Beta-Convergence of Russian regions: Sectoral and Spatial Aspects

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Motivation

Which regions grow faster: poor or rich? This issue is very relevant for such a large and heterogeneous country as Russia.

If that's the case with the poor regions, then there is hope that they will be able to approach rich regions in the future.

If the rich regions grow faster, then the gap between the regions may widen even more, which can lead to an undesirable increase in social tension.

Benchmark: Barro and Sala-i-Martin (1992) approach

JOURNAL ARTICLE

Convergence

Robert J. Barro and Xavier Sala-i-Martin
Journal of Political Economy
Vol. 100, No. 2 (Apr., 1992), pp. 223-251

Published by: The University of Chicago Press
https://www.jstor.org/stable/2138606
Page Count: 29

Evidence on Convergence for the U.S. States

We use the data on real per capita income or product, y_{it}, for a cross section of the U.S. states, $i = 1, \ldots, N$. Equations (10) and (11) imply that the average growth rate over the interval between any two points in time, t_0 and $t_0 + T$, is given by

$$\frac{1}{T} \cdot \log\left(\frac{y_{i,t_0+T}}{y_{i,t_0}}\right) = B - \left(\frac{1 - e^{-\beta T}}{T}\right) \cdot \log(y_{i,t_0}) + u_{i,t_0,t_0+T}, \quad (15)$$

Benchmark: Barro and Sala-i-Martin (1992) approach

$$\frac{1}{T} ln \frac{Y_{i(t_0+T)}}{Y^m_{it_0}} = \alpha + \beta ln Y_{it_0} + \sum_{j=1}^{K} \gamma_j X_{jit_0} + \varepsilon_i$$

If coefficient beta is negative (as in the case of convergence), this model predicts greater economic growth in regions with lower initial level of development.

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Models of regional growth with spatial effects

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Growth, convergence, Russian regional data
Literature

Benchmark: Barro and Sala-i-Martin (1992) approach

Article	Time period	Main results
Gluschenko (2012)		Russian regions are characterized with increased diversity and do not converge to the unique equilibrium path
Berkowitz and DeJong (2005)	1993-2000	Did not reveal convergence
Solanko (2008)	1992-2005	Initially poor regions had no clear trend of convergence or divergence, while initially rich regions demonstrated convergence
Guriev and Vakulenko (2012)	1995-2010	There was no convergence in the 1990s, and the situation changed dramatically in the 2000s: poor Russian regions grew out of the poverty traps, mobility of labour and capital increased, which led to a convergence among Russian regions

Growth, convergence, Russian regional data Literature

Article	Time period	Main results
Buccellato (2007)	1999-2004	The spatial component appears to be non-negligible and, consequently, conventional convergence estimates suffer a bias due to spatial dependence across observations.
Lugovoy et al, (2007)	1998-2004	The growth of a particular Russian region **depends on the growth of other Russian regions.**
Kolomak (2011)	1992-2005	Russian regions were found to be heterogeneous, and positive externalities were observed in the western regions, whereas negative externalities were observed in the eastern regions.
Ivanova (2017)	1996-2013	A positive influence for neighboring regions in the economic growth.
Kholodilin et al, (2012)	1996-2006	It was a strong regional convergence among high- income regions located near other high-income regions. The overall speed of regional convergence in Russia, being low by international standards, becomes even lower after controlling for spatial effects. Speed of convergence using **aggregate data may result in misleading conclusions** regarding the nature of convergence process among Russia's regions.

Novelty of this research

Gross regional product per capita was frequently used as an indicator characterizing the wealth of a region. However, gross regional product consists of various spheres of economic activity, for which various dependencies can be observed. We examine the areas of economic activity that make up most of the gross regional product, namely,

industry production, construction, agriculture, retail.

Data

Data source:

Federal State Statistics Service of the Russian Federation, www.gks.ru

79 Russian regions (Moscow and St. Petersburg were excluded)

Time periods 2000 – 2017, 2000 – 2008, 2009 – 2017

Dependent Variables

$\frac{1}{T} ln \frac{Y^m_{i(t_0+T)}}{Y^m_{it_0}}$ **is an annual growth (in logarithms)**

in industry production (m=1),

construction (m=2),

agriculture (m=3),

retail (m=4)

$[t_0, t_0 + T]$ **∈ {[2000 – 2017], [2000 – 2008], [2009 – 2017]}**

Modified Spatial Models

Spatial autoregression (SAR) model is

$$\frac{1}{T} ln \frac{Y^m_{i(t_0+T)}}{Y^m_{it_0}} = \alpha + \beta lnY^m_{it_0} + \sum_{k=1}^{K} \gamma_j X_{kit_0} + \rho \sum_{j=1}^{n} w_{ij} ln \frac{Y^m_{j(t_0+T)}}{Y^m_{jt_0}} + \theta \sum_{j=1}^{n} w_{ij} lnY^m_{jt_0} + \varepsilon_i$$

Spatial error model (SEM) is

$$\frac{1}{T} ln \frac{Y_{i(t_0+T)}}{Y^m_{it_0}} = \alpha + \beta lnY_{it_0} + \sum_{j=1}^{K} \gamma_j X_{jit_0} + u_i$$

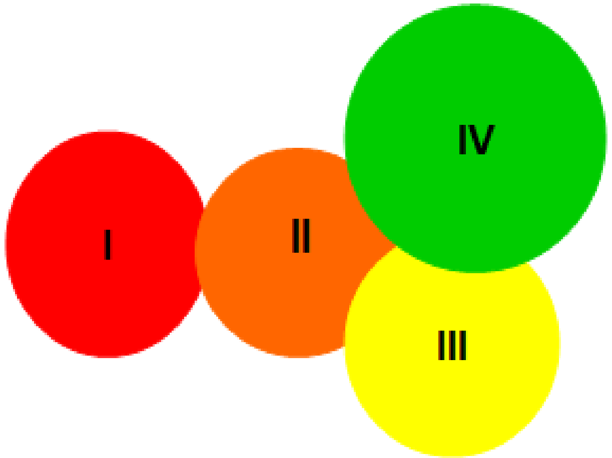
$$u_i = \lambda \mathbf{W} u_i + \varepsilon_i$$

Weighted Matrix

$$W = \begin{pmatrix} 0 & w_{12} & \cdots & w_{1n} \\ w_{21} & 0 & \cdots & w_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{n1} & w_{n2} & \cdots & 0 \end{pmatrix}$$

w_{ij} initially is equal to 1, if regions i and j have common borders . After that matrix W was row normalized, so w_{ij} accounts for the weights.

Example of Weighting matrix



$$W_b = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 1/3 & 0 & 1/3 & 1/3 \\ 0 & 1/2 & 0 & 1/2 \\ 0 & 1/2 & 1/2 & 0 \end{pmatrix}$$

Example of spatial lag

$$WY = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 1/3 & 0 & 1/3 & 1/3 \\ 0 & 1/2 & 0 & 1/2 \\ 0 & 1/2 & 1/2 & 0 \end{pmatrix} \begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \end{pmatrix} = \begin{pmatrix} Y_2 \\ 1/3(Y_1 + Y_3 + Y_4) \\ 1/2(Y_2 + Y_4) \\ 1/2(Y_2 + Y_3) \end{pmatrix}$$

Explanatory variables - 1

Explanatory variables	Previous articles
X1 = Urban share (as a measure of urbanization)	Spence et al., (2008); Turok & McGranahan, (2013); Chen et al., (2014); Castells-Quintana, (2017)
X2 = the ratio of investment in fixed assets to real GRP	Solow, (1956), Nwaogu, 2012; Huang& Wei, 2016
X3 = the proportion of the population with higher education in the labour force (as a measure of human capital)	The alternative indicator is the number of students per 1000 inhabitants, Solanko (2008), Kolomak(2011)
X4 = Ratio of exports and imports to the GRP of the region as an indicator of the openness of the region for trade	Harrison, (1996); Sachs et al., (1995); Yanikkaya, (2003); Waiczarg & Welch, (2008); Huchet-Bourdon, et al., (2011)
X5 = The density of highways as an indicator of the infrastructure quality	EBRD noted Turkey's progress in the development of high-speed road construction, which increase the mobility of the workforce

Explanatory variables - 2

Explanatory variables	Previous articles
X6 = RA Expert index of investment risk	Leonard et al. (2016); Libman (2013); Alexeev and Chernyavskiy (2015)
X7 = number of small enterprises per thousand of economically active population	Zemtsov and Smelov, (2018)
X8 = Herfindahl-Hirschman index (as the degree of diversification of regional economies)	Davidson and Mariev (2015); Vorobyov et al. (2014)
X9 = patent applications per 10000 population	Schumpeter (1934), Arrow (1962); Romer (1986; 1994). Fingleton & Lopez-Bazo, (2006); Le Sage & Fischer, (2008)
X10 = share of intergovernmental grants in regional budget revenue	Dall'Erba & Le Gallo (2008)

Method of estimation

Spatial-econometric SAR and SEM models cannot be estimated using OLS. The right side of the SAR model contains a spatial lag, so OLS estimates will be inconsistent. Estimates of SEM models will be consistent, but not effective, since the covariance matrix of the regression errors is not proportional to an identity matrix.

To obtain consistent estimates of the parameters of both models, maximum likelihood is used, details can be found in (Elhorst, 2014; Arbia, 2014). Estimation was carried out using the statistical package STATA, package spatwmat.

Results of estimation for industry production

Переменные	2000-2017		2000-2008		2009-2017	
	SAR	SEM	SAR	SEM	SAR	SEM
lnymanuf	0.0189**	0.0190**	0.0322**	0.0362***	-0.0110**	-0.0121***
wlnyman	-0.0038	-	0.006		-0.0058	-
urbansh	-0.0683*	-0.0731**	-0.1206**	-0.1218**	0.0644*	0.0637*
invgrp	-0.0435*	-0.0227	-0.0696*	-0.0531	0.0548**	0.0555**
highed	0.0895	0.1258*	-0.0166	0.013	0.0264	0.0316
impexp	-0.0019	-0.002	-0.0013	-0.0006	0.014	0.0177
road	0.0001*	0.0001**	0.0002**	0.0001**	0	0
risk	-0.0508**	-0.0823***	-0.0845**	-0.1164***	-0.0525**	-0.0556**
dot	0.0005**	0.0005***	0.0007*	0.0007**	0.0005	0.0006
hh	-0.0805	-0.1049	-0.142	-0.1814	-0.2786	-0.2335
patent	-0.0088	-0.0002	-0.0117	0.0021	0.0121	0.0084
smallbu	1.0647	0.7459	1.678	1.3882	0.2906	0.1559
cons	-0.0485	-0.0898*	-0.1794*	-0.1682*	0.1871**	0.1229*
rho	-0.2515	-	-0.3313*	-	-0.1766	-
sigma	0.0236***	0.0230***	0.0390***	0.0388***	0.0248***	0.0249***
lambda	-	-0.5069**	-	-0.4269*	-	-0.1855

Results of estimation for construction

Variables	2000-2017			2000-2008			2009-2017	
	SAR	SEM		SAR	SEM		SAR	SEM
lnycons	0.0035	0.0055		0.0135	0.0257*		0.0086	0.0009
wlnycons	0.0088	-		0.0343**	-		-0.0245	-
urbansh	-0.1386***	-0.1316***		-0.2227***	-0.2182***		0.0459	0.0306
invgrp	-0.1384***	-0.1296***		-0.1230*	-0.1474**		-0.0349	-0.0161
highed	0.0071	0.0025		-0.0732	-0.1324		-0.2657*	-0.2999**
impexp	0.0006	0.0005		0.0016	0.0003		0.0332	0.0444
road	0	0		0.0001	0.0001		0	0
risk	-0.0021	-0.0061		0.0228	0.0292		-0.0319	-0.0431
dot	0.0004*	0.0004*		0.0002	0.0005		0.0014**	0.0015**
hh	0.0389	0.0535		-0.0506	-0.0051		-0.3254	-0.0955
patent	-0.0047	-0.0186		-0.0112	0.0246		0.0656	0.053
smallbu	1.011	0.87		3.9639**	4.4161**		-1.034	-0.9607
cons	0.0516	0.0893*		-0.1205	0.0497		0.19	0.0138
rho	-0.233	-		0.0684	-		-0.1699	-
sigma	0.0277***	0.0282***		0.0458***	0.0468***		0.0473***	0.0471***
lambda	-	-0.2668		-	0.1647		-	-0.3071

Results of estimation for agriculture

Variables	2000-2017			2000-2008			2009-2017	
	SAR	SEM		SAR	SEM		SAR	SEM
lnagric	0.0049	0.0047		-0.0026	-0.0039		0.0016	0.0027
wlnagric	0.008	-		0.0084	-		0.0230**	-
urbansh	-0.0151	-0.0113		-0.0461	-0.0428		-0.0347	-0.0585
invgrp	0.0363*	0.0234		0.0338	0.0308		0.0284	0.0158
highed	-0.0214	-0.0801		-0.0416	-0.1382		-0.2233**	-0.1954**
impexp	0.0009	0.0011		0.0008	0.0004		-0.0179	-0.0123
road	0.0001*	0.0002***		0.0001	0.0002***		0.0001**	0.0001**
risk	0.0571***	0.0660***		0.0327	0.0347		0.0789***	0.0572**
dot	0.0001	0		0	-0.0001		-0.0007*	-0.0005
hh	0.0502	0.036		0.0369	0.0526		-0.0735	0.1325
patent	-0.0266	-0.0523		-0.0184	-0.0339		-0.0102	-0.0025
smallbu	1.3631*	1.7827***		1.3204	1.5228*		0.5579	0.356
cons	-0.1213	-0.0417		-0.0292	0.0644		-0.1474	0.0548
rho	0.4705***	-		0.5420***	-		0.3058**	-

Results of estimation for retail

Variables	2000-2017		2000-2008		2009-2017	
	SAR	SEM	SAR	SEM	SAR	SEM
lnretail	-0.0237***	-0.0224***	-0.0255*	-0.0287*	-0.0419***	-0.0368***
wlnyretail	0.0105	-	0.0355	-	-0.0296**	-
urbansh	-0.0326**	-0.0363**	-0.0058	-0.0009	-0.0273	-0.0132
invgrp	-0.0006	0.009	-0.0071	-0.021	0.0146	0.0193
highed	-0.0093	-0.0127	-0.0942	-0.1184	0.0459	0.0539
impexp	0.0004	0.0006	0.0019	0.0012	0.0108	0.0153
road	0.0001***	0.0001***	0	0.0001	0	0
risk	-0.0379***	-0.0354***	-0.0567*	-0.0486	-0.0437***	-0.0393**
dot	0	0	0.0002	0.0001	-0.0001	0.0001
hh	0.0049	0.02	-0.0083	-0.0087	0.4116**	0.4163**
patent	0.0437	0.0615*	0.1456*	0.1297	0.0058	-0.0006
smallbu	0.2429	0.2956	0.1544	0.3339	0.1782	0.1293
cons	0.2318*	0.2893***	0.0385	0.4121***	0.7889***	0.3762***
rho	-0.4325**	-	0.0728	-	0.0847	-
sigma	0.0120***	0.0121***	0.0266***	0.0268***	0.0156***	0.0163***
lambda	-	-0.4869**	-	0.2168	-	0.1361

Beta coefficients

- Beta coefficients are significant only in models for industry and retail.
- While for retail the estimates of beta coefficients are negative in all time periods, for industry production estimates of beta coefficients are positive in the interval 2000-2017 and 2000-2008 and negative in the interval 2009-2017.
- Thus, beta convergence processes take place only for retail in the entire 2000-2017 interval and for industry production in the 2009-2017 interval.

Half-life to convergence

$$HL = \tau T = -\frac{\ln 2}{\ln\frac{1+\beta-\rho}{1-\rho}}T$$

The interpretation of the absolute values of estimates of beta coefficients, if convergence takes place, is usually given in terms of the so-called "half-life to convergence", namely, by calculating the time required to reach half the distance separating the regional economies from their steady-states.

For retail, the estimated τ for the entire interval in the SAR model indicates a very long half-life: 28.899 rounds of 17 years (HL = 491.3 years).
For industrial production in the SAR model in the period 2009-2017, the estimated τ was 62.66 rounds of 8 years each (HL = 501.28 years).

Results concerning spatial effects

- **The spatial autocorrelation coefficient is significant and positive in all models for agriculture.**
- **If in one of the regions agricultural growth is observed, then it will take place in neighboring regions.**
- **The spatial autocorrelation coefficient is significant and negative in the model for retail in the time interval 2000-2017.**
- **If in one of the regions retail is growing, then in neighboring regions it is falling, that is, a competition mechanism exists in this area of economic activity.**

Influence of other factors

- In 2000-2008, in regions with a higher share of the urban population, the rates of economic growth in industry, construction and retail were lower. In 2009-2017, this dependence was found only for retail, for construction it became insignificant, and for the industry production it changed to the opposite dependence.
- Reducing the level of investment risk stimulates industrial production growth at all intervals considered, and for retail in 2009-2017. For agriculture, the dependence is the opposite, which is apparently due to the fact that the main agricultural areas are located in the south of Russia, and these regions also have an increased level of investment risk.
- The development of small enterprises stimulated growth in construction in 2000-2008, and in agriculture throughout the entire time period 2000-2017.
- An increase in the density of roads stimulated the development of agriculture, since the export of finished goods was facilitated.

Conclusions and policy implications

- In the four examined areas of economic activity (industrial production, construction, agriculture, retail), beta convergence was observed only in retail in 2000-2017 and in industrial production in 2009-2017.
- Industrial growth can be achieved through urbanization processes and reduction of investment risk.
- Growth in agriculture can be achieved through the development of small enterprises, as well as an increase in the density of roads. At the same time, there are positive spatial spillovers for agriculture. Agricultural growth in one of the regions stimulates growth in neighboring regions.
- Retail growth can be achieved by reducing the investment risk.

Thank you!

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