A STUDY OF REGIONAL DIFFERENTIATION OF THE FERTILITY RESOURCES BASED ON CONVERGENCE MODELS

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ABSTRACT

The problem of low fertility is one of the most important in Russia, and the imbalance in regional demographic development is historically relevant in Russia The purpose of our study is to investigate the processes of convergence/divergence of Russian regions on indicators reflecting the reproductive resource of fertility. Convergence was studied on the basis of two different models: σ-convergence and β-convergence (Barro regression). The use of the convergence analysis method made it possible to identify the features of regional differentiation of the reproductive resource of fertility and its dynamics in Russia. The results showed that Russian regions are markedly differentiated by the level of individual components of the reproductive resource, as well as by its integral indicator. The level of regional differentiation by these indicators has increased over the past almost two decades. The results of the study have a potential practical application, because they allow us to develop measures for a more complete realization of the reproductive resource of fertility in Russian regions based on the identified trends. Our results and the controversial issues arising from them provide an opportunity to determine the direction of further research.

INTRODUCTION

The problem of low fertility is one of the most important in Russia. The solution to this problem, which would lead to the increasing fertility, has economic, social, domestic and foreign political importance. It is obvious that stable demographic dynamics in the country cannot occur in conditions of a pronounced regional imbalance, whereas in Russia the problem of the imbalance of the regional demographic development is historically relevant. Nowadays, Russian demographers face a certain challenge. They assess the dynamics and identify the birth rate determinants, but they also need to have an analytical understanding of the reasons for differences in fertility dynamics and related indicators in the Russian regions, where the same state measures aimed at the stimulation of fertility and parenthood are implemented.

It is possible to solve the latter problem using the convergence / divergence models. There are several approaches to defining convergence in the scientific literature. The researchers speak of σ-convergence, absolute and relative β-convergence, γ-convergence, club convergence (e.g. Sala-I-Martin 1996; Barro and Sala-I-Martin 1992). At the same time, they note that the convergence / divergence of the studied processes can be investigated using a different set of statistical measures.

The method of convergence / divergence of Russian regions may be applied not only to the study of the direct indicators of the birth rate but also to the study of the dynamics of interregional variation of the potential determinants of fertility, as well as its conditions and resources.

The resource approach to the study of fertility is associated with an understanding of the multifactorial nature of this demographic process. Fertility resources are defined as certain conditions, change or development of which can help to obtain the desired result in the form of a definite quantity and quality of the country's human capital. These resources are conditions of fertility, which can be observed in various areas of social and individual life. For example, there are economic resources of fertility – material well-being of the population, housing provision, availability of stable employment, etc. The correlation of these resources with the birth rate is studied by many scholars (e.g. Raute 2019; Comolli 2017). The infrastructure resources include, in particular, the availability of maternity hospitals with high-quality medical equipment, children's hospitals, kindergartens, schools, organizations of additional education for children, etc. There are a number of studies showing the correlation of this resource with the birth rate (Sinitsa 2018).

In our opinion, it is necessary to accentuate the reproductive resource of fertility. This is the reproductive potential of the population, the measurement of which is possible both through objective and subjective indicators. For example, Shabunova and Lastochkina include reproductive health, reproductive behavior, and so-called reproductive loss in the reproductive potential (Shabunova and Lastochkina 2006). Reproductive

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behavior is studied through opinions, intentions and subjective assessments of the population, whereas data on health and reproductive losses (in particular, abortions) are collected by official Russian statistics.

We analyzed the correlation between five different fertility resources and the birth rate in our previous study (Bagirova and Shubat 2018). A statistically significant positive correlation was found only on indicators of reproductive resources. Therefore, the purpose of our study is to investigate the processes of convergence/divergence of Russian regions on indicators reflecting the reproductive resource of fertility.

DATA AND METHODS

1. A database of regional indicators was formed for the study. The following indicators constitute the reproductive resource of fertility in the region:

- population incidence rate (per 1000 people);
- abortion rate (per 1000 women of reproductive age);
- abortion rate (per 100 births).

It can be noted that this list of indicators is not complete and should include other indicators. However, the capacity of the Russian official statistics allowed us to form only this set of valid indicators of the reproductive resource.

The data required for the study is publicly available on the resource of the Unified Interdepartmental Information-Statistical System of Russia. The analysis covered the period from 2000 to 2017, when an increase in the total fertility rate (TFR) was registered. The study included all Russian regions with a complete set of necessary data for all the years of research (78 subjects of the Russian Federation).

2. The analysis was conducted in two stages. At the first stage, regional convergence / divergence was studied separately for each variable of the reproductive resource. At the second stage, a similar analysis was carried out for the integral indicator of the reproductive resource.

3. Convergence / divergence were studied on the basis of two different models, which evaluated regional convergence / divergence tendencies in different ways.

The first model is σ-convergence (sigma-model), which manifested in the fact that the interregional variation decreases with time. The scientific literature most often suggests using two well-known statistical indicators to measure σ-convergence: the standard deviation σ and the coefficient of variation Vσ, which is calculated on its basis (1):

$$V_\sigma = \frac{\sigma}{\bar{x}} \cdot 100 = \frac{\sqrt{\frac{(x_i - \bar{x})^2}{n}}}{\bar{x}}, \qquad (1)$$

where x_i – regional value of the indicator;

$\bar{x}$ – average value;

n – number of regions in the study.

The second convergence model in our study is the so-called β-convergence (beta-model), which was estimated on the basis of the Barro regression (Barro 1991) (2):

$$\frac{1}{T}\ln\left(\frac{y_{i,t+T}}{y_{i,t}}\right) = \alpha + \beta \cdot \ln y_{i,t} + \varepsilon_{i,t}\ , \qquad (2)$$

where $y_{i,t}$ and $y_{i,t+T}$ – levels of the studied indicator in region *i* at the initial and final point in time;

$\frac{1}{T}\ln\left(\frac{y_{i,t+T}}{y_{i,t}}\right)$ – average annual growth of the indicator in region *i* in the studied period of time (*t*, *t*+*T*);

α – constant;

β – regression coefficient;

$\varepsilon_{i,t}$ – random errors.

If the regression coefficient is statistically significant and it is less than zero, then the so-called "catch-up" effect is present in the studied data. This effect can manifest itself in two ways.

It is possible that regions with initially lower levels of the studied indicator show higher growth rates and, thus, "catch up" with regions with initially higher levels of the indicator. As a result, there is the effect of the regional convergence. This situation occurs when an upward trend is observed in the source data. If there is a downward trend in the dynamics of the studied indicator, the effect of convergence is manifested slightly differently. Regions with initially higher levels of the indicator show higher rates of decline and, thus, "catch up" with regions with lower levels of the studied indicator. This is also the effect of the convergence of regions.

The following features of the relationship of the two types of convergence can be noted. Firstly, σ-convergence is a sufficient, but not a necessary condition for β-convergence. This, in particular, was shown by Sala-I-Martin (Sala-I-Martin 1996). Secondly, the presence of β-convergence is a necessary, but not sufficient condition for σ-convergence. This, in particular, was shown in the work of Young and his co-authors (Young, Higgins & Levy 2008).

4. We converted the original data in order to obtain a generalized (integral) indicator of the reproductive resource. A standardization procedure was used, which reduced all data to the 0 to 1 range (3):

$$z_i = \frac{x_i - x_{min}}{x_{max} - x_{min}}, \qquad (3)$$

where x_i – actual value of the indicator;

$x_{min\ /\ max}$ – minimum and maximum value of the indicator.

The integral indicator of the reproductive resource level in the region (arithmetic mean of standardized indicators) was calculated on the basis of standardized values of variables for each region. Both variables that characterize the same phenomenon - the number of abortions - were taken with a weight of 0.5 in order to maintain parity in assessing the contribution of each variable to the total value of the integral indicator.

5. Boxplot and distribution percentiles were used for more in-depth study of data structures. For each year, we built a boxplot that showed the variation of regional values of the integral indicator of the reproductive resource. We carried out a comparative analysis of such graphs in order to identify trends in the convergence or divergence of regions by the level of this indicator. A comparative analysis of the distribution percentiles of the reproductive resource integral indicator for different years has also been used to obtain additional quantitative characteristics of the convergence/divergence trends of the Russian regions.

RESULTS

1. The study of the incidence rate variable did not allow us to make a confident conclusion about the regional convergence/divergence trend on this indicator. On the one hand, the sigma-model analysis of convergence showed that the imbalance of regional incidence rates has been growing since 2014 – the coefficient of variation has increased markedly since 2014. However, in our opinion, it is impossible to speak of convergence or divergence in the longer term. The period from 2000 to 2014 can be characterized rather as a period of some volatility of the variation coefficient (Figure 1).

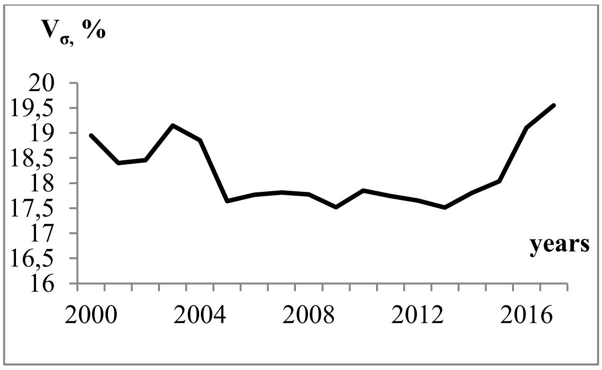

Figure 1: Regional σ-convergence of the incidence rate in Russia

The study of the regional convergence based on the beta-model also did not allow us to speak unequivocally of the convergence tendency. On the one hand, the β parameter in the equation is negative. Consequently, regional incidence rates are somewhat unified. The situation with the incidence of the population in the regions with the initially higher levels of incidence is improving more rapidly than in the regions where the situation was initially better. On the other hand, the explanatory power of the Barro-regression is very low – the coefficient of determination is only 16% (Tables 1-2).

Table 1: Model Summary (for the incidence rate)

R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson	F	Sig.
0.16	0.15	0.008	2.06	14.82	0.00

Table 2: Coefficients (for the incidence rate)

	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
Constant	0.12	0.03	4.02	0.00
Ln (population incidence rate, initial point in time)	-0.02	0.01	-3.85	0.00

We also note that, in general, it is impossible to determine a clear downward trend or, conversely, an increase in the incidence of the population in the country. In 60 regions, the incidence rate of the population was higher in 2017 than in 2000. At the same time, this indicator decreased in 28 regions.

2. The study of the variable “number of abortions per 1000 women” revealed the following features.

Firstly, the trend of reducing the number of abortions was characteristic of all regions of the country during the study period (unlike the situation with the incidence rate).

Secondly, the sigma-model analysis of the convergence allowed us to make an unambiguous conclusion about regional divergence. In the period from 2000 to 2017, there is an increase in the imbalance of regions in terms of abortion rates (Figure 2).

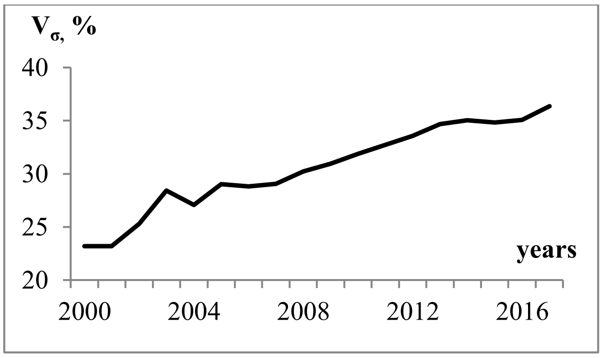

Figure 2: Regional σ-convergence of the number of abortions per 1000 women in Russia

Thirdly, the beta-model analysis of convergence did not show that the growth of regional imbalance is due to the internal systematicity of this process. Model parameters are statistically insignificant, the coefficient of determination is close to zero (Tables 3-4).

Table 3: Model Summary
(for the number of abortions per 1000 women)

R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson	F	Sig.
0.00	-0.01	0.02	2.66	0.07	0.80

Table 4: Coefficients
(for the number of abortions per 1000 women)

	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
Constant	-0.06	0.02	-2.60	0.01
Ln (number of abortions per 1000 women, initial point in time)	0.00	0.01	0.26	0.80

Thus, we cannot claim that Russian regions are converging or diverging due to different growth rates of the number of abortions in two types of regions – relatively prosperous and disadvantaged. Both types of regions may show identical rates of decline in the number of abortions, or, on the contrary, regions of the same type can demonstrate completely different rates of decline in this indicator.

Note that the process of evaluating the Barro regression for the variable "number of abortions per 1000 women" revealed outliers – regions with atypically low indicators which noticeably "stretched" the regression line. As a result, the quality estimates of the model and its parameters were overstated. These outliers are two Caucasian regions - Dagestan and Ingushetia. The estimates presented in Tables 3 and 4 were obtained after the exclusion of these regions from the analyzed population.

3. We obtained similar results in the process of investigating the variable "number of abortions per 100 births":

- a decrease in the level of this indicator was recorded in all regions of the country in the period from 2000 to 2017;
- a divergence of Russian regions by the "number of abortions per 100 births" indicator is observed in the studied period of time (Figure 3);

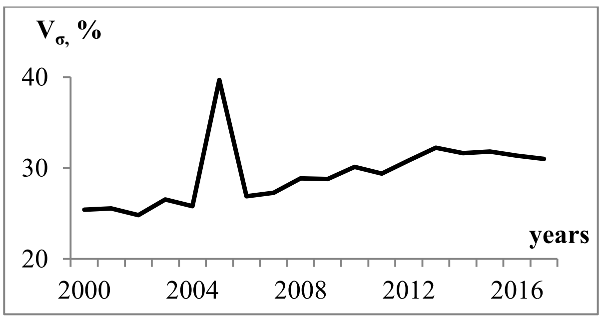

Figure 3: Regional σ-convergence of the number of abortions per 100 births in Russia

- the beta-convergence model did not confirm the presence of any trends in the rate of abortion decline in different types of regions - prosperous and disadvantaged (Table 5-6).

Table 5: Model Summary
(for the number of abortions per 100 births)

R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson	F	Sig.
0.10	0.08	0.02	2.46	6.86	0.01

Table 6: Coefficients
(for the number of abortions per 100 births)

	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
Constant	0.02	0.04	0.58	0.56
Ln (number of abortions per 100 births, initial point in time)	-0.02	0.01	-2.62	0.01

4. The study of the integral indicator of the region's availability of reproductive resources yielded the following results.

Firstly, the sigma-model confirmed the presence of regional divergence. Thus, the growth of regional imbalance of reproductive resources in Russian regions is observed in the period from 2000 to 2017 (Figure 4).

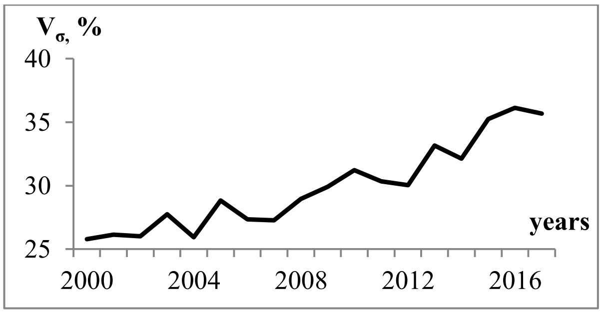

Figure 4: Regional σ-convergence of the integral indicator of the reproductive resource in Russia

Secondly, the beta-model of convergence, as expected, did not reveal the presence of any pattern in changing the rate of decline / growth of the integral indicator in different regions. Model parameters were not statistically significant (Table 7-8).

Table 7: Model Summary
(for the integral indicator of the reproductive resource)

R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson	F	Sig.
0.02	0.01	0.02	2.07	10.46	0.23

Table 8: Coefficients
(for the integral indicator of the reproductive resource)

	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
Constant	-0.02	0.00	-5,78	0.00
Ln (integral indicator of the reproductive resource, initial point in time)	0.01	0.01	1,21	0.23

Thirdly, the study of boxplot revealed the following trend. In the period from 2000 to 2009, three Russian regions (Ingushetia, Kabardino-Balkaria and Karachaevo-Cherkessia) were identified as outliers due to low values of the reproductive resource indicator. Boxplot for the 2002 is given as an example (Figure 5). However, over time, the trend towards a decrease in the values of the integral indicator in the regions led to the fact that these territories were no longer identified as outliers. There have been no outliers at the bottom of distribution graphs since 2013. Boxplot for the 2014 is given as an example (Figure 5).

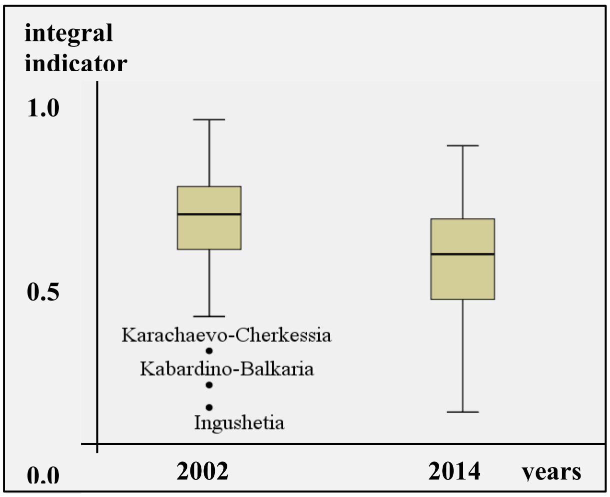

Figure 5: Boxplot of the distribution of Russian regions by the level of the integral indicator of reproductive resource availability in 2002 and 2014

The downward trend of the integral indicator is confirmed by the distribution percentiles. Thus, 10% of Russian regions in 2000 had an integral indicator of the reproductive resource below the value of 0.37. In 2017, a third of all regions (33%) had an indicator below this value.

DISCUSSIONS

The results of the study showed that Russian regions are markedly differentiated by the level of individual components of the reproductive resource, as well as by its integral indicator. Moreover, the level of regional differentiation, or regional inequality, by these indicators has increased over the past almost two decades. It is important to note that the observed inequality occurs at the time identical federal measures, which are aimed at supporting and stimulating fertility, being implemented throughout the country. Consequently, these measures cannot provide a univocal increase in the level of reproductive resource, which is in positive correlation with the total fertility rate. This fact makes it necessary to admit that the state measures aimed at the stimulation of fertility, which have been implemented in recent years, are not effective enough.

In our opinion, results of the analysis primarily draw attention to the problem of the dynamics of the number of abortions, which is directly related to the dynamics of the birth rate. Note that one of our previous studies revealed this positive correlation in Russian regions (Bagirova and Shubat 2018 - MSED). The reasons for the positive correlation between TFR and the number of abortions among women of childbearing age for the totality of Russian regions can be different. These reasons may include, for example, different prevalence of contraceptives among women in different regions; the “qualitative composition” of the category of women of fertile age by age, marital status, education, employment level that varies in regions; sexual activity of the population that differs in Russian territories (for example, in different climatic zones), etc. Testing hypotheses regarding the influence of these factors on the identified correlation is a topic for separate studies. It should be noted that full or partial abortion ban is considered today as a measure of increasing the birth rate in a number of countries. In this case, it is most likely assumed that abortion ban creates conditions for a more complete realization of the reproductive potential of the population.

The experience of Soviet history shows the ineffectiveness of abortion bans. Consequently, other measures are necessary to ensure a systematic increase in the birth rate due to this component of the resource. In particular, the following measures may be introduced at the federal level:

- legal measures (for example, the state’s guarantee that it will pay for minor children in case of impossibility of collecting alimony from the father of the child);
- economic measures (for example, earlier provision of children who are brought up by single parents with municipal kindergartens);
- socio-psychological measures (for example, free psychological counseling for single parents; promotion of a positive image of all parents, including single parents).

Regional measures are also important. For instance, socio-psychological measures should certainly take into account national, cultural, religious contexts of individual Russian regions. Consequently, we consider it necessary to have a two-level type of attention to the problem of abortion in the regions. The first level is federal, which implies the introduction of systemic legal and economic measures by the government (authorities). The second level is regional, which draws public attention to the problems of single parents. It must take into account the socio-cultural characteristics of the population in a particular Russian region. Such a two-level impact will reduce the divergence of the Russian regions in this component of the reproductive resource and therefore increase the birth rate in certain Russian territories.

The development and implementation of regional measures should also take into account the possible presence of the spatial dependence of the distribution of the reproductive resources level throughout Russia. For example, it can be determined on the basis of the calculation of the Moran's spatial autocorrelation indices (Moran 1950). The Moran's index shows whether the values of a certain attribute (in this case, the components of the reproductive resource of fertility) in the neighboring territories are more or less close to each other than they would be if the distribution of this attribute was random. For instance, an analysis of mortality, which was conducted by Russian scientist Inna Danilova, showed the presence of high spatial autocorrelation (Danilova 2018). One of the conclusions of her study suggests that the neighboring territories of regions with lower life expectancy will most likely also have a lower life expectancy. Conversely, neighboring territories of regions with high life expectancy also often have higher values of life expectancy.

The analysis of fertility resources in Russian regions may bring to similar results. In this case, the design of unique measures for each region separately is not relevant. It makes sense to implement a series of steps typical for neighbouring regions, which have similar fertility resource dynamics.

CONCLUSIONS

The analysis led us to the following conclusions.

Firstly, the use of the convergence analysis method made it possible to identify the features of regional differentiation of the reproductive resource of fertility and its dynamics in Russia.

Secondly, the results of the study have a potential practical application, because they allow us to develop measures for a more complete realization of the reproductive resource of fertility in Russian regions based on the identified trends. We demonstrated that taking regional specifics into account when developing such measures will reduce the existing divergence of Russian regions in terms of reproductive resource indicators and, consequently, increase the birth rate in Russia.

Thirdly, the results of the study and the controversial issues arising from them provide an opportunity to determine the direction of further research. First of all, we reiterate the need to analyze fertility on the basis of other approaches to the beta-convergence modeling. In our opinion, the spatial autocorrelation regression model is the most productive among such approaches. The assumption of spatial dependence of the observations (for example, dependencies between neighboring regions) underlies this approach

It is advisable to study interregional birth rate convergence in Russia on the basis of other beta-convergence models: conditional convergence models, time series, panel data models. Each of these models allows analyzing specific features of the regional differentiation of fertility. In addition, a complementary use of two fundamentally different approaches can be effective in modeling regional differences: 1) cluster analysis with the identification of groups of regions with a similar situation in the population reproduction; 2) analysis of the regional convergence of the reproduction state with the identification of the convergence/divergence tendency for regions.

In addition, the most important research task is to identify the causes of divergent tendencies in the Russian demographic sphere. This requires separate studies based on correlation and regression analysis and modeling. It is important to note that the specificity of the studied processes requires the inclusion not only of quantitative (statistical) indicators in the analysis, but also of qualitative indicators obtained, for example, during sociological surveys. In our opinion, analysis based on mixed-methods research is promising in this case. Conducting such research is our future priority.

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