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Determinants of Regional Fertility in Russia*

A Dynamic Panel Data Analysis

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Abstract: The aim of this paper is to empirically examine the regional determinants of fertility rate in Russia using panel data for the period of 2005–2015. The estimation results of a system GMM dynamic model revealed that economic growth, employment opportunity, favorable local business conditions, educational opportunity, quality of social infrastructure, and housing supply serve to increase the fertility rate in Russian regions, while the presence of a Slavic population, migration inflow, poverty and ecological risks tend to suppress it. Furthermore, we found that combinations of factors that strongly affect the reproductive behavior of Russian women vary greatly among age groups and regions. To mitigate the declining trend of fertility in Russia, it is necessary to implement policies that take generational differences and regional heterogeneity into serious consideration.

Key words: total fertility rate, age-specific fertility rate, dynamic panel data analysis, Russian regions

JEL classification numbers: C23, J11, J13, P25, R23

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1. Introduction

Following the collapse of socialism, Central and Eastern Europe countries, as well as the former Soviet Union, experienced a population crisis characterised simultaneously by a deterioration in fertility rates and an increase in death rates. Among these countries, Russia attracted particular interest with respect to this phenomenon (Philipov and Dorbritz, 2004). Russia experienced a sharp decline in gross domestic product (GDP) during the "transformational recession" (Kornai, 1994; Iwasaki and Kumo, 2019) from 1992 to 1998 which had a strong negative impact on the country's demographic trends; the fertility rate decreased and the death rate increased sharply, which resulted in the total fertility rate (TFR) dropping to 1.157 in 1999. During this period, the country's total population also continued to shrink. In tandem with the recovery of the national economy, however, the fertility rate bottomed out in 1999, from which point it increased until 2015 (Antonov, 2008; Rosstat, 2009). As a result, in 2015, the TFR reached a rate of 1.777, the highest level ever recorded in modern Russia.

Despite the recovery in the fertility rate in recent years, Russia still faces serious demographic difficulties. This is clear from Russia's population structure, in which an age group with an extremely small population at the beginning of the 1990s would reach 20 years of age, making a decline in the population of persons of reproductive age and a simultaneous drop in the working-age population unavoidable in the 2010s (Kumo et al., 2017).[1] One of the consequences of this critical phenomenon is that, in Russia, the working-age population declined by more than one million people each year in the two consecutive years of 2015 and 2016.[2] State authorities of Russia are extremely concerned about this issue, and in response, the federal government and parliament have come out with a number of measures to tackle the low fertility rate in the country. The Childbirth and Childrearing Allowance Increase Act and the Maternity Capital Act,[3] which were enacted in December 2006, are regarded to be symbolic of their policy action.

Perhaps due to the highly centralized political power in the country, these policy measures are generally uniform nationwide. They also are seen as age indifferent. In fact, the "Mothers' Capital" provides a total of 250,000 rubles (approximately 10,000 U.S. dollars at the time) to parents with two or more children as a subsidy for housing, education, or pension. This measure is applied on a uniform basis in big cities, where the TFR is far below the population reproductive

[1] According to Russian labor statistics, "working-age population" is defined as males aged 16–59 years and females aged 16–54 years. The typical age of eligibility to receive a pension differs for men and women, being 60 years of age for the former and 55 years of age for the latter.

[2] See the website of the Federal State Statistics Service (hereinafter, "Rosstat") at http://www.gks.ru/.

[3] These acts denote the Federal Law of the Amendment of Several Federal Laws and Regulations Concerning State Assistance for Citizens with Children dated December 5, 2006, and the Federal Law of Additional State Support for Families with Children dated December 29, 2006, respectively.

level and almost all residences are apartment houses, and in rural areas, where the TFR rate is far higher than 3.0 and most households reside in separate houses. In other words, the fund does not take differences in regional living conditions into account at all[4]. The same problem applies to the Childbirth and Childrearing Allowance Increase Act. There is doubt about whether these policy measures are effective or are suited to the actual circumstances in Russia, which is marked by a vast territory and diverse ethnic groups. Which country- and region-level factors can contribute to improving the fertility rate in Russia? Is it not the case that there are notable differences in regional socioeconomic circumstances and demographic structure? Answering these questions is important for Russia from a policy standpoint. It is also a valuable challenge from the standpoint of population economics.

To tackle the downward trend of fertility in Russia, it is necessary to consider not only individual-level factors but also possible impacts of socioeconomic conditions, which greatly vary from region to region, on the reproductive behavior of Russian women. For instance, in 2015, the TFR in Moscow was 1.41, one of the lowest figures in the Russian Federation, whereas the Tuva Republic enjoyed the highest TFR, 3.39. Meanwhile, the average nominal income in Moscow in the same year was 59,000 rubles per month (placing it fourth out of all federal subjects), while in the Tuva Republic, it was just 15,200 rubles per month (ranking 83rd). Therefore, the significant regional disparities in Russia are the subject of long-term debate by researchers from economic policy perspectives (Dolinskaya and Tytell, 2002; Benini and Czyżewski, 2007).

Using figures from the United Kingdom in 2013 for comparison, the income differential between the city of London (Nomenclature of Territorial Units for Statistics [NUTS] 1) and shires such as West Midlands or South Yorkshire (NUTS 2) was less than 1.63 times. In the same time

[4] The amount of "mother's capital" was 429 thousand rubles in 2014. The necessary amount to buy a standard apartment with an average floor space for one person in Moscow city in the year was 2,570 thousand rubles, and this meant that the mother's capital could compensate less than 17% of this cost. Even in the Russian Far East, in the peripheral but comparatively urbanized areas, the amount of mother's capital is less than 29% of the price for a standard apartment for one person on average. Note that the nominal amount of mother's capital does not differ from region to region: hence, the meaning of mother's capital must be very limited in Moscow or in other urban areas. On the other hand, if one calculates in the same way for the Republic of Kalmykia, where more than 50% of people are rural residents and the average price of apartments is the cheapest in Russia, the mother's capital could compensate more than 69 % of the cost for a standard apartment for one person (all the data are available at the Rosstat Website [http://www.gks.ru/] and Rosstat, 2017). Then the scheme of mother's capital may have some effects on fertility in rural areas. In Russia, however, the urbanization ratio is well above 70%; therefore the significance of this policy may not be nation-wide one. This is the reason why the authors pay special attention to the regional variation of living conditions in determining fertility rates. We acknowledge a debt of gratitude to Charles M. Becker for his suggestions.

period, the TFR was lowest in North East Scotland, at 1.53, and highest in West Midlands, at 2.02, making for a differential of less than 1.4 times (Office of National Statistics of the United Kingdom, 2015; Eurostat, 2018). In the case of Japan, the income differential in 2015 between the city of Tokyo and prefectures such as Okinawa, Miyazaki, and Aomori was less than 1.63 times. The TFR for Japan in the same year was lowest in Tokyo, at 1.24 out of 47 prefectures, and highest in Okinawa, at 1.96, making for a differential of less than 1.6 times. The case is the same for the United States as well. TFR in 2015 was lowest in the District of Colombia, at 1.48, and highest in Utah, 2.29, while the income differential between Maryland and Mississippi was less than 1.87 times.[5]

In contrast with the small territories within ethnically homogenous countries such as the United Kingdom and Japan, large regional disparities within Russia may be inevitable. This also implies that policies that could be applied nationwide in the United Kingdom and Japan without causing major problems may result in unwanted outcomes in Russia. However, as shown above, when compared with the United States, which has a huge territory, the regional disparity in Russia is more clearly evident.

Therefore, in the case of Russia, it is important to question the efficacy of policies that are designed to boost the fertility rate but do not take into account the distinctive characteristics of the different regions. For this reason, the relationship between fertility and regional factors is an significant research topic in the study of Russian demographics; thus, the objectives of this study are twofold. First, this study attempts to identify the effects of various regional socio-economic factors on fertility and clarify the different effect sizes based on region. Second, the study applies dynamic panel data analysis in order to obtain robust results.

In this paper, to achieve the above research objective, we will employ handcrafted panel data on Russian regions for the period from 2005 to 2015 and empirically examine the regional determinants of the TFR and age-specific fertility rates. The estimation results of a system GMM dynamic model revealed that economic growth, employment opportunity, favorable local business conditions, educational opportunity, quality of social infrastructure, and housing supply serve to increase the fertility rate in Russian regions, while the presence of a Slavic population, migration inflow, poverty and ecological risks tend to suppress it. Furthermore, we found that the combinations of factors that strongly affect the reproductive behavior of Russian women vary greatly among age groups and regions, suggesting that to restrain or mitigate the declining trend of fertility in Russia, it is necessary to implement policies that give serious consideration to generational differences and regional heterogeneity.

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[5] National Center for Health Statistics, https://www.cdc.gov/nchs/nvss/births.htm, accessed on August 24, 2019; United States Census Bureau, https://www.census.gov/, accessed on August 24, 2019.

The remainder of the paper is structured as follows: In the next section, we review the related literature and develop a testable hypothesis concerning the determinants of regional fertility in Russia. In Section 3, we provide a statistical overview of the dynamics of fertility rates in the Russian Federation, federal districts, and federal subjects and discuss their basic characteristics. In Section 4, we test our hypothesis by conducting a dynamic panel data analysis of the TFR and age-specific fertility rates. Finally, in Section 5, we summarize major findings obtained from the empirical analysis and argue policy implications.

2. Determinants of Regional Fertility Rates: Discussion of Previous Research and Theoretical Hypothesis

As stated at the beginning of this paper, Russia experienced a rapid decline in its fertility rate after the collapse of the Soviet Union, and much effort was spent on studying the factors that caused the decline. In fact, it can be said that these investigations began immediately after the collapse of the Soviet Union (Vishnevskiy, 1994), and most of the debate—whether it was conducted in foreign countries or domestically—on fertility rates in modern Russia, which lacked a tradition of quantitative analysis because of the paucity of data, involved little more than a description of facts. Initially, hardly any attempt was made to employ statistical and quantitative techniques to investigate the determinants of fertility rates. Approaches based on micro-data, meanwhile, take a fair amount of time to accumulate the required data; so, in the case of Russia, the discussions have relied mainly on country-level data or regional data. In fact, *World Development*, an influential journal, came out with a special issue on Russian population dynamics in 1998 that also discussed the sharp decline in the fertility rate; however, all of the papers relied on descriptive approaches.

Over the years, many academics have regarded the drop in Russia's fertility rate to be a result of the extreme stagnation in national economic activity that occurred in conjunction with the transformation to a market economy (DaVanzo and Grammich, 2001). In other words, the view was that income levels and economic/employment conditions during a certain period directly affected the fertility rate. Such assertions can be said to emphasize the economic cost of raising children, but the theoretical and empirical support for them was insufficient. Further, it has been argued that if the historical trend in the cohort fertility rate is compared with that of other countries, Russia's experience mirrors the long-term trend in other nations (Avdeev and Monnier, 1995; Kharikova and Andreev, 2000); however, studies advocating such views have not gone as far as examining the various determinants of long-term changes in Russian population dynamics.

Therefore, in the next section, we discuss the variables used in this paper's empirical analysis and present hypotheses concerning their signs by tracing the discussions in previous research that focused on the determinants of the fertility rate in Russia. In doing this, we will pay attention to findings in the field of population economics that have been published relatively recently, that is, after the advanced countries and Russia had entered the era of low fertility rates and aging populations.

2.1 Economic Conditions and the Fertility Rate

Easterlin's (1966) "relative income hypothesis" is frequently cited when considering the impact of the economic environment on the fertility rate. It is cited in the context of changes in the fertility rate within a single country after that country has achieved a certain level of economic development, rather than for comparing countries—such as advanced countries with developing ones—with significant differences in levels of economic development. As per this hypothesis, the standard of living that one has experienced in the past affects decisions on whether to have children; thus, if a high standard of living is expected in the future, the person concerned is predicted to have children. The relative income hypothesis leads to the prediction that an improvement in future economic prospects can be expected to result in an increase in the fertility rate. In this context, when discussing factors that affect the fertility rate, it is normal to consider not only the economic growth rate but also the trend in the degree of employment stability and the price level, in addition to the quality and quantity of social capital.

Here it can be assumed that both economic growth and employment opportunities will lead to an increase in fertility. Based on this assumption, there have been numerous studies on the relationship between economic conditions and fertility rate. For example, Kohler et al. (2002) examined trends in fertility rates not only in former socialist countries, but also in European ones, and asserted that deteriorated economic conditions and rising uncertainty reduces the fertility rate. The same claim was made by Billingsley (2010), who used macroeconomic data on former socialist countries in transition to show that the rate of GDP growth and the citizen's income had a significant and positive effect on the fertility rate. Conversely, rising prices have been shown to have a significant and negative effect on fertility rate (Rodin, 2011; Gentile, 2005).

Similarly, the risks of poverty and unstable business conditions in the region must affect fertility negatively because they decrease "relative income" (Easterlin, 1966). In fact, Rodin (2011) argued that while economic growth in Eastern European countries serves to increase fertility rate, the increase in unemployment rate, inflation, and other economic risks in those countries has a negative effect on fertility rates.

Regional infrastructure should be considered because preferable socio-economic conditions may increase fertility, as described above. On the contrary, environmental risks, the down side of poor infrastructure development, will affect fertility negatively. Gentile (2005), whose study focused on Central Asia, claimed that favorable political and economic conditions, as well as progress in infrastructure development, had a positive effect on fertility rates in the region, but growing poverty and deterioration of the environment or health led to a decline in fertility rates. The view that a fall in economic prosperity and rise in livelihood risks reduces fertility rates was emphasised by Sobotka (2011), who conducted a comprehensive study of the economic crisis in Central and Eastern Europe and the period of robust economic growth during the second half of the 2000s.[6]

Studies on transition-period Russia have presented views similar to those in the previous research discussed above. Kharikova and Andreev (2000), whose work was mentioned earlier, and who conducted one of the first such studies, used the aggregated results of a micro-census that was conducted in Russia in 1994 to assert that the economic contraction during the transition process led to a decline in the fertility rate. As in Kharikova and Andreev (2000), DaVanzo and Grammich (2001), who relied on macro-statistics, argued that the slump in economic activity that resulted from the transformation of the economic system led to a sharp drop in the fertility rate. Popova's (2014) study covered the 2000s and used descriptive statistics to develop the view that economic stability or growth during that period resulted in a rise in Russia's fertility rate.

Meanwhile, although the indicators for social infrastructure are limited in official statistics, we can assume that the number of educational facilities, equipped hospitals and adequate housing, will result in an increase in fertility. Kurushina and Druzhinina (2015) used regional data to report that fertility rate was significantly and positively affected by factors such as the availability higher education opportunities, the level of infrastructure development (measured by taking the density of paved roads), and housing conditions (measured by taking the floor area of dwellings). Furthermore, Popova (2016), who studied population policies of the Russian government, argued that rising incomes and employment stability at the regional level played a key role in improving fertility rate.

As the above discussion has shown, when Easterlin's (1966) relative income hypothesis is used to assume that the level of optimism about future economic prospects has a major impact on the fertility rate, factors such as economic growth and certainty with regard to obtaining employment are likely to have a positive influence on the fertility rate; further, other factors, such as the financial health of companies, the abundance of social capital, favorable living environments, and the availability of educational opportunities, are likely to have a similar significance. On the flipside, a range of factors, such as poverty and ecological risks, could bring down the fertility rate.

2.2 Perspectives on Regional Characteristics

[6] Research in Japan has produced similar findings, with Kamata (2009) using prefectural data to perform empirical research. The findings indicate a significant negative correlation between the unemployment rate and the fertility rate; further, the rate of employment has a significant and positive effect on the fertility rate.

If it is claimed that economic conditions explain fluctuations in the fertility rate, it could be argued that it is appropriate to use micro-data on the economic conditions of households, rather than regional data, to perform analyses. However, what needs to be emphasized here is that the characteristics, which cannot be fully grasped using micro-data, do exist spatially. For example, whether the region is urban or rural can lead to big differences in housing conditions and support for childrearing, so it should be no surprise that this results in people with the same individual characteristics exhibiting differences in fertility rates.

Differences in fertility rates between urban and rural areas have been discussed at length (Kulu, 2011), but there could be various factors other than individual characteristics. At the individual level, numerous studies, such as that by Jasilioniene et al. (2014), have identified differences in fertility rates arising from ethnic differences; however, if a more macroscopic view is taken, and research is conducted at the regional level, researchers such as Basten et al. (2011) and Fiori et al. (2014) have suggested that regional differences in assimilation with the local community could have a greater impact on fertility rates than do ethnic differences. In such cases, it is difficult to claim that individual characteristics are appropriate indicators to explain regional differences in fertility rates. In fact, Woods et al. (2014) has shown that the impact of macroeconomic variables on fertility differs significantly across regions. Both Frejka and Gietel-Basten (2016), who analyzed Central and Eastern European countries, and Gentile (2005), who studied the population geography of Central Asia, concluded that the fact that the same population policy differs in its effectiveness across regions points to the fact that a different policy is needed for each region.

Regional differences in fertility rates in Russia are fully recognised by researchers, and there are numerous views concerning them. Climate conditions, especially in the northern regions, should be discussed because difficult living conditions lead to negative effects on fertility. For example, Popova and Shishkina (2017) find that fertility rates in northern regions such as the Magadan and Arkhangelsk Oblasts are lower than the average for the Russian Federation. Nevertheless, the researchers contend that the fertility rates are higher in ethnic federal districts or republics, where the proportion of ethnic Russians is small.

The ethnic composition of the region should be considered when thinking about regional disparity in fertility rates because Slavs clearly show lower fertility than Caucasians, Central Asians, or other ethnic groups. Revich (2008) also focused on the ethnic differences regarding fertility rates and the low fertility rates in northern regions, and highlighted the need to consider regional characteristics in analytical research on Russian demographics. Other popular topics are the decline in fertility rates as a result of assimilation with ethnic Russians and the relatively low fertility rates observed among Slavs. A comparatively recent study by Agadjanian et al. (2008)

illustrated differences in population dynamics arising from differences in the ethnic structures of Kazakhstan.

In addition to addressing these points, Shishkina and Popova (2017) paid attention to the scale of regional differences in fertility rates resulting from the age structure. The authors of these papers state that unless policies take into account the individual characteristics of regions, they probably will not be as effective as hoped. Archangelsky and Dzhanaeva (2015) also paid attention to the notion that regional age structure results in differences in fertility rates at the regional level and stated that changes in population structure owing to interregional population migration could influence fluctuations in fertility rates.

Lastly, population migration flows affect the demographic composition of regions and have certain influences on demographic trends. The impact of interregional population migration is both supported and denied in research on various countries around the world, as well as in research that is limited to Russia. However, if migration to urban/economic centres and resource-rich northern regions makes up the bulk of population inflows, interregional population migration could have a negative effect on the fertility rate of Russia as a whole. In fact, it should be emphasised here that Kumo (2017) clarified that the interregional population migration within Russia flows into economically advanced areas and resource-abundant regions.

Based on the above arguments, we identify factors that may significantly affect fertility in Russian regions. As indicated in **Table 1**, we predict that economic growth, employment opportunity, favorable business conditions, educational opportunity, the quality of social infrastructure, and the housing supply in a region are positively associated with the fertility rate in the region, while climate hardship, the presence of a Slavic population, migration inflow, poverty and ecological risks negatively affect it. As a first step to empirically verify these hypotheses, the next section attempts to grasp the dynamics and basic characteristics of fertility in Russia and its regions.

3. Dynamics of Fertility in the Russian Federation and Regions: A Statistical Overview

Taking the arguments in the previous section into account, this section will provide a statistical overview of the dynamics of fertility in the Russian Federation, federal districts, and federal subjects and discuss their characteristics.

Figure 1 plots the long-term trend in the TFR in Russia from 1961 until 2015. According to the figure, the TFR for the entire Russian population stayed at around 2.0 or higher through the period from the 1960s to the 1980s. However, in the 1990s, when the economic and political crisis that followed the collapse of the socialist regime brought with it stark realities and shook the entire nation, the fertility rate began a sharp decline, finally reaching its lowest point of the period, 1.157, in 1999. Later, between 2000 and 2005, the TFR exhibited minor fluctuations, but from 2005 onward, it finally began a long-term rise, albeit one that was extremely slow. The average annual increase during 2005–2015 was 0.048, and no year-on-year declines were seen. In other words, the period of 2005–2015 is characterized as a period of steady recovery in Russian fertility.[7]

Figure 1 also shows trends in the TFR of urban and rural populations, and a characteristic of these trends coincides with that for the total population described above. However, a comparison of the two reveals that the TFR of the rural population exceeded that of the urban population by as much as 1.215 in 1986/87 but that this gap had narrowed to 0.369 in 2005. During the period from 2005 to 2015, the gap between the urban and rural populations widened in most years, though it narrowed in 2009 and 2015. In sum, the interrelationship in terms of fertility dynamics between rural and urban areas was not stable. This is an important point for understanding fertility dynamics in Russian regions, which exhibit large disparities in the rate of urbanization.

While keeping in mind the above-mentioned trend for the Russian Federation as a whole, let us take a look at the dynamics of regional fertility rates. **Figure 2** compares a line graph of the TFR for the entire Russian population in recent years with a bar graph of indicators for each federal district.[8] As shown in this figure, to a greater or lesser extent, all eight federal districts show the recovery trend of fertility seen in the federation as a whole. Another point worthy of attention is the relative relationships of federal districts. In other words, throughout the period 2005–2015, the TFR of the North Caucasus federal district was the highest of the eight districts. The North Caucasus district was followed by the Ural, Siberia, and Far East districts, which all had similar fertility rates. These three federal districts were followed by the South and Volga counterparts, which constituted the third group. The Northeast district came seventh and the remaining Central district recorded the lowest fertility rate of the eight districts in every single year of the period. These two characteristics suggest that the dynamics of the Russian fertility rate are strongly affected not only by factors that have an influence throughout all regions but also by

[7] In 2016 and 2017, the TFR in Russia decreased, possibly due to the social tension caused by conflict with Ukraine and economic sanctions introduced by the United States and many European countries.

[8] A "federal district" is a regional zone under the control of a plenipotentiary representative of the president that is established for the purpose of overseeing and supervising regional administration. Federal districts differ from "federal entities," which are general administrative divisions and comprise federal cities, republics, krais, oblasts, autonomous oblasts, and autonomous okrugs. Federal districts comprise federal entities with a great deal in common geographically, historically, and ethnically. Federal districts, therefore, constitute administrative zones useful for identifying and comparing general characteristics of Russian regions.

other factors that solidify the interrelationships between regions.

From **Figure 3**, we can confirm that the above characteristics of federal districts are more or less in line with those for each federal entity. In this figure, using the tenth through ninetieth percentiles of the TFR for each federal entity for 2005–2015, all 89 federal subjects are identified using eight colors.[9] Each panel in **Figure 3** reflects the nationwide recovery trend in the fertility rate during the period, with the entire map becoming darker as time passes. From the figure, we can confirm that the TFR exhibited stable growth in the majority of federal subjects, and no dramatic change is seen in the relative relationships within federal districts or between federal subjects. In fact, of the 83 federal subjects for which data exists, only the Chechen Republic shows a decline of 0.150 in the TFR in 2015 from the value in 2005. In all of the remaining 82 regions, the TFP increased within the range of 0.150 (Karachay-Cherkess Republic) to 1.240 (Tuva Republic) (mean: 0.491; median: 0.490). Furthermore, the coefficients of variation for each of the 83 federal subjects in order of the TFR during 2005–2015 range from 0.000 (Leningrad Oblast) to 0.996 (Republic of Ingushetia), and their mean, median, and standard deviation are 0.172, 0.136, and 0.151, respectively. Moreover, 32 federal subjects have a coefficient of variation of less than 0.100, and 23 have one between 0.100 and 0.200; together, they account for 66.3% of all federal subjects. This indicates that it is highly likely that the determinants of fertility rates in federal subjects also consist of two types: time-series factors that affect a wide area across the entire territory of Federal Russia and relatively time-invariant factors that tend to fix disparities among regions.

However, the above TFR trends do not necessarily apply to the fertility of every age group. In addition to the TFR, Rosstat publishes the average number of children born to 1,000 women aged 15–19, 20–24, and 30–34 years.[10] In 2015, the mean (median) of these age-specific fertility rates for each federal entity is 25.91 (24.55) for the 15–19 age group, 97.06 (91.75) for the 20–24 age group, 114.55 (111.80) for the 25–29 age group, and 82.87 (82.60) for the 30–34 age group.[11] These figures indicate that the reproductive opportunities of Russian women reach a peak in their late 20s, and women in the five-year age brackets above and below that also produce many children.

Figure 4 shows scatter plots of region-level TFRs during the period of 2005–2015 and of age-specific fertility rates. In each panel of the figure, the fractional polynomial fitted line and its

[9] White indicates a region for which data was not available. Rosstat has not published fertility rates for six autonomous districts since 2010.

[10] Although the age range of women subject to the calculation of the total specific fertility rate is 15–49, Rosstat does not publish life-stage fertility rates for women aged 35 years or older, so it is impossible to perform analyses of these higher age groups.

[11] The mean (median) of the TFR for each federal entity in the same year is 1.836 (1.815).

95% confidence interval are also presented. **Figure 5** shows time-series changes in the standard deviations of these five variables, with the TFR presented as a line graph and age-specific fertility rates presented as a bar graph. As shown in panel (a) of **Figure 4**, the approximation curve for the TFR exhibits a gradual upward trend, and according to **Figure 5**, the interregional variance of the TFR switched from a widening trend to a narrowing trend in 2011. Nevertheless, none of the age-specific fertility rates share all of these TFR characteristics. In other words, according to panels (d) and (e) of **Figure 4**, the fertility rate for the 25–29 and 30–34 age groups demonstrate the same upward trend as the TFR, while panels (b) and (c) prove that the fertility rate for the 15–19 age group has a gentle inverse U trend and that for the 20–24 age group is flat for the entire period. In addition, **Figure 5** indicates that the standard deviation of the fertility rate for the 15–19 age group traces that of the TFR, whereas the fertility rates for other age groups display a very different time-series variation.[12]

The above facts not only imply that the determinants of Russian regional fertility rates may differ greatly between the TFR and age-specific fertility rates in terms of direction, effect size, and statistical significance, they also strongly suggest that there may be significant differences among the age-specific fertility rates. Keeping this point in mind, the next section empirically tests the hypotheses proposed in the previous section.

4. Dynamic Panel Data Analysis of Regional Fertility Rate

In this section, we will conduct an empirical analysis of Russian regional fertility rates. Here we will estimate a regression model that gives consideration to the path-dependent and autoregressive nature of the fertility rate and the past referential integrity of human decision-making behavior. More specifically, using region-level panel data for the period of 2005–2015, we will estimate the dynamic model that takes a regional fertility rate as the dependent variable. In the setting we take its (regional fertility rate's) lagged endogenous variable, which controls for the psychological effects of social entrainment pressure (collective pressure) and social inertia with regard to childbirth and childcare in Russian families, and three-year moving averages of other factors that

[12] Here, attention needs to be paid to the 15–19 age group. During the period of 2005–2015, the proportion of children born outside of wedlock in Russia as a whole declined fairly steadily from more than 29% to less than 22%, but for the 15–19 age group, it remained in the 47–49% range, which is far higher than the figures for the 20–34 age group, which did not exceed 30% at any point during the period. In other words, the proportion of unmarried mothers is extremely high among the younger age groups, and it is highly likely that this factor could result in reproductive behavior that differs from that seen in other age groups. However, the focus of the subsequent analysis in this paper is to show that fertility determinants for each age group differ, so the issue of why fertility determinants differ is beyond this paper's scope. To answer that question, analysis involving micro-data will be required.

may affect reproductive behavior of Russian women as the independent variables:

$$y_{it} = \mu + \gamma y_{it-1} + \sum_{j=1}^{n} \beta_j \left(\sum_{k=t-1}^{t-3} x_{ijk} \Big/ 3 \right) + \varphi_i + \varepsilon_{it},$$

where y_{it} is a fertility rate in region i in period t (i=1, …, 83; t=2005, …, 2015), μ is the constant term, x_{ijt} is the jth reproductive behavior–influencing factor (j=1, …, n), φ_i is the individual effect of region i, ε_{it} is the disturbance term, and γ and β_j are parameters to be estimated. We will estimate the above equation using the Arellano–Bover/Blundell–Bond system generalized method of moments (system GMM) estimator.

To this end, in the next subsection, we will select the variables to be used in the regression analysis, then report the estimation results in Subsection 4.2. In Subsection 4.3, we will test the robustness of the estimation results.

4.1 Variable Selection

For the dependent variable, we will use the region-level TFR and age-specific fertility rates mentioned in the previous section. The right-hand side of the regression model will contain a one-year lagged value of the dependent variable and the following 12 types of variables:

Climate hardship is represented by the average temperature in January, which is the coldest time in Russia. The impact of the presence of a Slavic population on the fertility rate is tested by the share of three Slavic ethnicities, namely Russian, Ukrainian, and Belorussian, in the total number of residents in the region concerned. The effect of migration inflow is assessed using the number of migrants per 10,000 residents. To examine the effect of economic growth, the real growth rate of gross regional product (GRP) is employed. Employment opportunity and local business conditions are represented by the number of firms and organizations per 10,000 residents and the proportion of firms and organizations in fiscal deficit, respectively.

To evaluate the impact of poverty risk on the fertility rate, we utilize the share of the total population of residents whose monetary income is lower than the poverty line defined by the minimum living expenses determined for each region by the federal government. The availability of educational opportunity and the quality of social infrastructure are expressed by the number of graduates of higher education per 10,000 residents and the number of hospital beds per 10,000 residents, respectively. As a proxy for the intensity of housing supply, floor space per capita is used. The effect of ecological risk is examined using the ecological-risk ranking of federal subjects produced by the Expert RA Rating Agency.

If the hypotheses stated in Section 2 are supported, regression coefficients for the average January temperature, real GRP growth rate, number of firms and organizations, number of graduates of higher education, number of hospital beds, and per capita floor space should be estimated to be positive, while those for the share of Slavic population, migration rate, share of firms and organizations in fiscal deficit, share of population under the poverty line, and ecological risk should show a negative value. As mentioned above, all 11 of these independent variables take lagged three-year moving averages. The use of a lagged moving average accords with the assumption of the past referential integrity of reproductive decision-making. In addition, this measure is effective to avoid possible endogeneity between the dependent and independent variables.

In addition to the above 11 variables, we introduce a time-trend variable into the right-hand side of the regression equation as a control variable in order to capture the long-term tendency in fertility rates. The definitions, descriptive statistics, and sources of all aforementioned variables are presented in **Table 2**.[13]

4.2 Estimation Results

Table 3 shows the estimation results of the regression model that takes the TFR as the dependent variable. Models [1] to [8] report the estimates of individual independent variables or a pair of independent variables where the area of inquiry is similar. Meanwhile, Model [9] displays the simultaneous estimation results of all 11 variables. As shown in this table, the regression coefficient of the lagged endogenous variable (y_{it-1}) is estimated to be positive at the 1% significance level in all nine models, illustrating the strength of the path dependency and autoregressive nature of fertility rates.[14] The time-trend variable also produced a positive coefficient with statistical significance at the 1% level in all models and, thus, suggests the stable recovery tendency in the regional TFR as we described in Section 3.

With Models [1] to [8], all of the independent variables, from the average temperature in January to ecological risk, are estimated at the 10% significance level or higher. In addition, all of their signs matched our predictions, with the average January temperature being the only exception. In other words, the estimation results verify that six factors, namely economic growth, employment opportunity, favorable local business conditions, educational opportunity, quality of

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[13] **Appendix 1** reports a correlation matrix of the dependent variables and correlation coefficients between the dependent variables and independent variables.

[14] As the table shows, the Arellano–Bond test for AR(2) rejects the null hypothesis of no autocorrelation at the 10% significance level for two of the nine models only, indicating that the assumption of the disturbance term is adequately satisfied for the system GMM estimation. Although we have omitted the test results, the test for AR(1) rejected the null hypothesis for all of the models reported in this paper at the 5% significance level or lower. On the other hand, the Sargan test rejects the null hypothesis that overidentifying restrictions are valid in all cases. The estimation results of the dynamic model, therefore, have some room for improvement in model specification.

social infrastructure, and housing supply, contribute to increase the fertility rate in the region concerned, while four factors, including the presence of a Slavic population, migration inflow, poverty and ecological risks, tend to suppress it. According to Model [9], however, if these factors are simultaneously controlled for, the statistical significance of ecological risk becomes less than 10%, indicating that it is less robust than the other 10 factors.

Figure 6 displays partial correlation coefficients (PCC) of the independent variables computed using the estimation results of Model [9] in **Table 3**. PCC is "a measure of the association of a dependent variable and the concerned independent variable when other variables are held constant" (Iwasaki and Kumo, 2019, p. 160). It enables the relative impact on the dependent variable of independent variables measured in different units to be compared. According to this figure, the average temperature in January and the number of hospital beds demonstrate a relatively large effect size, while the effect size of ecological risk remains low. The other 8 variables from the proportion of the Slavic population to the floor space per capita have almost the same effect size ranging from -0.062 to 0.092. In sum, although the impacts of climate hardship and quality of social infrastructure on fertility are notable, other socioeconomic factors except the ecology variable also have important implications for fertility in Russian regions.

Table 4 represents the regression models with age-specific fertility rates as the dependent variable. As pointed out in Section 3, the time-series dynamics and distribution of the age-specific fertility rates differ greatly from those of the TFR and also from each other. The estimation results in **Table 4** clearly reflect the differences between fertility indicators. More specifically, the factor that has a statistically significant effect on the fertility rate of all four age groups is limited to the quality of social infrastructure, though educational opportunity and housing supply affect the fertility rate of three of the age groups. Five factors, migration inflow, economic growth, employment opportunity, poverty and ecological risks, only have statistically significant effects on the fertility rates of two age groups, while local business conditions only affect the fertility rate of the 25–29 age group. The presence of a Slavic population hardly exhibits any correlation with age-specific fertility rates. Climate hardship, meanwhile, affects the fertility rates of three age groups, but as was the case with the TFR, its effect does not correspond with our expectation. Great caution needs to be exercised with respect to the fact that combinations of statistically significant independent variables differ markedly. The asymmetry between different age groups provides important clues for understanding the causes of the late childbearing and the decline in birthrate in Russia. The estimation results in **Table 4** also suggest that, as long as there are great differences in age structure from region to region, the focus and content of the policy measures need to be carefully adjusted for each region.[15]

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[15] If regional differences in age structure are attributable to the determinants of fertility rates, direct

Russia is a vast country, and the historical background of social progress, as well as the level of economic development and ethnic composition, differs greatly among regions. To investigate the impact of regional heterogeneity, we classified eight federal districts into four groups from the viewpoint of similarity of socioeconomic characteristics and presented the estimation results for each group in **Table 5**.[16] As indicated in the results using the age-specific fertility rates in **Table 4**, from this table, we can see that the regional factors that affect the reproductive behavior of Russian women differ greatly from the east to west and north to south of the country. Actually, in **Table 5**, apart from the lagged endogenous variable, no independent variable is significantly estimated in all four models. Among them, three are recognized as having a comparatively broad effect. These are migration inflow, economic growth, and educational opportunity, showing significant estimates in three of the four models. On the other hand, the other nine variables are only significant in one or two models. Nevertheless, if the average January temperature is excluded, none of the sign relationships of these significantly estimated independent variables are inconsistent with the theoretical predictions discussed in Section 2.

Russian regions are characterized by a large gap in economic development and urbanization as well as remarkable differences in ethnic composition. We therefore conducted a supplementary regression estimation by dividing the federal subjects into an upper group and a lower group, referring to the medians of the 2005 per capita GRP, urban population ratio, and Slavic population ratio. The results are shown in **Table 6**. They demonstrate a marked asymmetry between the estimation results of the paired models and, hence, imply that the differences in economic development, urbanization, and ethnic composition are closely related to the effect size and statistical significance of the factors that influence fertility rates in Russian regions. It is likely that the combined effect of these factors led to the estimation results for each federal district shown in **Table 5**.

4.3 Robustness Check

To test the statistical robustness of the estimation results reported in **Tables 3** to **5**, following Iwasaki et al. (2016), we performed a supplementary estimation, in which various sample restrictions were placed on the regression models, and confirmed that these limitations do not substantially change the major empirical findings. More specifically, supplementary regressions were conducted in the following seven settings: (a) excluding Moscow and St. Petersburg, which

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control for the female population in each age group in each region could be adopted for regression analysis. In Russia, however, fertility-rate data for each five-year age bracket is not available. Furthermore, estimates to extrapolate the population in each bracket are not made between each census. This is the reason we employed this approach for our study.

[16] **Appendices 2** to **5** report corresponding estimation results using age-specific fertility rates.

are under the direct control of the federal government (i.e., federal cities), from observations; (b) excluding republics, autonomous oblasts, and autonomous okrugs whose ethnic composition differs substantially from the typical Russian regions from observations; (c) excluding so-called “resource-rich” regions from observations; (d) dividing observations into those for 2005–2010 and those for 2011–2015; (e) dividing observations into two subsamples by the median of GRP per capita in 2005; (f) dividing the regions into two subsamples based on the median of the TFR or the age-specific fertility rates in 2005; and (g) limiting regions to those with a TFR or an age-specific fertility rate within the mean ±1 standard deviation.

We also conducted estimations using the unemployment rate, the number of institutions of higher education, the number of graduates of secondary education per 1,000 residents, and the number of mobile phones and personal computers per 1,000 residents as alternative variables for employment opportunity, educational opportunity, or the quality of social infrastructure. Although these variables show less statistical significance than the variables employed in this paper, their estimated signs did not go against the theoretical hypotheses.

As an additional robustness check, we performed the estimation using a series of alternative estimators including the pooling OLS, between effects, population averaged, random effects, fixed effects, random effects with AR(1) disturbances, and fixed effects with AR(1) disturbances and found no remarkable differences from the estimation results reported in the previous subsection.[17]

The above results of the robustness check led us to the judgment that the estimation results reported in this paper are fairly robust across the various specifications.

5. Conclusions

In this paper, using newly prepared regional panel data on Russian federal subjects, we attempted to specify factors that determined the region-level TFR and age-specific fertility rates in the period of 2005–2015, during which the Russian fertility rate began gradually yet steadily increasing following the long-term economic slump triggered by the collapse of socialism. Based on the theoretical arguments and empirical evidence in the previous literature, we first hypothesized that 11 factors, from climate hardship to ecological risk, would have a pronounced effect on Russian regional fertility, then empirically examined our predictions by performing a dynamic panel data estimation using a system GMM model.

The estimation results reported in the previous section are summarized in the following seven points: First, in line with the theoretical hypotheses in Section 2, six factors consisting of

[17] The results are reported in **Appendix 6**.

economic growth, employment opportunity, favorable local business conditions, educational opportunity, quality of social infrastructure, and housing supply serve to improve the fertility rate in the region concerned. Second, in contrast, four factors including the presence of a Slavic population, migration inflow, poverty and ecological risks tend to suppress it. The effect of ecological risk, however, is less statistically certain than that of the other factors. Third, contrary to our predictions, climate hardship is positively related to regional birthrates. Fourth, the TFR is significantly affected by almost all of the influential factors we focused on, though factors that are closely linked with age-specific fertility rates are rather limited. Fifth, despite these results, the impacts of significantly estimated factors correspond well with our theoretical expectations. Sixth, combinations of factors that strongly influence the reproductive behavior of Russian women differ greatly depending on age. Seventh, factors that are significantly associated with the TFR vary extremely from the east to west and north to south of the country.

Although the TFR in Russia began increasing steadily from 2005 onward, it remains at a low level. Therefore, this trend does not overturn the pessimistic predictions regarding the country's population dynamics in the near future. Furthermore, the dynamics of age-specific fertility rates clearly indicate that the tendency in Russia for women to have children later in life is becoming a more serious issue. As the experience in European countries shows, it is not impossible to halt declining fertility rates by implementing a policy measure(s). From this perspective, the above fourth through seventh empirical findings are worthy of attention: If the factors that strongly affect the reproductive behavior of women in Russia vary among age groups and regions, policy guidelines and institutional designs that reflect this reality should prove highly effective. As we stated in the Introduction, due to the high degree of centralization of political power in Russia, the federal government and parliament are inclined to adopt comprehensive and nondiscriminatory policies that apply nationwide. However, the empirical findings in this paper suggest that in terms of measures to tackle the low fertility rate, the formulation and implementation of more finely tuned policies that take careful account of differences in the age structure of regions and local circumstances would not only be expected to be more effective but could also be more sensible from a fiscal perspective. From this viewpoint, it may be worth experimenting with the decentralization of budgets and authority.

We should note, in this regard, that in addition to the federal government's nationwide policies, individual regions have introduced their own countermeasures to solve the demographic crisis. For instance, since 2016, the Nenets Autonomous Okrug has paid 366,000 rubles to families having a third or subsequent child. This is a large subsidy, more or less equal to the average per capita annual income of Russian citizens.[18] However, this surprisingly generous

[18] In 2016, the nationwide average was 359,000 rubles per year, while in the Nenets Autonomous

policy is facilitated by conditions specific to the Nenets Autonomous Okrug, where the population is extremely small but the region produces large quantities of oil. Actually, neighboring Arkhangelsk Oblast provides a similar kind of allowance, yet the amount is limited to just 50,000 rubles. Many other regions have introduced so-called "regional maternity capital" policies, but given the amounts, eligibility requirements, and other factors, they are not adequate to boost childbirth. Under federal law, "maternity capital" only concerns the second child or subsequent children. In almost all regions, however, the regional maternity capital is applied only to the third and subsequent children. Hence, obtaining the allowance is an immense challenge. In light of the empirical findings presented in this paper, the introduction of unique policies for each region is probably worth viewing positively, but the realities of Russia may demand that each region carries out even more powerful and distinctive measures that go far beyond the uniform policies being spearheaded by the federal government. We therefore hope that the Putin administration will exercise both prudence and decisiveness to seek a resolution of the country's population crisis.

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Table 1. Theoretical prediction of the impacts of geographical and socioeconomic factors on fertility in Russian regions

Factor	Predicted impact on fertility
Climate hardship	-
Presence of a Slavic population	-
Migration inflow	-
Economic growth	+
Employment opportunity	+
Favorable local business conditions	+
Poverty risk	-
Educational opportunity	+
Quality of social infrastructure	+
Housing supply	+
Ecological risk	-

Note: The sign "+" denotes a positive correlation between a given factor and fertility, "-" for a negative correlation.

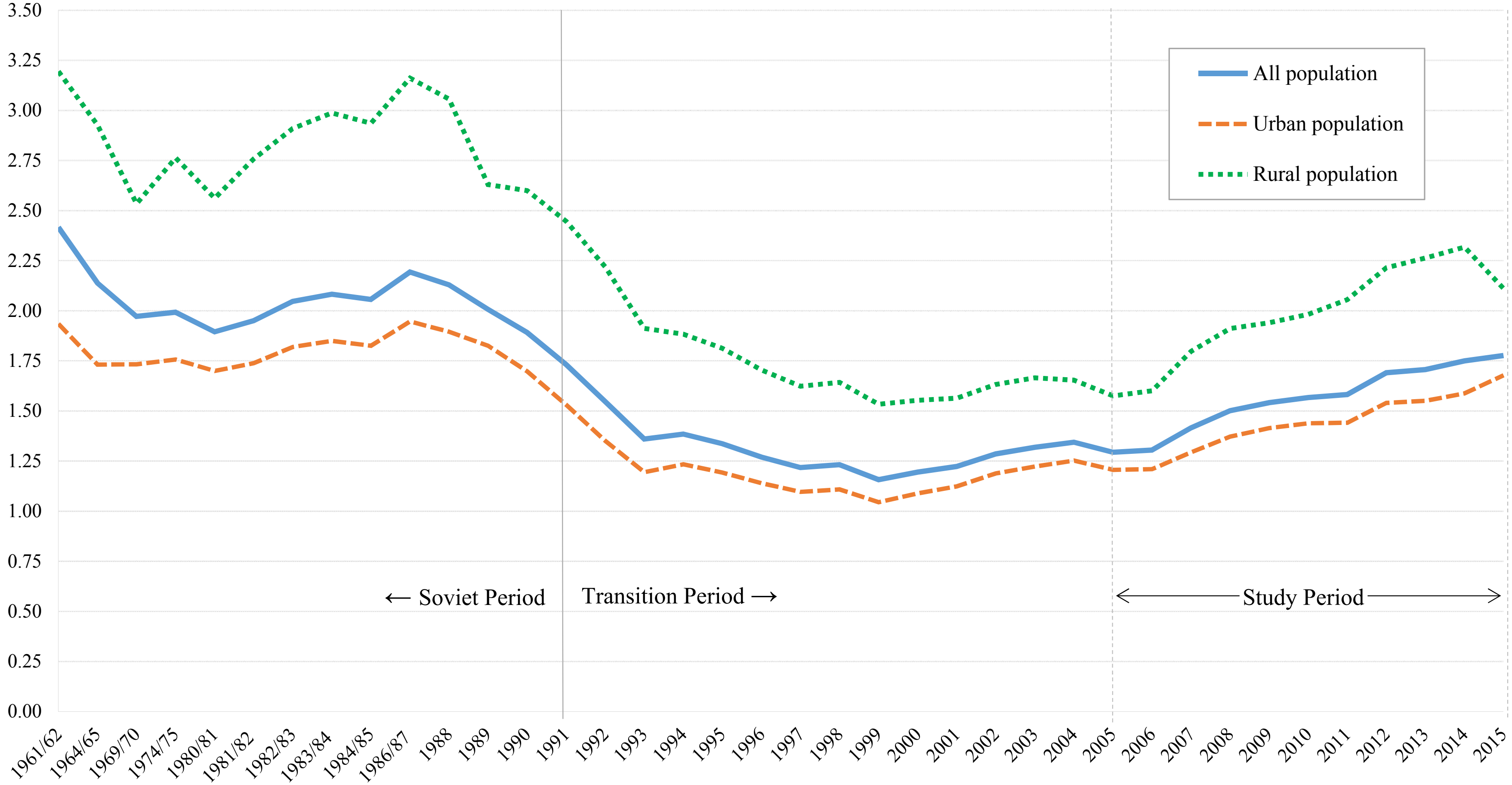


Figure 1. Long-term trend of total fertility rate in Russia, 1961–2015

Note: Total fertility rate denotes the average number of children that would be born to a woman over her lifetime (in ages 15–49).
Source: Authors' illustration based on Demograficheskii ezhegodnik Rossii (2005, Tables 2–4; 2015, Tables 2–6) and the data available at the Rosstat website (https://www.fedstat.ru/indicator/)

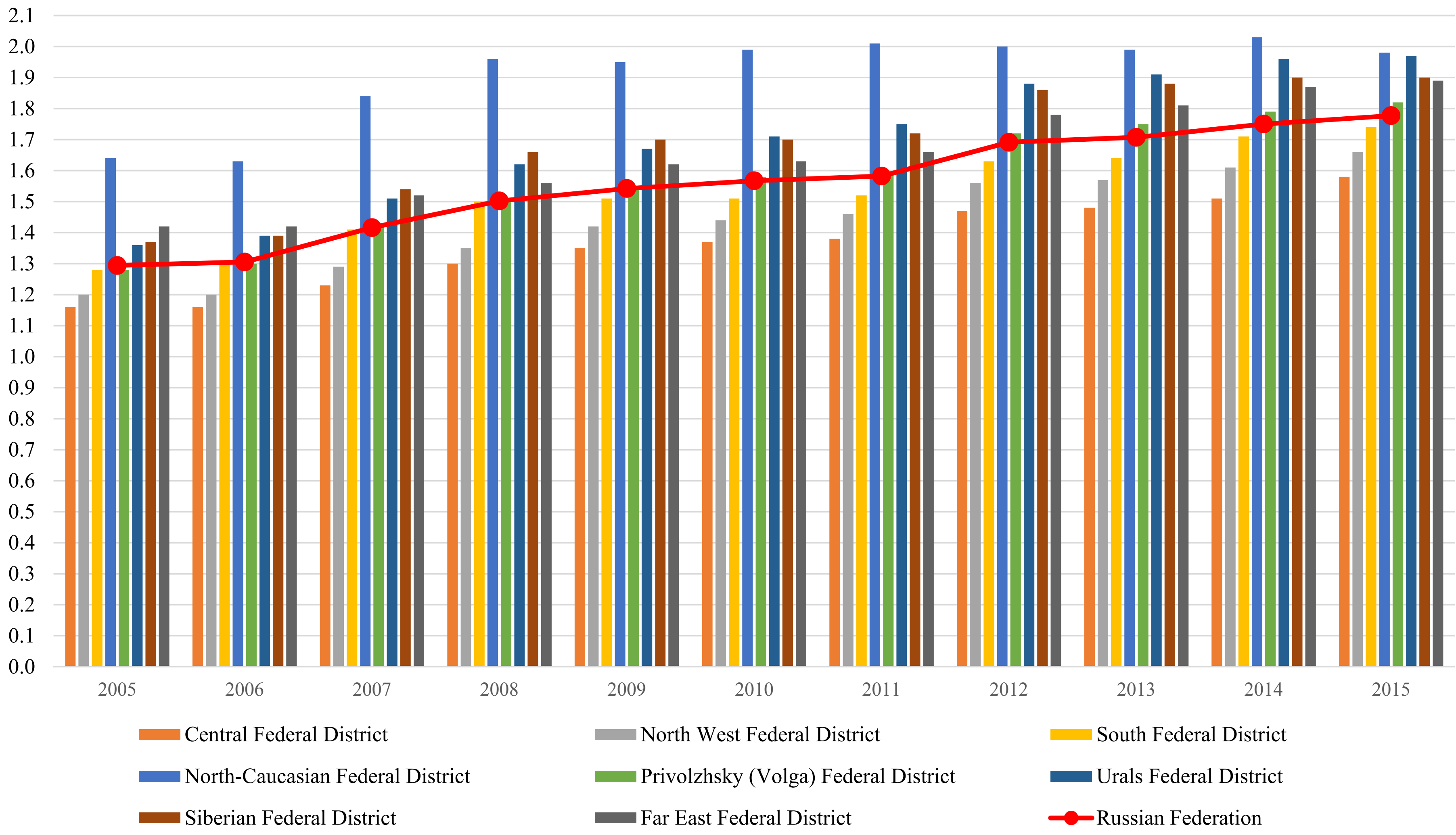
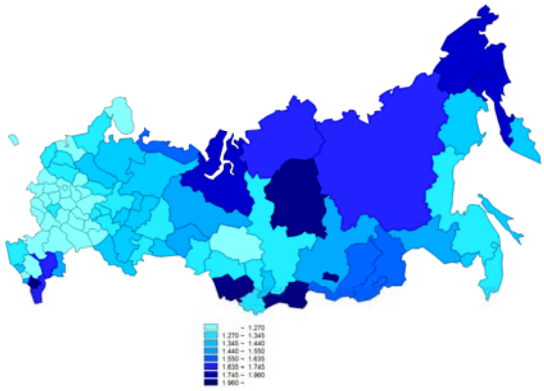


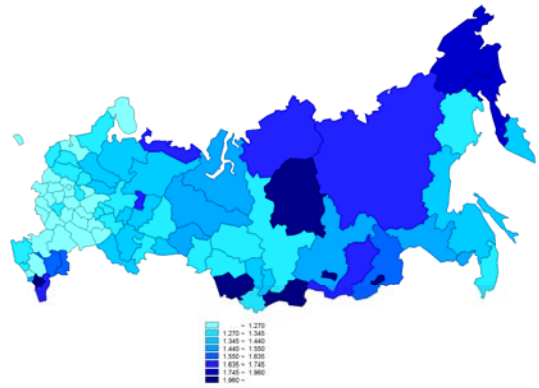
Figure 2. Dynamics of total fertility rate in Russian Federation and federal districts, 2005–2015

Source: Authors' illustration based on the data available at the Rosstat website (https://www.fedstat.ru/indicator/)

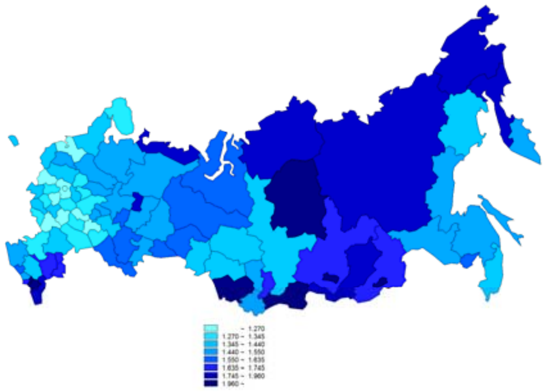
(a) 2005



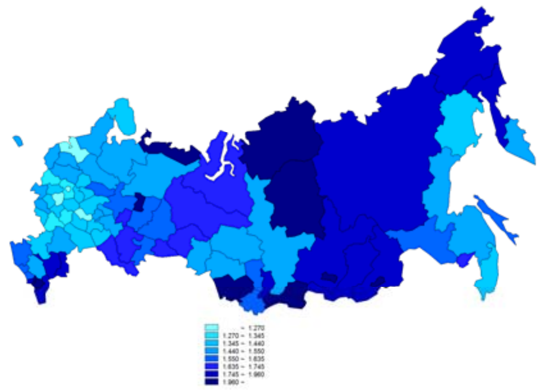
(b) 2006



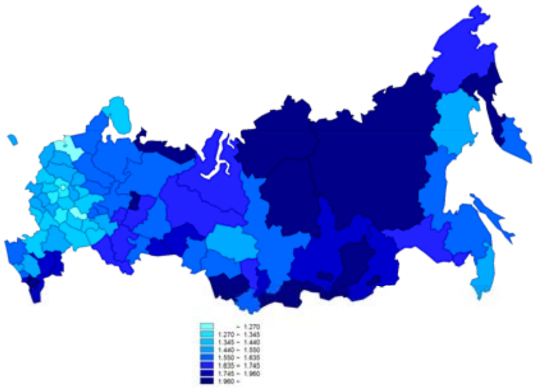
(c) 2007



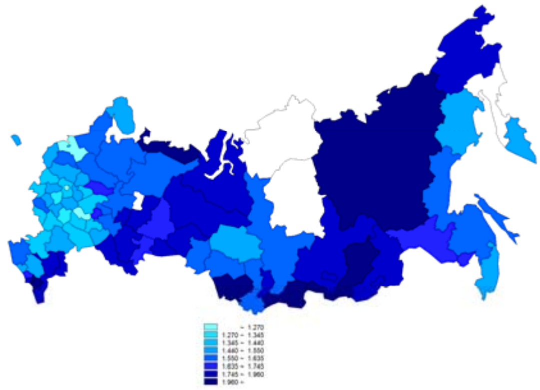
(d) 2008



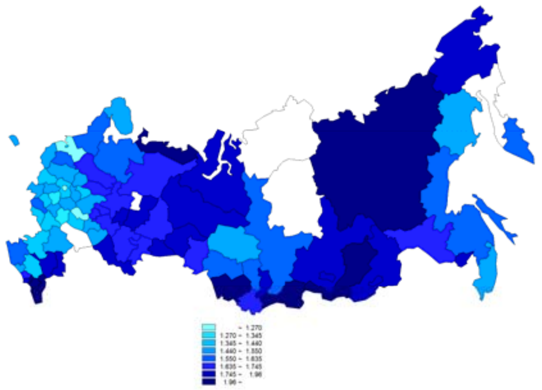
(e) 2009



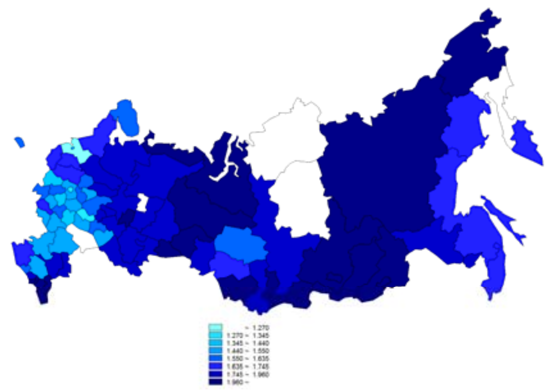
(f) 2010



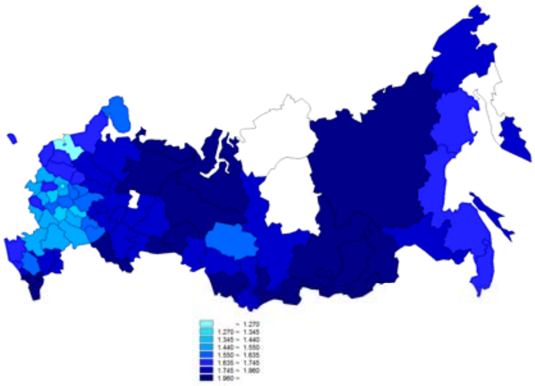
(g) 2011



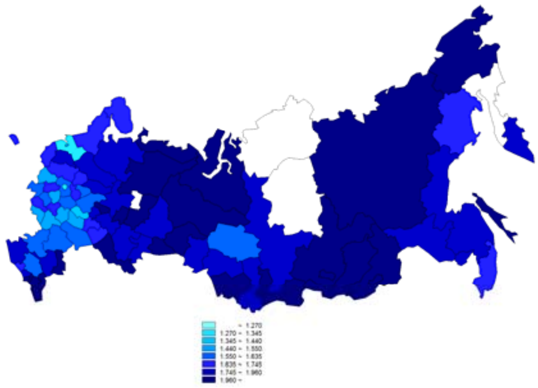
(h) 2012



(i) 2013



(j) 2014



(k) 2015

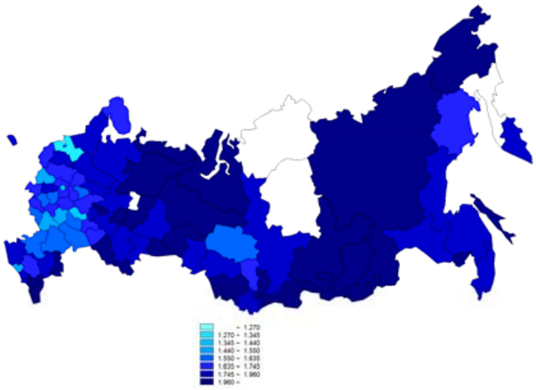
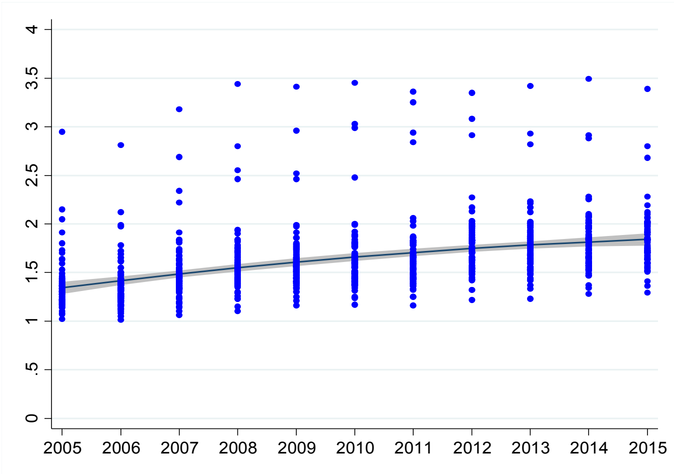


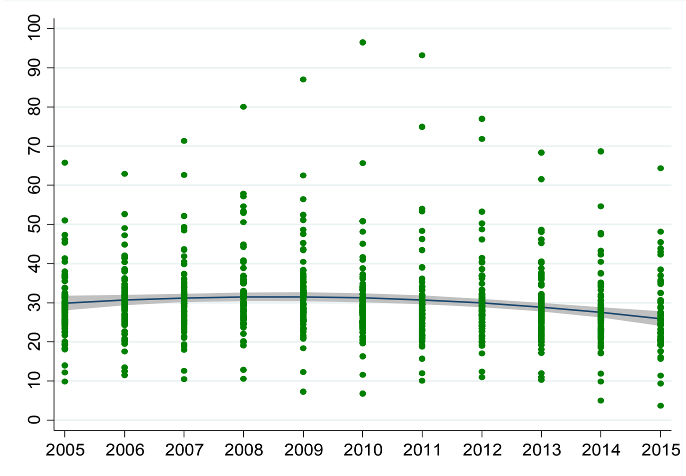
Figure 3. Dynamics of total fertility rate in Russian federal entities, 2005–2015

Note: Data for regions in white is missing.
Source: Authors' illustration based on the data available at the Rosstat website (https://www.fedstat.ru/indicator/)

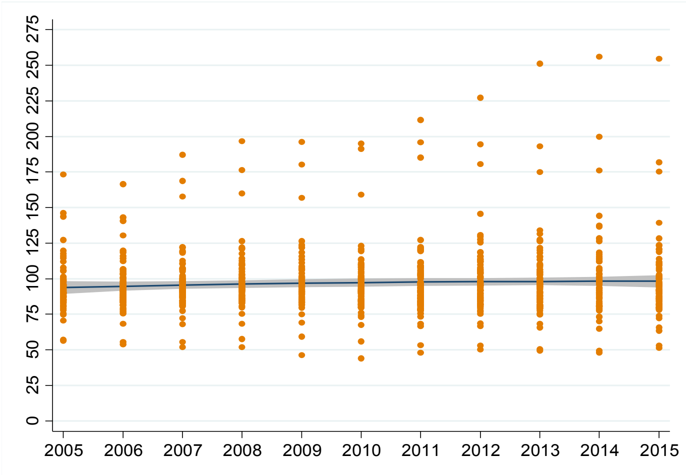
(a) Total fertility rate



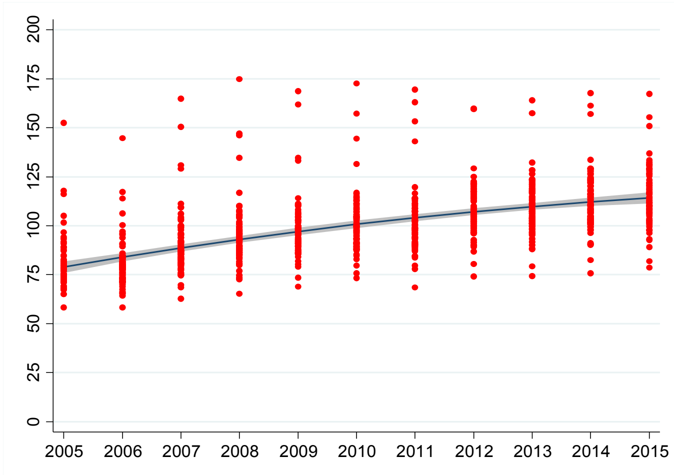
(b) Fertility rate late 10s



(c) Fertility rate early 20s



(d) Fertility rate late 20s



(e) Fertility rate early 30s

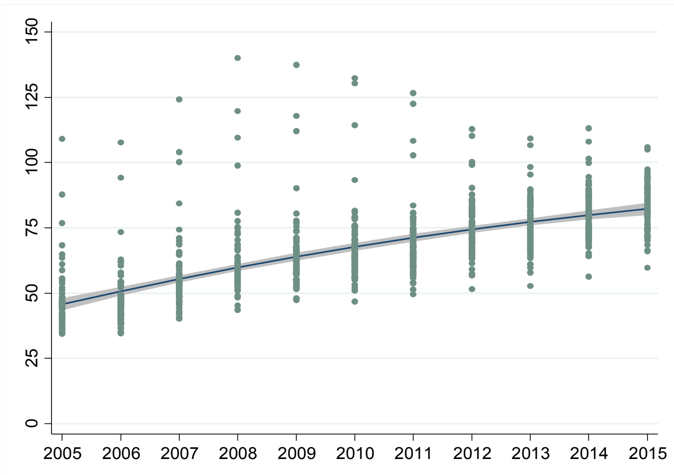


Figure 4. Scatter plot, fractional polynomial fitted line, and its 95% confidence interval of regional fertility rate by year, 2005–2015

Note: Fertility rates late 10s, early 20s, late 20s, and early 30s denote the average number of children bone to 1,000 women ages 15–19, 20–24, 25–29, and 30–34, respectively.
Source: Authors' illustration based on the data available at the Rosstat website (https://www.fedstat.ru/indicator/)

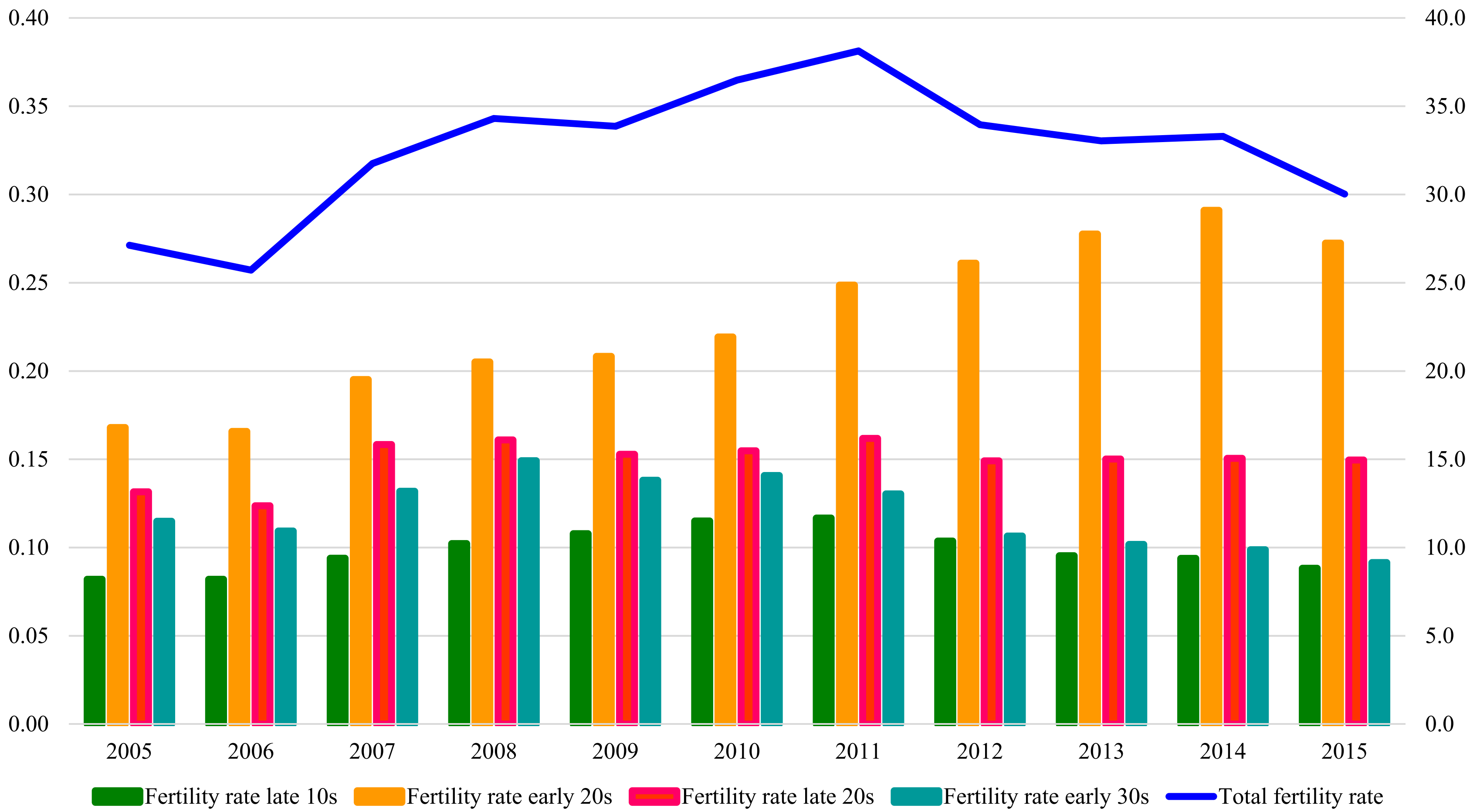


Figure 5. Changes in standard deviation of regional fertility rate, 2005–2015

Source: Authors' illustration based on the data available at the Rosstat website (https://www.fedstat.ru/indicator/)

Table 2. Definitions, descriptive statistics, and sources of variables used in the empirical analysis

Variable group and name	Additional definition	Descriptive statistics					Source
		Mean	S.D.	Median	Max	Min	
Dependent variables							
Log of total fertility rate	The average number of children that would be born to a woman over her lifetime (in ages 15–49)	0.47	0.20	0.45	1.25	0.01	Rosstat (http://www.gks.ru/)
Log of fertility rate late 10s	The average number of children born to 1,000 women in ages 15–19	3.35	0.32	3.35	4.57	1.28	Rosstat
Log of fertility rate early 20s	The average number of children born to 1,000 women in ages 20–24	4.55	0.21	4.52	5.54	3.78	Rosstat
Log of fertility rate late 20s	The average number of children born to 1,000 women in ages 25–29	4.58	0.18	4.58	5.16	4.06	Rosstat
Log of fertility rate early 30s	The average number of children born to 1,000 women in ages 30–34	4.16	0.25	4.18	4.94	3.54	Rosstat
Independent variables							
Average temperature in January	In centigrade; lagged 3-year moving average	-11.72	7.68	-10.10	3.60	-36.70	Rosstat
Share of Slavic population	In % of total population; lagged 3-year moving average	76.88	25.39	88.98	98.10	0.50	Authors' estimation based on the 2002, 2010, and 2015 National Census of the Russian Federation
Migration rate	Number of immigrants per 10,000 residents; lagged 3-year moving average	-11.07	66.78	-8.57	207.33	-501.90	Rosstat
GRP (Gross Regional Product) growth rate	Annual real growth rate (%); lagged 3-year moving average	4.49	3.53	4.43	19.97	-7.73	Rosstat
Log of the number of firms and organizations per 10,000 residents	Lagged 3-year moving average	5.48	0.40	5.45	6.96	4.05	Rosstat
Share of firms and organizations in fiscal deficit	In % of total firms and organizations; lagged 3-year moving average	34.87	7.47	34.10	60.77	17.70	Rosstat
Share of population under the poverty line	In % of total population; lagged 3-year moving average	18.87	8.22	17.10	78.73	6.90	Rosstat
Log of the number of graduates of higher education per 1,000 persons	Lagged 3-year moving average	2.24	1.01	2.19	5.60	-0.27	Rosstat
Log of the number of hospital beds per 10,000 residents	Lagged 3-year moving average	4.66	0.21	4.65	5.50	3.78	Rosstat
Log of floor space per capita	Basic unit is m^2; lagged 3-year moving average	3.08	0.16	3.10	3.51	1.88	Rosstat
Ecological risk	Regional ranking (lowest ecological risk=1); lagged 3-year moving average	41.85	23.17	41.33	86.67	1.33	Expert RA Rating Agency (http://www.raexpert.ru/ratings/regions/)
Time trend	2005=0	5	3.16	5	10	0	Authors' calculation

Table 3. System GMM dynamic estimation of the total fertility rate, 2005–2015

Dependent variable	Log of total fertility rate								
Model	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Lagged dependent variable	0.39308 ***	0.39411 ***	0.37053 ***	0.30921 **	0.24235 ***	0.39865 ***	0.37882 ***	0.38827 ***	0.27375 ***
	(0.1398)	(0.0329)	(0.1244)	(0.1397)	(0.0942)	(0.1264)	(0.0329)	(0.0334)	(0.0855)
Average temperature in January	-0.00413 ***								-0.00317 ***
	(0.0011)								(0.0006)
Share of Slavic population		-0.00701 ***							-0.00272 *
		(0.0010)							(0.0016)
Migration rate		-0.00015 ***							-0.00033 **
		(0.0000)							(0.0002)
GRP growth rate			0.00229 ***						0.00168 ***
			(0.0007)						(0.0006)
Log of the number of firms and organizations per 10,000 residents				0.07718 **					0.07185 *
				(0.0394)					(0.0401)
Share of firms and organizations in fiscal deficit				-0.00318 ***					-0.00152 **
				(0.0006)					(0.0008)
Share of population under the poverty line					-0.00390 ***				-0.00153 **
					(0.0011)				(0.0008)
Log of the number of graduates of higher education per 1,000 persons						0.16122 ***			0.05631 *
						(0.0214)			(0.0313)
Log of the number of hospital beds per 10,000 residents						0.16429 ***			0.16034 ***
						(0.0458)			(0.0376)
Log of floor space per capita							0.05154 *		0.13149 **
							(0.0289)		(0.0516)
Ecological risk								-0.00077 ***	-0.00018
								(0.0002)	(0.0004)
Time trend	0.01814 ***	0.01832 ***	0.02119 ***	0.01765 ***	0.01868 ***	0.01872 ***	0.02082 ***	0.01925 ***	0.01871 ***
	(0.0050)	(0.0011)	(0.0043)	(0.0045)	(0.0025)	(0.0050)	(0.0012)	(0.0011)	(0.0035)
Constant term	0.15527 ***	0.73926 ***	0.18604 ***	-0.07104	0.33542 ***	-0.93082 ***	0.35333 ***	0.23198 ***	-1.17348 ***
	(0.0419)	(0.0789)	(0.0305)	(0.2501)	(0.0462)	(0.2239)	(0.0873)	(0.0122)	(0.2607)
N	796	796	792	792	786	782	792	789	769
Arellano–Bond test [a]	0.116	-1.351	-1.190	-1.954 *	-1.939 *	-1.560	-1.530	-1.465	-0.167
Sargan test [b]	766.533 ***	756.414 ***	764.956 ***	678.117 ***	704.600 ***	644.427 ***	778.856 ***	775.832 ***	521.767 ***
Wald test (χ^2) [c]	3875.83 ***	2554.71 ***	3036.87 ***	3001.71 ***	2000.63 ***	2092.31 ***	3903.39 ***	3120.67 ***	3887.99 ***

Notes:

[a] Autocorrelation test for AR(2). Null hypothesis: no autocorrelation.

[b] Test results that use estimates with normal standard errors. Null hypothesis: overidentifying restrictions are valid.

[c] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are robust standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

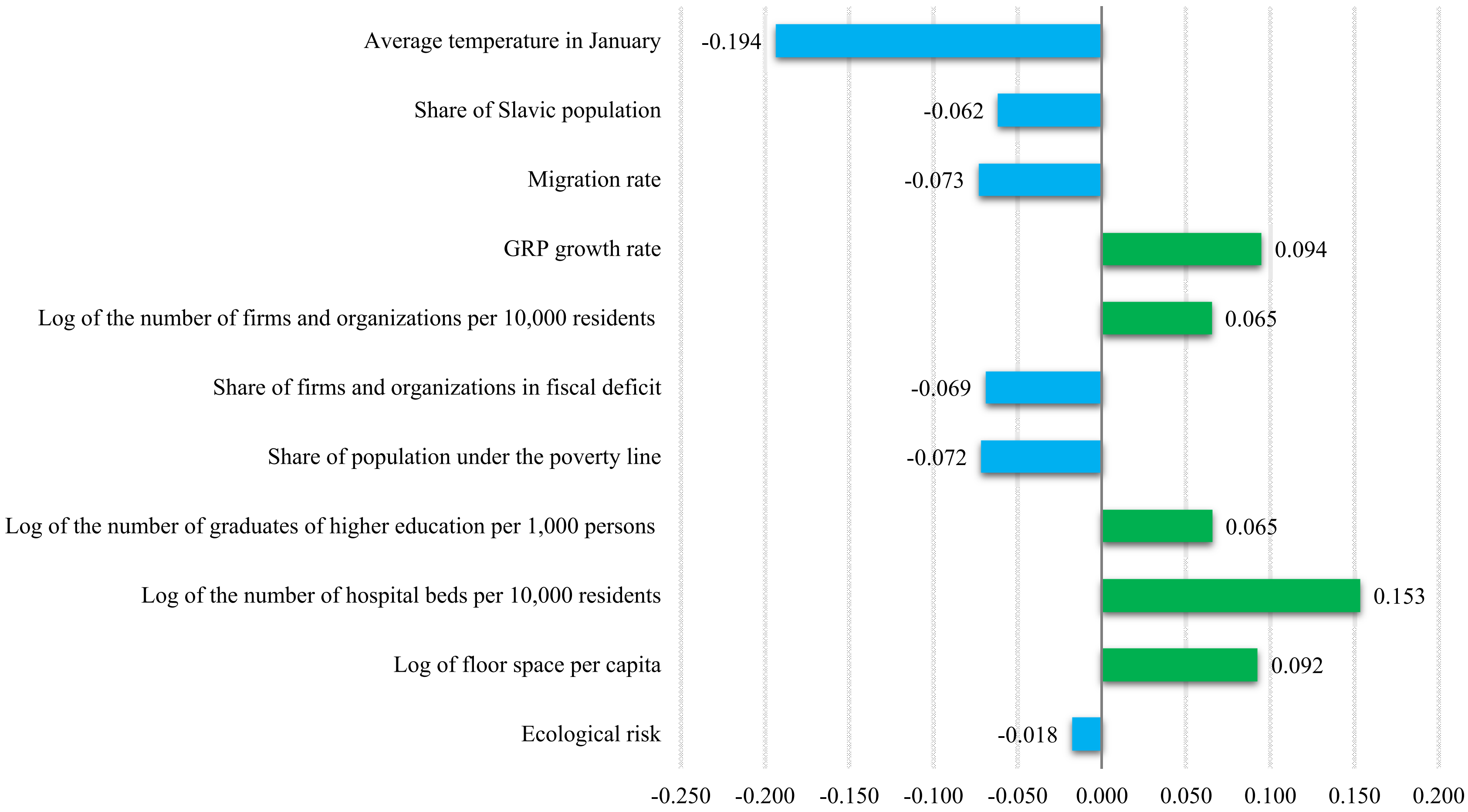


Figure 6. Partial correlation coefficients of independent variables

Source: Authors' illustration using the estimation results of Model [9] in Table 3. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

Table 4. System GMM dynamic estimation of the age-specific fertility rates, 2005–2015

Dependent variable	Log of total fertility rate	Log of fertility rate late 10s	Log of fertility rate early 20s	Log of fertility rate late 20s	Log of fertility rate early 30s
Model	Reference [a]	[1]	[2]	[3]	[4]
Lagged dependent variable	0.27375 ***	0.79972 ***	0.39481 ***	0.17845 ***	0.42586 ***
	(0.0855)	(0.0945)	(0.1075)	(0.0636)	(0.0740)
Average temperature in January	-0.00317 ***	-0.00851 ***	-0.00444 ***	-0.00180 **	-0.00059
	(0.0006)	(0.0018)	(0.0008)	(0.0008)	(0.0010)
Share of Slavic population	-0.00272 *	-0.00398	-0.00106	0.00054	-0.00073
	(0.0016)	(0.0028)	(0.0017)	(0.0014)	(0.0020)
Migration rate	-0.00033 **	-0.00140 ***	-0.00009	-0.00031	-0.00045 ***
	(0.0002)	(0.0003)	(0.0001)	(0.0003)	(0.0001)
GRP growth rate	0.00168 ***	0.00062	0.00171 ***	0.00078	0.00257 **
	(0.0006)	(0.0020)	(0.0006)	(0.0007)	(0.0013)
Log of the number of firms and organizations per 10,000 residents	0.07185 *	0.03051	-0.01344	0.10761 **	0.21558 ***
	(0.0401)	(0.0685)	(0.0318)	(0.0508)	(0.0470)
Share of firms and organizations in fiscal deficit	-0.00152 **	-0.00053	0.00011	-0.00166 *	-0.00220
	(0.0008)	(0.0015)	(0.0007)	(0.0009)	(0.0015)
Share of population under the poverty line	-0.00153 **	0.00018	-0.00213 **	-0.00167 *	0.00031
	(0.0008)	(0.0021)	(0.0009)	(0.0009)	(0.0012)
Log of the number of graduates of higher education per 1,000 persons	0.05631 *	0.12440 *	0.04559	0.12674 ***	0.17102 ***
	(0.0313)	(0.0669)	(0.0296)	(0.0376)	(0.0599)
Log of the number of hospital beds per 10,000 residents	0.16034 ***	0.23419 ***	0.13100 ***	0.12627 **	0.22481 ***
	(0.0376)	(0.0798)	(0.0453)	(0.0645)	(0.0751)
Log of floor space per capita	0.13149 **	0.35857 **	0.10660 **	0.10616 **	0.00904
	(0.0516)	(0.1658)	(0.0518)	(0.0513)	(0.0808)
Ecological risk	-0.00018	-0.00101	-0.00062 *	-0.00053	-0.00105 **
	(0.0004)	(0.0007)	(0.0003)	(0.0003)	(0.0005)
Time trend	0.01871 ***	-0.01481 ***	-0.00116	0.02292 ***	0.03110 ***
	(0.0035)	(0.0033)	(0.0019)	(0.0038)	(0.0047)
Constant term	-1.17348 ***	-1.66272	1.81482 **	1.89782 ***	-0.24308
	(0.2607)	(1.1209)	(0.7319)	(0.4771)	(0.5617)
N	769	773	773	773	773
Arellano–Bond test [b]	-0.167	0.972	0.463	1.717 *	-0.344
Sargan test [c]	521.767 ***	306.133 ***	364.650 ***	386.745 ***	526.879 ***
Wald test (χ^2) [d]	3887.99 ***	1063.12 ***	1099.91 ***	4676.75 ***	6221.18 ***

Notes:

[a] Model [9] in Table 3

[b] Autocorrelation test for AR(2). Null hypothesis: no autocorrelation.

[c] Test results that use estimates with normal standard errors. Null hypothesis: overidentifying restrictions are valid.

[d] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are robust standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

Table 5. System GMM dynamic estimation of the total fertility rate by group of federal districts, 2005–2015

Dependent variable	Log of total fertility rate				
Target districts	Whole federation	North Caucasus and Southern Districts	Central and North West Districts	Volga and Ural Districts	Siberian and Far East Districts
Model	Reference [a]	[1]	[2]	[3]	[4]
Lagged dependent variable	0.27375 ***	0.44963 ***	0.08033 *	0.24474 ***	0.28107 ***
	(0.0855)	(0.0547)	(0.0445)	(0.0569)	(0.0574)
Average temperature in January	-0.00317 ***	-0.00347	-0.00039	-0.00497 ***	-0.00380 ***
	(0.0006)	(0.0034)	(0.0012)	(0.0010)	(0.0009)
Share of Slavic population	-0.00272 *	-0.01232	-0.00083	-0.00385	-0.00716 *
	(0.0016)	(0.0091)	(0.0011)	(0.0046)	(0.0043)
Migration rate	-0.00033 **	-0.00035 ***	-0.00023 *	0.00040	-0.00050 ***
	(0.0002)	(0.0001)	(0.0001)	(0.0003)	(0.0002)
GRP growth rate	0.00168 ***	0.00309 ***	0.00150 *	0.00167 **	-0.00049
	(0.0006)	(0.0009)	(0.0009)	(0.0008)	(0.0014)
Log of the number of firms and organizations per 10,000 residents	0.07185 *	0.16100 **	0.04284	0.09237 *	-0.03390
	(0.0401)	(0.0740)	(0.0529)	(0.0551)	(0.0240)
Share of firms and organizations in fiscal deficit	-0.00152 **	0.00223	0.00156	-0.00144	-0.00387 ***
	(0.0008)	(0.0018)	(0.0013)	(0.0010)	(0.0011)
Share of population under the poverty line	-0.00153 **	-0.00198	0.00031	-0.00205	-0.00233 *
	(0.0008)	(0.0015)	(0.0010)	(0.0013)	(0.0014)
Log of the number of graduates of higher education per 1,000 persons	0.05631 *	0.19602 **	0.06320 **	0.10253 *	-0.03904
	(0.0313)	(0.0853)	(0.0300)	(0.0564)	(0.0450)
Log of the number of hospital beds per 10,000 residents	0.16034 ***	0.29957 ***	0.06586	0.06218	0.22479 ***
	(0.0376)	(0.0902)	(0.0517)	(0.0641)	(0.0574)
Log of floor space per capita	0.13149 **	-0.00488	0.07616	0.49530 ***	0.30235 ***
	(0.0516)	(0.0621)	(0.1199)	(0.1817)	(0.1180)
Ecological risk	-0.00018	-0.00236 ***	-0.00078 **	-0.00033	-0.00006
	(0.0004)	(0.0007)	(0.0004)	(0.0005)	(0.0006)
Time trend	0.01871 ***	0.01128 ***	0.02845 ***	0.00923	0.01700 ***
	(0.0035)	(0.0039)	(0.0034)	(0.0063)	(0.0034)
Constant term	-1.17348 ***	-1.73762 ***	-0.64571	-2.56289 ***	-0.73209
	(0.2607)	(0.6082)	(0.4402)	(0.8673)	(0.7047)
N	769	120	280	176	193
Arellano–Bond test [b]	-0.167	-0.853	-0.665	2.879 ***	-1.018
Sargan test [c]	521.767 ***	99.972 **	173.407 ***	121.948 ***	146.724 ***
Wald test (χ^2) [d]	3887.99 ***	15100.00 ***	5942.27 ***	12684.82 ***	2002.76 ***

Notes:

[a] Model [9] in Table 3

[b] Autocorrelation test for AR(2). Null hypothesis: no autocorrelation.

[c] Test results that use estimates with normal standard errors. Null hypothesis: overidentifying restrictions are valid.

[d] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are robust standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

Table 6. System GMM dynamic estimation of the total fertility rate for upper and lower groups of federal entities in terms of economic development, urbanization, and ethnicity composition, 2005–2015

Dependent variable	Log of total fertility rate					
Target regions	More developed regions [a]	Les developed regions [b]	More urbanized regions [c]	Less urbanized regions [d]	Regions with a higher Slavic population share [e]	Regions with a lower Slavic population share [f]
Model	[1]	[2]	[3]	[4]	[5]	[6]
Lagged dependent variable	0.16292 ***	0.35344 ***	0.14519 ***	0.37598 ***	0.07206 **	0.41782 ***
	(0.0489)	(0.0827)	(0.0530)	(0.0858)	(0.0344)	(0.0911)
Average temperature in January	-0.00252 ***	-0.00346 ***	-0.00221 ***	-0.00370 ***	-0.00248 ***	-0.00536 ***
	(0.0007)	(0.0010)	(0.0008)	(0.0010)	(0.0006)	(0.0013)
Share of Slavic population	-0.00132	0.00148	0.00086	-0.00249	0.00190	-0.00372
	(0.0011)	(0.0032)	(0.0022)	(0.0018)	(0.0024)	(0.0024)
Migration rate	-0.00042 ***	-0.00045 ***	-0.00029 *	-0.00038 ***	-0.00018	-0.00035 **
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0002)
GRP growth rate	0.00089	0.00218 **	0.00050	0.00192 **	0.00171 **	0.00122
	(0.0006)	(0.0010)	(0.0006)	(0.0008)	(0.0007)	(0.0009)
Log of the number of firms and organizations per 10,000 residents	-0.00802	0.15563 ***	-0.02596	0.16869 ***	-0.02439	0.09402 *
	(0.0223)	(0.0451)	(0.0170)	(0.0457)	(0.0205)	(0.0521)
Share of firms and organizations in fiscal deficit	-0.00341 ***	0.00040	-0.00374 ***	0.00033	-0.00255 ***	-0.00041
	(0.0007)	(0.0014)	(0.0008)	(0.0009)	(0.0006)	(0.0013)
Share of population under the poverty line	-0.00162	-0.00299 ***	-0.00171 *	-0.00295 ***	-0.00245 ***	-0.00108
	(0.0012)	(0.0008)	(0.0011)	(0.0009)	(0.0009)	(0.0012)
Log of the number of graduates of higher education per 1,000 persons	0.02816	0.14011 ***	0.02010	0.11497 ***	0.05541 *	0.06609
	(0.0342)	(0.0505)	(0.0404)	(0.0448)	(0.0300)	(0.0675)
Log of the number of hospital beds per 10,000 residents	0.06526	0.03766	0.05067	0.13612 **	0.09025 **	0.19777 ***
	(0.0456)	(0.0562)	(0.0423)	(0.0618)	(0.0388)	(0.0728)
Log of floor space per capita	0.10796	0.17703 ***	0.24995 **	0.08838	0.12714	0.10825
	(0.1267)	(0.0674)	(0.1086)	(0.0710)	(0.0882)	(0.0890)
Ecological risk	-0.00010	0.00015	-0.00033	-0.00001	0.00068 *	-0.00051
	(0.0004)	(0.0005)	(0.0003)	(0.0005)	(0.0004)	(0.0005)
Time trend	0.02340 ***	0.00699 *	0.02126 ***	0.01107 ***	0.02395 ***	0.01632 ***
	(0.0027)	(0.0040)	(0.0025)	(0.0043)	(0.0023)	(0.0041)
Constant term	-0.18577	-1.65976 ***	-0.59110	-1.59369 ***	-0.66784	-1.45985 ***
	(0.4760)	(0.4332)	(0.4039)	(0.2641)	(0.4179)	(0.3284)
N	390	379	386	383	413	356
Arellano–Bond test [g]	1.654 *	-0.759	0.568	-0.476	-0.523	-0.217
Sargan test [h]	250.854 ***	285.815 ***	255.312 ***	267.048 ***	224.209 ***	286.076 ***
Wald test (χ^2) [i]	3544.06 ***	2254.13 ***	3790.39 ***	2122.06 ***	4013.49 ***	1796.54 ***

Notes:

[a] Denotes regions with the median or more of per capita GRP in 2005

[b] Denotes regions with per capita GRP less than the median value in 2005

[c] Denotes regions with the median value or more of the share of urban population in 2005

[d] Denotes regions with a value lower than the median of the share of urban population in 2005

[e] Denotes regions with the median value or more of the share of Slavic population in 2005

[f] Denotes regions with a value lower than the median of share of Slavic population in 2005

[g] Autocorrelation test for AR(2). Null hypothesis: no autocorrelation.

[h] Test results that use estimates with normal standard errors. Null hypothesis: overidentifying restrictions are valid.

[i] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are robust standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

Appendix 1. Correlation of variables used in the empirical analysis

Variable group and name	Correlation coefficient				
	Log of total fertility rate	Log of fertility rate late 10s	Log of fertility rate early 20s	Log of fertility rate late 20s	Log of fertility rate early 30s
Dependent variables					
Log of total fertility rate	1.000				
Log of fertility rate late 10s	0.441 ***	1.000			
Log of fertility rate early 20s	0.777 ***	0.740 ***	1.000		
Log of fertility rate late 20s	0.941 ***	0.232 ***	0.592 ***	1.000	
Log of fertility rate early 30s	0.882 ***	0.074 **	0.410 ***	0.944 ***	1.000
Independent variables					
Average temperature in January	-0.321 ***	-0.435 ***	-0.320 ***	-0.237 ***	-0.213 ***
Share of Slavic population	-0.537 ***	-0.014	-0.474 ***	-0.476 ***	-0.436 ***
Migration rate	-0.350 ***	-0.392 ***	-0.455 ***	-0.228 ***	-0.154 ***
GRP growth rate	-0.261 ***	-0.023	-0.065 *	-0.299 ***	-0.324 ***
Log of the number of firms and organizations per 10,000 residents	-0.245 ***	-0.345 ***	-0.509 ***	-0.122 ***	-0.012
Share of firms and organizations in fiscal deficit	-0.070 **	0.219 ***	0.232 ***	-0.245 ***	-0.314 ***
Share of population under the poverty line	-0.050	0.205 ***	0.259 ***	-0.201 ***	-0.291 ***
Log of the number of graduates of higher education per 1,000 persons	-0.285 ***	-0.418 ***	-0.501 ***	-0.118 ***	-0.046
Log of the number of hospital beds per 10,000 residents	-0.181 ***	0.460 ***	0.134 ***	-0.297 ***	-0.378 ***
Log of floor space per capita	-0.315 ***	-0.164 ***	-0.398 ***	-0.187 ***	-0.134 ***
Ecological risk	-0.037	0.198 ***	0.011	-0.089 ***	-0.079 **
Time trend variable	0.506 ***	-0.153 ***	0.037	0.638 ***	0.741 ***

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' calculation. See Table 2 for definitions and descriptive statistics of the variables.

Apendix 2. System GMM dynamic estimation of the fertility rate of women ages 15–19 by group of federal districts, 2005–2015

Dependent variable	Log of fertility rate late 10s				
Target districts	Whole federation	North Caucasus and Southern Districts	Central and North West Districts	Volga and Ural Districts	Siberian and Far East Districts
Model	Reference [a]	[1]	[2]	[3]	[4]
Lagged dependent variable	0.79972 ***	0.82584 ***	0.37215 ***	0.37243 ***	0.33712 ***
	(0.0945)	(0.0337)	(0.0671)	(0.1035)	(0.0944)
Average temperature in January	-0.00851 ***	0.00027	-0.00495	-0.01009 ***	-0.00768 ***
	(0.0018)	(0.0055)	(0.0038)	(0.0021)	(0.0017)
Share of Slavic population	-0.00398	-0.02491	-0.00178	-0.00090	-0.01009
	(0.0028)	(0.0206)	(0.0024)	(0.0061)	(0.0104)
Migration rate	-0.00140 ***	-0.00158 ***	-0.00044	0.00040	-0.00081 ***
	(0.0003)	(0.0002)	(0.0004)	(0.0005)	(0.0003)
GRP growth rate	0.00062	-0.00136	0.00641 ***	0.00650 ***	0.00511 **
	(0.0020)	(0.0050)	(0.0015)	(0.0013)	(0.0023)
Log of the number of firms and organizations per 10,000 residents	0.03051	0.33598 ***	0.18446 *	0.29247 ***	-0.12725 **
	(0.0685)	(0.1218)	(0.1115)	(0.0848)	(0.0543)
Share of firms and organizations in fiscal deficit	-0.00053	0.00153	0.00105	0.00207	-0.00589 **
	(0.0015)	(0.0061)	(0.0016)	(0.0022)	(0.0026)
Share of population under the poverty line	0.00018	-0.00353	-0.00212	-0.00443 *	-0.00336
	(0.0021)	(0.0026)	(0.0023)	(0.0024)	(0.0026)
Log of the number of graduates of higher education per 1,000 persons	0.12440 *	0.34013 *	0.16539 ***	0.16722 **	-0.04633
	(0.0669)	(0.1839)	(0.0573)	(0.0830)	(0.0637)
Log of the number of hospital beds per 10,000 residents	0.23419 ***	0.41794 *	0.37084 ***	0.28217 **	0.05807
	(0.0798)	(0.2407)	(0.1005)	(0.1164)	(0.1416)
Log of floor space per capita	0.35857 **	0.24487	-0.45786	0.60796 *	0.11140
	(0.1658)	(0.2715)	(0.2789)	(0.3606)	(0.2275)
Ecological risk	-0.00101	-0.00320 **	-0.00130 *	0.00029	-0.00058
	(0.0007)	(0.0015)	(0.0007)	(0.0005)	(0.0011)
Time trend	-0.01481 ***	-0.02108 ***	-0.01141 *	-0.03396 ***	-0.01290
	(0.0033)	(0.0074)	(0.0068)	(0.0093)	(0.0088)
Constant term	-1.66272	-3.07001 **	0.55137	-3.11625 ***	3.53746 ***
	(1.1209)	(1.4052)	(0.7443)	(1.1653)	(1.2053)
N	773	120	280	180	193
Arellano–Bond test [b]	0.972	1.781 *	-0.282	2.513 **	-0.666
Sargan test [c]	306.133 ***	108.882 ***	161.136 ***	105.747 ***	124.788 ***
Wald test (χ^2) [d]	1063.12 ***	142106.05 ***	635.86 ***	4021.84 ***	474.79 ***

Notes:

[a] Model [1] in Table 4

[b] Autocorrelation test for AR(2). Null hypothesis: no autocorrelation.

[c] Test results that use estimates with normal standard errors. Null hypothesis: overidentifying restrictions are valid.

[d] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are robust standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

Apendix 3. System GMM dynamic estimation of the fertility rate of women ages 20–24 by group of federal districts, 2005–2015

Dependent variable	Log of fertility rate early 20s				
Target districts	Whole federation	North Caucasus and Southern Districts	Central and North West Districts	Volga and Ural Districts	Siberian and Far East Districts
Model	Reference [a]	[1]	[2]	[3]	[4]
Lagged dependent variable	0.39481 ***	0.30782 ***	0.30081 ***	0.37449 ***	0.54787 ***
	(0.1075)	(0.0841)	(0.0889)	(0.0718)	(0.0872)
Average temperature in January	-0.00444 ***	-0.00032	-0.00276	-0.00657 ***	-0.00518 ***
	(0.0008)	(0.0034)	(0.0018)	(0.0019)	(0.0015)
Share of Slavic population	-0.00106	-0.01047 **	-0.00170	0.00772 *	0.00141
	(0.0017)	(0.0052)	(0.0015)	(0.0040)	(0.0067)
Migration rate	-0.00009	0.00001	-0.00016	0.00027	-0.00082 ***
	(0.0001)	(0.0001)	(0.0002)	(0.0003)	(0.0003)
GRP growth rate	0.00171 ***	0.00230 *	0.00139	0.00201 **	0.00039
	(0.0006)	(0.0012)	(0.0010)	(0.0008)	(0.0015)
Log of the number of firms and organizations per 10,000 residents	-0.01344	0.05712	0.04140	0.10112 *	-0.02908
	(0.0318)	(0.0407)	(0.0636)	(0.0557)	(0.0218)
Share of firms and organizations in fiscal deficit	0.00011	0.00070	0.00025	-0.00058	-0.00203
	(0.0007)	(0.0013)	(0.0012)	(0.0014)	(0.0015)
Share of population under the poverty line	-0.00213 **	-0.00446 ***	0.00022	-0.00090	-0.00268
	(0.0009)	(0.0011)	(0.0014)	(0.0021)	(0.0017)
Log of the number of graduates of higher education per 1,000 persons	0.04559	-0.05009	0.02312	0.06760	0.05636
	(0.0296)	(0.0623)	(0.0517)	(0.0541)	(0.0412)
Log of the number of hospital beds per 10,000 residents	0.13100 ***	0.62107 ***	0.07157	-0.05997	0.02253
	(0.0453)	(0.1191)	(0.0528)	(0.0970)	(0.0693)
Log of floor space per capita	0.10660 **	-0.08707	0.03881	0.52205 ***	0.45249 ***
	(0.0518)	(0.0765)	(0.1144)	(0.1781)	(0.1216)
Ecological risk	-0.00062 *	-0.00109 **	-0.00002	0.00009	0.00178
	(0.0003)	(0.0005)	(0.0006)	(0.0006)	(0.0012)
Time trend	-0.00116	0.01220 ***	-0.00184	-0.01749 ***	-0.01028 ***
	(0.0019)	(0.0035)	(0.0033)	(0.0048)	(0.0033)
Constant term	1.81482 **	0.99629 **	2.48609 ***	0.24332	0.50472
	(0.7319)	(0.4731)	(0.8177)	(1.1320)	(1.2418)
N	773	120	280	180	193
Arellano–Bond test [b]	0.463	-0.900	-0.410	1.746 *	-0.690
Sargan test [c]	364.650 ***	95.506 **	155.167 ***	131.835 ***	123.412 ***
Wald test (χ^2) [d]	1099.91 ***	389.63 ***	84.26 **	216.13 ***	1003.20 ***

Notes:

[a] Model [2] in Table 4

[b] Autocorrelation test for AR(2). Null hypothesis: no autocorrelation.

[c] Test results that use estimates with normal standard errors. Null hypothesis: overidentifying restrictions are valid.

[d] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are robust standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

Apendix 4. System GMM dynamic estimation of the fertility rate of women ages 25–29 by group of federal districts, 2005–2015

Dependent variable	Log of fertility rate late 20s				
Target districts	Whole federation	North Caucasus and Southern Districts	Central and North West Districts	Volga and Ural Districts	Siberian and Far East Districts
Model	Reference [a]	[1]	[2]	[3]	[4]
Lagged dependent variable	0.17845 ***	0.41161 ***	0.09342 **	0.30336 **	0.05356
	(0.0636)	(0.0705)	(0.0446)	(0.1472)	(0.0813)
Average temperature in January	-0.00180 **	-0.00428	0.00062	-0.00304 **	-0.00251 **
	(0.0008)	(0.0035)	(0.0012)	(0.0014)	(0.0011)
Share of Slavic population	0.00054	-0.00705	0.00031	0.00588	-0.00670 *
	(0.0014)	(0.0055)	(0.0011)	(0.0041)	(0.0040)
Migration rate	-0.00031	-0.00037 ***	-0.00015	0.00058	-0.00012
	(0.0003)	(0.0001)	(0.0002)	(0.0004)	(0.0002)
GRP growth rate	0.00078	0.00305 ***	-0.00087	0.00150	-0.00049
	(0.0007)	(0.0011)	(0.0012)	(0.0011)	(0.0020)
Log of the number of firms and organizations per 10,000 residents	0.10761 **	0.15237 ***	0.02915	0.17802 **	-0.05570 **
	(0.0508)	(0.0576)	(0.0630)	(0.0785)	(0.0284)
Share of firms and organizations in fiscal deficit	-0.00166 *	0.00295	-0.00272 **	0.00146	-0.00404 ***
	(0.0009)	(0.0024)	(0.0011)	(0.0024)	(0.0010)
Share of population under the poverty line	-0.00167 *	0.00051	-0.00135	-0.00748 **	-0.00339 **
	(0.0009)	(0.0009)	(0.0013)	(0.0033)	(0.0017)
Log of the number of graduates of higher education per 1,000 persons	0.12674 ***	0.32501 ***	0.08905 ***	0.13237 **	-0.02928
	(0.0376)	(0.0585)	(0.0321)	(0.0575)	(0.0673)
Log of the number of hospital beds per 10,000 residents	0.12627 **	0.19233 *	0.04995	-0.05996	0.26692 **
	(0.0645)	(0.1006)	(0.0507)	(0.0767)	(0.1125)
Log of floor space per capita	0.10616 **	0.10195 **	0.24552	0.42274 **	0.16027
	(0.0513)	(0.0516)	(0.1619)	(0.2010)	(0.1533)
Ecological risk	-0.00053	-0.00242 ***	0.00110 ***	0.00038	-0.00014
	(0.0003)	(0.0006)	(0.0004)	(0.0007)	(0.0009)
Time trend	0.02292 ***	0.01026 **	0.02874 ***	0.00313	0.02789 ***
	(0.0038)	(0.0048)	(0.0038)	(0.0098)	(0.0042)
Constant term	1.89782 ***	0.29595	2.62296 ***	0.44044	3.55896 ***
	(0.4771)	(0.5190)	(0.5515)	(1.1101)	(1.0791)
N	773	120	280	180	193
Arellano–Bond test [b]	1.717 *	0.099	0.689	2.446 **	0.042
Sargan test [c]	386.745 ***	92.302 *	152.019 ***	103.073 **	105.809 ***
Wald test (χ^2) [d]	4676.75 ***	103000.00 ***	5631.10 ***	11321.14 ***	5507.66 ***

Notes:

[a] Model [3] in Table 4

[b] Autocorrelation test for AR(2). Null hypothesis: no autocorrelation.

[c] Test results that use estimates with normal standard errors. Null hypothesis: overidentifying restrictions are valid.

[d] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are robust standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

Apendix 5. System GMM dynamic estimation of the fertility rate of women ages 30–34 by group of federal districts, 2005–2015

Dependent variable	Log of fertility rate early 30s				
Target districts	Whole federation	North Caucasus and Southern Districts	Central and North West Districts	Volga and Ural Districts	Siberian and Far East Districts
Model	Reference [a]	[1]	[2]	[3]	[4]
Lagged dependent variable	0.42586 ***	0.59651 ***	0.12159 **	0.11176 *	0.14235 **
	(0.0740)	(0.0794)	(0.0506)	(0.0653)	(0.0569)
Average temperature in January	-0.00059	0.00259	0.00184	-0.00133	-0.00224
	(0.0010)	(0.0057)	(0.0016)	(0.0017)	(0.0018)
Share of Slavic population	-0.00073	-0.01293	-0.00114	0.00045	-0.01155
	(0.0020)	(0.0106)	(0.0015)	(0.0074)	(0.0072)
Migration rate	-0.00045 ***	-0.00028 **	0.00023	0.00063 *	0.00029
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0004)
GRP growth rate	0.00257 **	0.00703 ***	0.00150	0.00098	-0.00341
	(0.0013)	(0.0014)	(0.0015)	(0.0016)	(0.0021)
Log of the number of firms and organizations per 10,000 residents	0.21558 ***	0.16012 **	0.02360	0.07517	-0.03749
	(0.0470)	(0.0802)	(0.0765)	(0.0935)	(0.0535)
Share of firms and organizations in fiscal deficit	-0.00220	0.00270	-0.00310 *	-0.00499 ***	-0.00432 ***
	(0.0015)	(0.0027)	(0.0017)	(0.0017)	(0.0016)
Share of population under the poverty line	0.00031	0.00188	-0.00269 *	-0.00484 **	-0.00466 *
	(0.0012)	(0.0021)	(0.0016)	(0.0020)	(0.0024)
Log of the number of graduates of higher education per 1,000 persons	0.17102 ***	0.41765 ***	0.14394 ***	0.12554	-0.06149
	(0.0599)	(0.1045)	(0.0377)	(0.0820)	(0.0596)
Log of the number of hospital beds per 10,000 residents	0.22481 ***	0.26405 ***	0.17261 **	0.06427	0.35443 ***
	(0.0751)	(0.0995)	(0.0827)	(0.1007)	(0.1336)
Log of floor space per capita	0.00904	-0.05105	0.02206	1.00933 **	0.36891 **
	(0.0808)	(0.1429)	(0.1900)	(0.4950)	(0.1867)
Ecological risk	-0.00105 **	-0.00324 ***	0.00093 **	-0.00015	-0.00300 ***
	(0.0005)	(0.0008)	(0.0004)	(0.0008)	(0.0011)
Time trend	0.03110 ***	0.01696 ***	0.05304 ***	0.02315 *	0.04102 ***
	(0.0047)	(0.0033)	(0.0051)	(0.0138)	(0.0074)
Constant term	-0.24308	-0.55180	2.21726 ***	-0.35904	2.26999 **
	(0.5617)	(0.7167)	(0.5717)	(2.2258)	(0.9201)
N	773	120	280	180	193
Arellano–Bond test [b]	-0.344	-0.626	-1.928 *	0.868	-2.064 **
Sargan test [c]	526.879 ***	89.887	152.973 ***	124.851 ***	163.163 ***
Wald test (χ^2) [d]	6221.18 ***	10780.36 ***	4738.29 ***	24073.20 ***	5191.73 ***

Notes:

[a] Model [4] in Table 4

[b] Autocorrelation test for AR(2). Null hypothesis: no autocorrelation.

[c] Test results that use estimates with normal standard errors. Null hypothesis: overidentifying restrictions are valid.

[d] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are robust standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.

Apendix 6. Supplement regression analysis using alternative estimators, 2005–2015

Dependent variable	Log of total fertility rate						
Estimator	Pooling OLS	Between effects	Population averaged	Random effects	Fixed effects	Random effects with AR(1) disturbances	Fixed effects with AR(1) disturbances
Model	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Average temperature in January	-0.00587 ***	-0.00502 **	-0.00469 ***	-0.00514 ***	-0.00346 ***	-0.00434 ***	-0.00184 ***
	(0.0006)	(0.0020)	(0.0008)	(0.0007)	(0.0008)	(0.0007)	(0.0008)
Share of Slavic population	-0.00200 ***	-0.00169 ***	-0.00383 ***	-0.00384 ***	0.00057	-0.00348 ***	-0.00266 *
	(0.0002)	(0.0006)	(0.0005)	(0.0004)	(0.0012)	(0.0004)	(0.0016)
Migration rate	-0.00026 ***	-0.00045	-0.00018 ***	-0.00017 ***	-0.00020 ***	-0.00018 ***	-0.00015 **
	(0.0001)	(0.0003)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)
GRP growth rate	0.00070	0.00134	0.00035	0.00041	0.00004	0.00037 *	0.00023 *
	(0.0011)	(0.0071)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Log of the number of firms and organizations per 10,000 residents	0.00357	0.00124	0.09015 ****	0.08169 ***	0.11151 ***	0.05198 ***	0.05386 ***
	(0.0117)	(0.0317)	(0.0135)	(0.0133)	(0.0142)	(0.0147)	(0.0203)
Share of firms and organizations in fiscal deficit	-0.00293 ***	-0.00412	-0.00237 ***	-0.00239 ***	-0.00208 ***	-0.00250 ***	-0.00224 ***
	(0.0007)	(0.0029)	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0006)
Share of population under the poverty line	-0.00063	-0.00044	-0.00056	-0.00064	-0.00027	-0.00071	0.00004
	(0.0007)	(0.0026)	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0009)
Log of the number of graduates of higher education per 1,000 persons	0.04226 ***	-0.04145 **	0.02787 ***	0.03356 ***	0.03179 *	0.03407 ***	0.00339
	(0.0075)	(0.0160)	(0.0108)	(0.0095)	(0.0177)	(0.0088)	(0.0235)
Log of the number of hospital beds per 10,000 residents	0.03312	0.03397	0.04291 *	0.04200 *	0.03551	0.07131 **	0.00928
	(0.0342)	(0.0859)	(0.0249)	(0.0250)	(0.0256)	(0.0294)	(0.0337)
Log of floor space per capita	0.38546 ***	0.44214 ***	0.14297 ***	0.09109 **	0.23644 ***	-0.01182	0.14469 **
	(0.0422)	(0.1118)	(0.0462)	(0.0455)	(0.0491)	(0.0482)	(0.0615)
Ecological risk	0.00014	0.00019	-0.00025 *	0.00022	-0.00041 ***	0.00008	-0.00011
	(0.0002)	(0.0007)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Time trend	0.03508 ***	0.03881	0.02561 ***	0.02646 ***	0.02353 ***	0.02895 ***	0.02449 ***
	(0.0020)	(0.0497)	(0.0013)	(0.0013)	(0.0013)	(0.0015)	(0.0019)
Constant term	1.58162 ***	1.76089 ***	-0.41888 **	-0.20117	-1.26454 ***	0.12276	-0.17546 ***
	(0.2025)	(0.5697)	(0.1868)	(0.1825)	(0.2218)	(0.1967)	(0.0543)
N	850	850	850	850	850	850	772
Overall R^2	0.755	0.751	-	0.621	0.035	0.670	0.429
Wald test (χ^2) [a]	202.13 ***	14.02 ***	5569.41 ***	5299.86 ***	480.64 ***	3243.67 ***	127.11 ***

[a] Null hypothesis: all coefficients are zero.

Figures in parentheses beneath regression coefficients are standard errors (robust standard errors, if applicable). ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' estimation. See Table 2 for definitions and descriptive statistics of the variables used in the estimation.