevskaya 2022). In other words, the results of our research can form the foundation for developing a segmented state information policy in the demographic sphere by considering the clusters revealed. This will allow regions to promote population policy measures using informational content to address specific fertility rate problems identified by the cluster analysis. For example, the dynamics of second birth are the most apparent problem in the regions of the second and third clusters. First and second birth dynamics are a problem for the regions of the first and fourth clusters. To counter this, regional policies can emphasize relevant concerns in the informational promotion of demographic goals.

Fifth, the findings can be used as the basis for a social experiment. An informational program can be developed for regions that fall into the same cluster that can be based on the intensive promotion of family values and only applied in some regions in one cluster. This program is suggested to pay special attention to the popularization of previously introduced measures aimed at supporting families with children. The informational program must have a certain period of exposure, after which the degree of information impact can be assessed by comparing the fertility rate in the regions of one cluster before and after the informational treatment. The results of such an experiment would allow us to investigate the role of the information resources in state population policy and the possibility of scaling such approaches to other clusters.

It is crucial to note that some degree of cautiousness is required when using cluster analysis for demographic studies and developing state support programs for fertility. Research devoted to the development of methodological and applied aspects of clustering algorithms (Blashfield–Aldenderfer 1988, Edelbrock 1979, Milligan 1980) reveals the following disadvantages.

– Sensitivity to the clustering method and the distance metric between objects. The choice of parameters affects the composition of the resulting clusters; therefore, changing the metrics and methods can lead to radically different clustering results, which may be expressed in a different number of clusters and varying compositions.
– Sensitivity to the number of clusters chosen. Since there are no unambiguous and strict criteria for determining the possible number of clusters, researchers must rely on heuristics and practical considerations based on personal knowledge of the subject area and theoretical methods for assessing the validity of clusters. Thus, the number of identified significant groups in the studied set of objects requires researchers' subjective decisions.
– Sensitivity to the presence of outliers and the initial parameters of the clustering method, which is particularly relevant for k-means clustering.
– Difficulty in assigning boundary object points to a particular cluster when the chosen proximity measure allows the object to be assigned to more than one cluster. In this case, the researchers must rely on experience and knowledge of the field of study, and the problem of subjective decisions or informed choice arises again.

Conclusion

Based on hierarchical cluster analysis, this study identifies clusters of Russian regions that differ significantly in fertility trends differentiated by birth order. The most depressive trends in fertility are observed in the first cluster, which is characterized by the most noticeable drop in TFR1, TFR2, and even a drop in TFR3+, which is not typical for other clusters. In contrast, the second identified cluster is characterized by the most significant growth of TFR3+ and the least pronounced fall of TFR1 and TFR2. The fertility dynamics in this cluster are better than the average Russian trends. The third and fourth clusters have specific differences and occupy intermediate positions between the first two. The existence of such different patterns of fertility dynamics in the Russian demographic space actualizes the search for factors that could explain these differences. Identifying such factors is essential for developing effective state support measures for fertility and overcoming negative demographic trends in the country.

Our analysis did not confirm that fertility dynamics differentiated by birth order are determined by traditionally recognized economic factors. The analysis also did not find that the age of first birth is a determinant of fertility. Russian authorities responsible for developing pronatalist policies now often link this factor to total fertility, speaking of the need for earlier childbirth (Egorsheva 2024); however, no convincing evidence emerged concerning a direct relationship.

Another important finding of our study is that the factors that affected fertility dynamics in the recent past may differ today. Based on the results of this study, we can emphasize the need to search for new determinants of fertility and its dynamics, including lesser-known determinants such as "birth tourism," informational support for regional programs to increase the fertility rate, and others.

The results of our study can provide a foundation for developing a segmented state information policy in the demographic sphere. The findings also indicate the need for continuous monitoring of the reasons behind declining birth rates differentiated by birth order and the related stereotypes among various sociodemographic population groups. As noted, we also see the possibility of conducting a social experiment based on our results by implementing a particular informational program based on the intensive promotion of family values in some regions of one cluster. This would allow us to yield conclusions regarding the role of information resources in the demographic sphere.

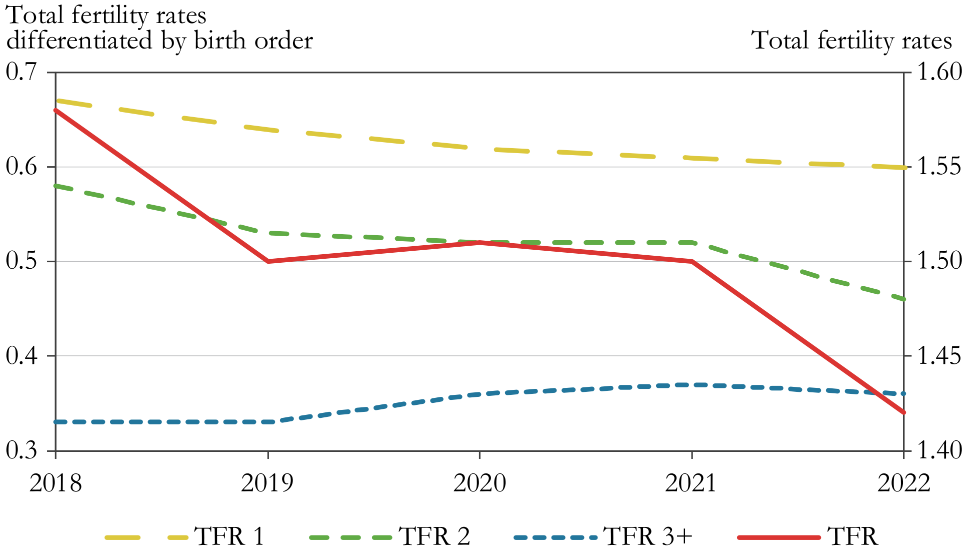
Acknowledgment

We gratefully acknowledge the research funding from the Ministry of Science and Higher Education of the Russian Federation (Ural Federal University Program of Development within the Priority-2030 Program).

Appendix

Figure A1

Fertility trends in Russia differentiated by birth order



Sources: [1], [3], [4].

Figure A2

Hierarchical clustering dendrogram

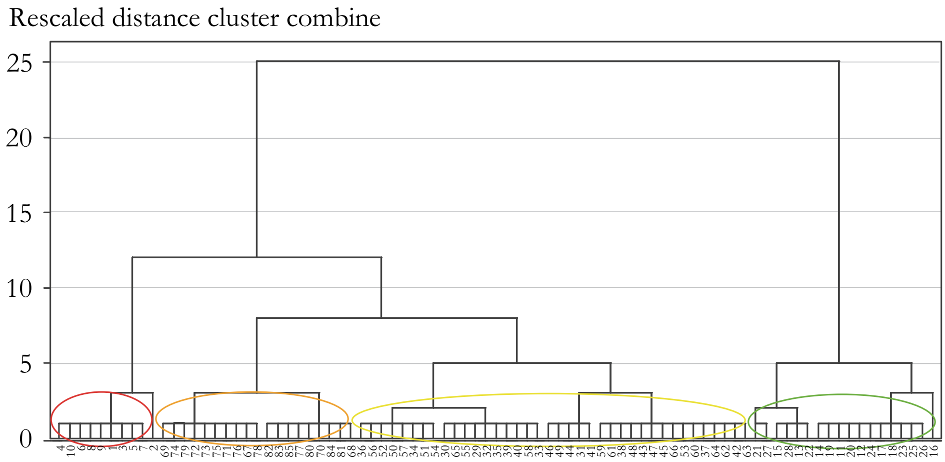


Table A1

ANOVA (for clustering variables)

		Sum of squares	df	Mean square	F	Significance
PC_TFR1	between groups	0.259	3	0.086	40.882	0.000
	within groups	0.171	81	0.002		
	total	0.430	84			
PC_TFR2	between groups	0.196	3	0.065	36.276	0.000
	within groups	0.146	81	0.002		
	total	0.342	84			
PC_TFR3+	between groups	0.303	3	0.101	34.738	0.000
	within groups	0.236	81	0.003		
	total	0.539	84			

Table A2

Kruskal–Wallis Test Statistics (for clustering variables)*

	PC_TFR1	PC_TFR2	PC_TFR3+
Chi-square	52.754	44.515	46.057
df	3	3	3
Asymptotic significance	0.000	0.000	0.000

* Grouping variable: cluster membership.

Figure A3

Clusters of Russian regions

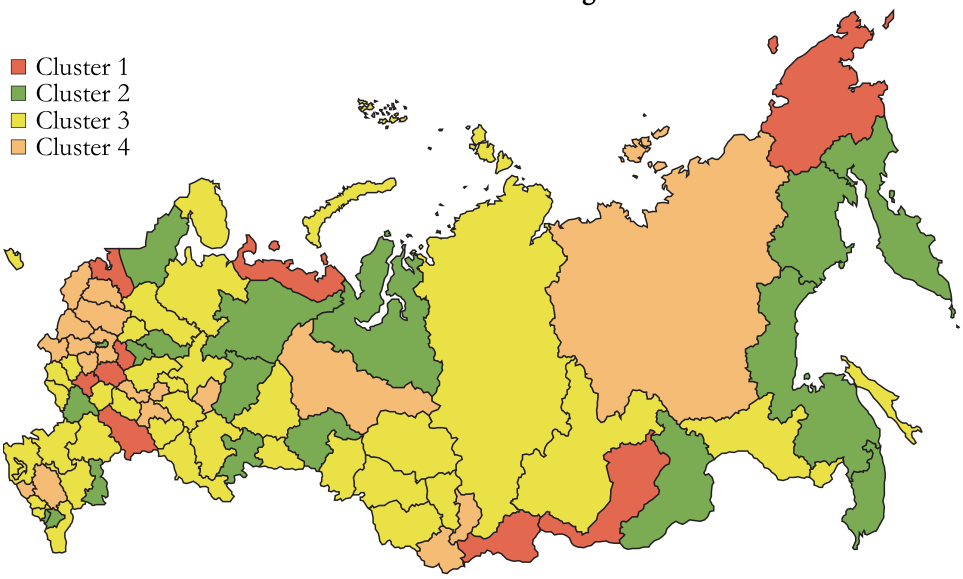


Figure A4

Total fertility rates in clusters in 2022

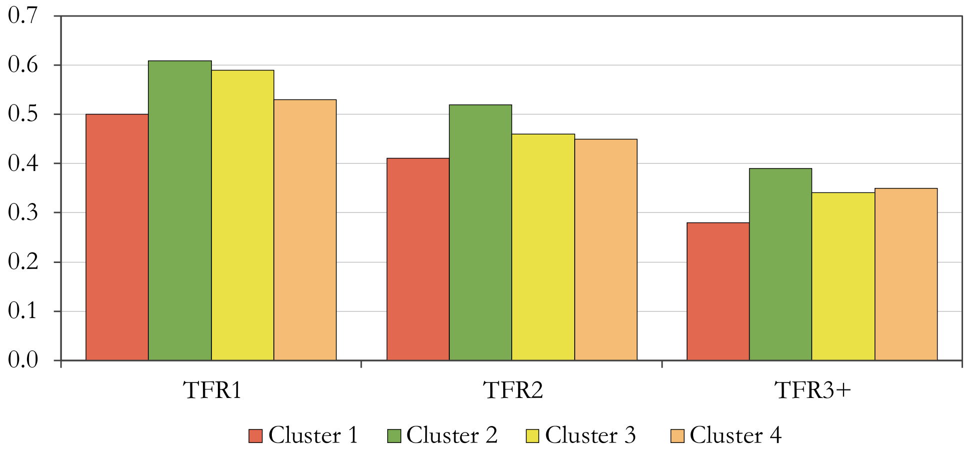


Table A3

ANOVA (for total fertility rates in 2022)

		Sum of squares	df	Mean square	F	Significance
TFR1	between groups	0.095	3	0.032	6.519	0.001
	within groups	0.395	81	0.005		
	total	0.491	84			
TFR2	between groups	0.040	3	0.013	3.512	0.019
	within groups	0.306	81	0.004		
	total	0.345	84			
TFR3+	between groups	0.225	3	0.075	1.771	0.159
	within groups	3.429	81	0.042		
	total	3.654	84			

Table A4

Kruskal–Wallis test statistics (for total fertility rates in 2022)*

	TFR1	TFR2	TFR3+
Chi-Square	52.754	44.515	46.057
df	3	3	3
Asymptotic significance	0.000	0.000	0.000

* Grouping variable: cluster membership.

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