Preliminary draft, to be completed

Spatial interaction of Russian regions as a factor of their economic growth: an empirical analysis

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Statement of problem and project's objective

Empirical evidence shows that different regions grow with different speed, and their growth rates are likely to be spatially correlated. Russia is a large and heterogenous country, so it is natural to conjecture that the role of geography should be essential. Are the differences between Russian regions due to more favorable geographic location? Is location a source of economic advantages for regions? Do spillovers across Russian regions impact substantially the regional growth rates?

Existing empirical works on Russian regional data cover a short time period, mostly less than ten years. They reveal different results: divergence, conditional convergence, convergence clubs, it depends on key indicators and time periods. During last several years researchers find β-convergence, so one can use Barro regressions for estimation impact of spatial determinants on economic growth of Russian regions.

Also existing papers are based only on regions, which are highly heterogeneous in Russia, and do not concern more disaggregate data. In this paper I estimate if there is convergence on city-level data.

Objective of the project is to reveal the impact of geography on regional convergence and to measure the strength of spatial externalities across Russian regions.

Literature review

Baumol (1986) found that poorer countries like Japan and Italy substantially closed the per capita income gap with richer countries like the United States and Canada in the years from 1870 to 1979. Growth rates are positively correlated with the starting gap between the initial per capita income of a region and the steady-state per capita income level, which is the same for all regions. Regions on the steady growth trajectory are characterized by constant growth rates of per capita income. According to the model, poor regions should grow at higher pace than wealthy regions, so that the long-run perspective should tend to smooth regional differences in economic development.

Empirical works on different countries' data sets show different rates of convergence. As a possible explanation of the slow rate of convergence, Barro et at. (1992) suggest that the level of the technology can be different in different states or countries and try to model its dynamics.

Starting from Romer (1992), theoretical models of endogenous growth predict that long-term growth rates are positively related to the market size. Jones (1995) challenges these models for generating scale effects for which he could not find any evidence based on U.S. time series.

There are several works with spatial determinants of regional economic growth on Russian data. Spatial autocorrelations of Russian regions are shown by means of Moran's tests (Zverev, Kolomak, 2010, Lugovoy et al., 2007). Moran's tests are also used for revealing so-called spatial convergence clubs. Lugovoy et al. don't find any convergence clubs in the scatterplot for logarythm of GRP per capita in 1998 (using traveling time geographical weight matrix).

Kolomak (2010) tests a model where the spatial externalities generated by regional growths are considered as a source for development of neighboring territories. Such externalities do affect the other regions' growth rates. She finds that the character of such influence depends on location of the region.

Lugovoy et al. (2007) explore disparity in regional growth in Russia and investigate the role of geographic, economic, and institutional factors in economic growth over rather short time period 1996–2004. They find out significance of the sectoral specialization for Russia, particularly, the share of fuel industry in industrial output are significant in the equation of conditional regression.

Kholodilin et al. (2009) investigate convergence of Russian regions in income for 1998–2006. They identify spatial regimes using exploratory spatial data analysis. Also they examine the impact of spatial effects on the convergence process. Their results show that the overall speed of regional convergence in Russia, being low by international standards, becomes even lower after controlling for spatial effects. However, when accounting for the spatial regimes, they find a strong regional convergence among high-income regions located near other high-income regions. Their results indicate that estimation of speed of convergence using aggregate data may result in misleading conclusions regarding the nature of convergence process among Russia's regions.

Shepotilo (2008) applies a non-parametric heteroscedasticity and autocorrelation consistent estimator of error terms in the context of the spatial autoregressive model of GDP per capita convergence of European regions. He introduced the spatial dimension and investigated how the equilibrium distribution of GDP per capita of EU regions evolved both in time and space dimensions. Results demonstrate that the global spatial spillovers of growth rates make an important contribution to the process of convergence by reinforcing economic growth of neighboring regions.

Strong σ-divergence simultaneously with $beta$-convergence is found by Solanko (2003). The results indicate that per capita income in Russian regions may be converging towards two separate steady states. The poorest regions seem to be converging among themselves, while growth experiences among other regions have been highly heterogenous. The role of geography is tested by means of the variable "distance from the capital Moscow" in one of the conditional convergence regressions. This variable results as completely insignificant. The time period of used data is 1992–2001.

Carluer (2005) examines the evolution of Russian regional disparities in the light of the theory of convergence clubs. The key conclusion is the strong diversity of regional evolutions, which are characterized by both inertia (rich regions remain rich, poor regions remain poor) and mobility (some rich regions become poor and vice versa). The value of an analysis of downward mobility relative to upward mobility (34 regions to 11), as well as of economic geography through specific spatial dynamics, are demonstrated. The main results based on the per-capita regional income of the Russian data over period 1985–1999.

Buccellato (2007) analyses convergence across Russian regions using the toolkit of spatial econometrics in addition to the traditional β-convergence techniques as derived from the neoclassical theoretical settings. The analysis covers the years from 1999 to 2004, he investigates 77 regions, Kaliningrad and Chukotka regions are excluded. Variables such as hydrocarbon supply, openness to trade and FDI per capita are found to have an unambiguous, positive and statistically significant impact on growth.

Using a panel of 77 Russian regions from 1990–1998, R. Ahrend (2005) conducts the analysis of possible determinants affecting Russian regional economic growth. He finds that factors such as capital endowment, human capital and natural resources as well as urbanization can be positively correlated with growth.

Guriev and Vakylenko (2012) find there was no convergence in 1990s, but the situation changed dramatically in 2000s. While interregional GDP per capita gaps still persist, the differentials in incomes and wages decreased substantially. They investigate the phenomenon of recent convergence using panel data on the interregional reallocation of capital and labor and show that economic growth and financial development has substantially decreased the barriers to labor mobility.

Mostly, existing empirical works cover a short time period (less than ten years) and examine the very beginning of the market economy with transition period. Moreother, most authors reluctantly work with the historical data. Also they do not use city-level data.

Research hypothesis

As a starting point I formulate hypothesis.

Hypothesis 1. *Spatial externalities exist.*
If yes, are they rather positive or negative?

Russia has a huge territory with very heterogeneos regions. This seems to be a sufficient reason to conjecture that geography matters for region-level economic development. One of interesting questions related to the role of space in the Russian economy is whether regions which are doing relatively well are close to regions which are also doing well (in the sense of economic performance). To put it simplier, is being close to Moscow city a source of comparative advantage for the central European regions of Russia?

Hypothesis 2.
Urbanization and regional growth are positively associated.

In some recent studies new economic geography models are used together with endogenous growth models in order to explore interdependence between agglomeration and growth. These studies show that agglomeration and growth have reinforcing impact on each other, that leads to faster growth of agglomerations and metropolitan areas and fosters overall economic growth. The main feature of this impact is innovation diffusion and migration of qualified workers. All innovations (including technologies, models of business development, institutional changes etc.) are subject to diffusion in space. Spillovers allow regions to take advantage of more efficient technology (institution) and increase their factor productivity. Agglomeration influences growth, since they provide better market access to final or intermediate goods, a wider supply of high-quality infrastructures, better matching between employees, the more rapid diffusion of information and innovation (Duranton, Puga, 2004).

With regards to Combes et al. (2008), agglomerations economies play a central role in determining labor productivity.

Regional growth is related to spatial location of industries (Fujita M., Thisse J., 2002).

Papers on Russian data show comparative success of larger cities and of their bordering areas contrasted by degradation of rural areas not involved in agglomeration networks.

I am going to measure agglomeration effects in Russian regions and their impact on economic growth.

Methodology

Estimation

I use the regression as follows for testing the proposed hypotheses:

$$\frac{1}{T}(\ln y_{Ti} - \ln y_{0i}) = a + b \ln y_{0i} + c' X_{0i} + \varepsilon_i, \tag{1}$$

i – region, $i = 1, 2, ..., n$,
T – time (years),
y_{0i} – initial real GDP per capita,
y_{Ti} – real GRP in the year T,
X_i – a vector of control variables,
ε_i – errors, $\epsilon_i \sim iid$ with 0 mean and finite 2nd moment.

Control variables are chosen according to the hypotheses.

Formally, the panel version of the growth equation (1) can be expressed in the following way:

$$\ln y_{(t+1),i} - \ln y_{ti} = a + b \ln y_{ti} + c' X_{ti} + \varepsilon_{ti}, \tag{2}$$

where $t = 0, ..., T$.

Within the panel setting regional dummies are useless because I estimate the fixed effect model.

I consider a spatial version of the growth equation – a **spatial error model** (**SEM**):

$$\ln y_{(t+1),i} - \ln y_{ti} = a + b \ln y_{ti} + c' X_{ti} + u_{ti}, \tag{3}$$

$$u_{ti} = \lambda W u_{ti} + \varepsilon_{ti},$$

where W – a matrix of spatial weights,

λ – a spatial autoregressive parameter,

ε – a vector of homoskedastic and uncorrelated errors (Anselin, Hudak, 1992).

In what follows, I use several different strategies of constructing the matrix of spatial weights W.

Then I estimate the impact of each set of variables.

In order to check if results are robust, I use different key indicators of economic output and growth in (1):

- GDP per capita (as shown above);
- GDP per worker;
- GDP-by industry per capita;
- GDP-by industry per worker;
- GDP per capita re-estimated without natural resources (hydrocarbon supply);
- income per capita

and estimate corresponding regressions.

Testing hypothesis 1.

Methods for revealing regions with specific growth paths:

- to add dummies in regression models:
  - for regions with high or low growth rates (outliers – regions with specific growth paths);
  - location dummies:
    - border dummies (for regions bordering with foreign countries);
    - sea dummies (for regions with a navigable non-freezing sea port);
- to add "Soviet heritage" variables in regression models (using variables which can affect growth and which has not changed much after the Soviet period and which can be considered as an indicator for location advantage/disadvantage).
- to plot regional spatial interaction using matrix of weights; to measure spatial interaction of regions by means of spatial autocorrelation (Moran's I):

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

where N is the number of spatial units indexed i by and j, X is the variable of interest; $\bar{X}$ is the mean of X; and w_{ij} is an element of a matrix of spatial weights.

Testing hypothesis 2.

The best way to measure agglomeration effect is to consider metropolitan areas. But there is no available data on metropolitan areas in Russia.

To measure the role of urbanization and agglomerations in the regional growth I estimate the regression of GRP-by-industry growth rates:

$$\ln \frac{y_{(t+1),i}}{y_{ti}} = a + b \ln y_{ti} + c' X_{ti} + u_{ti}, \qquad u_{ti} = \lambda W u_{ti} + \varepsilon_{ti}, \tag{4}$$

$GDPind$ – GDP-by-industry per capita,

- $X_{ti} = (Aggl_{ti}, H_{ti}, Innov_{ti}, Edu_{ti}, MP_{ti})'$ – a vector of control variables;

I use additional explanatory variables in (4) to account for likely differences in accumulation and depreciations rates, technical change and so on:

- $Aggl$ – an indicator of agglomeration (it is calculated as: 1) population of the biggest city in region i (Lugovoy et al., 2007); 2) population of an average city of the region: $CitySize_i$ – a ratio of urban population to number of cities); 3) population of the biggest city of the region);
- H_{ti} – indicator of sectoral diversity (Herfindhal-Hirshman index);
- $Innov_{ti}$ – measure of own innovative activity; $Innov_{ti} = \frac{Pat_{ti}}{GDPind_{ti}}$, where Pat_{ti} is a number of patent applications in the industry;
- Edu_{ti} – share of skilled workers in the industry;
- $MP_{ti} = \sum_{j \neq i} \frac{GRPind_{tij}}{Dist_{ij}}$ – real market potential, $Dist_{ij}$ – distance between regional centers.

Also I test beta-convergence model on city-level data, in this case I consider personal income as a key indicator. Spatial interaction matrix is constructed as inverse distance matrix.

I estimate the equation

$$\ln y_{(t+1),i} - \ln y_{ti} = a + b \ln y_{ti} + c_1 \ln CitySize_{ti} + c_2 X' + \varepsilon_{ti}. \quad (5)$$

$CitySize$ stands for the population of the city, X'– control variables.

This variable $CitySize$ is likely to be endogenous. Therefore, in the estimation of the equation (5) I instrument the variable by means of historical data. Following Mikhailova (2011), who investigates long-term dynamics urban population and city growth, according to the population census in Russian Empire in 1897, in USSR (1926, 1937, 1939, 1959, 1970, 1979, 1989) and in Russian Federation (2002), I instrument population by means of these census data.

Law of motion for the log of population (Davis & Weinstein, 2002):

$$\ln CitySize_{ti} = \Omega_{ti} + \nu_{ti},$$

Ω_{ti} – target size (assume it is stable over time, $\Omega_{ti} = \Omega_{t+1,i} = \Omega$), ν_{ti} – a random shock:

$$\nu_{t+1,i} = \rho \nu_{ti} + \xi_{t+1,i}, 0 \leq \rho < 1, \ \xi_{t+1,i} \text{ are iid.}$$

Instrument population by means of data of population census in Russian Empire, in USSR and in Russian Federation.

Data sources

Indicators of the economic and social development of Russian regions are presented in the statistical yearbooks "Russian regions", "Social development and quality of life in Russia".

Russian regions are not homogenous, so one should carefully choose data. Some of the autonomous "okrugs" are at the same time parts of other regions, so the most of statistical data is not available. Also there is no available data for Chechen Republic. So, I consider 79 Russian regions (Chechen Republic is excluded; composite regions are considered as single regions), and 2 regions (Moscow city and Saint-Petersburg city) are cities with federal status and do not belong to Moscow oblast and Leningrad oblast respectively (Fig. 1).

Covered time period for the most data is 1996–2010.

Fig. 1. Regions of Russia (source:
http://www.world-geographics.com/maps/eurasia/map-of-russian-regions)

Web-sites:

- indicators of the economic and social development: statistical yearbooks "Russian regions", "Social development and quality of life in Russia":

http://www.gks.ru;

- distances between regional centers: K.Glushchenko's web-site:

http://econom.nsu.ru/staff/chair_et/gluschenko/index.htm;

- population census data: T.Mikhailova's web-site:

http://sites.google.com/a/nes.ru/tatiana-mikhailova/home;

- climate data:

http://www.meteorf.ru

- city-level data: http://multistat.ru

Preliminary results (testing hpothesis 1)

Preliminary results are based on estimating the basic equation of convergence on cross-section data. I reveal regions with specific growth paths in order to take decision how to organize data for panel version of SEM.

Key indicators of regional growth. The nominal figures of GDP per capita are deflated by the cost of a fixed basket of goods and services in regions to arrive at real incomes measured in 2010 roubles. Data for the cost of a fixed basket of goods and services in regions is available since 2002, so I use regional consumer price index for the earliest years.

Dynamics of regional per capita GDP from 1996 to 2010 is shown in the figure below.

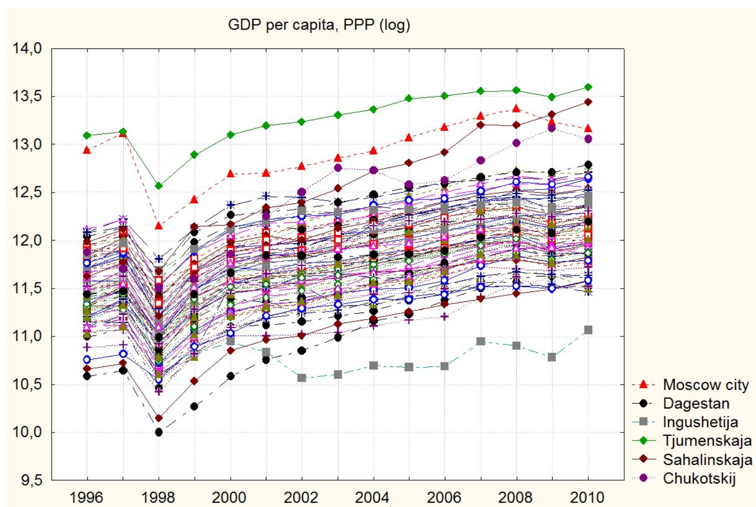

Fig. 2. Dynamics of per capita GDP (log), 1996–2010.

Regions with high per capita GDP are: Moscow city (the capital of Russia), Tyumen oblast (oil and gas region with a huge territory), Chukotka Autonomous Okrug, Sakhalin oblast. Moscow city and Tyumen oblast growth rates do not display drastic deviations from the average across all regions, while Chukotka Autonomous Okrug and Sakhalin oblast look like outliers. There are also outliers with low values of GDP: Ingushetia Republic and Dagestan Republic (regions close to Chechen Republic).

Also I use estimation based on cross-sections in order to find out regions with specific growth paths.

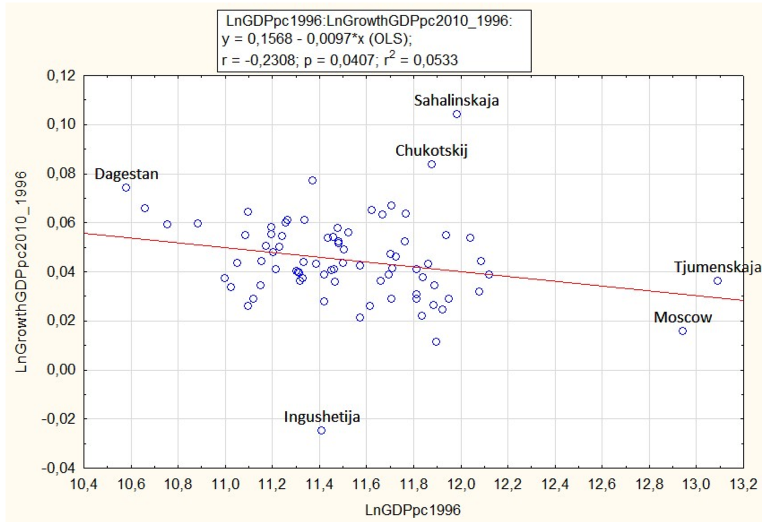

Fig. 3. Scatterplot for log of real per capita GDP in 1996 and log of average annual per capita GDP growth rate in 1996–2010.

One can get similar scatterplots with the same outliers for cross-section data with another initial year instead of 1996.

Dynamics of the second key indicator – average income per capita (deflated in the same way as GDP per capita) – is shown in the Fig. 4.

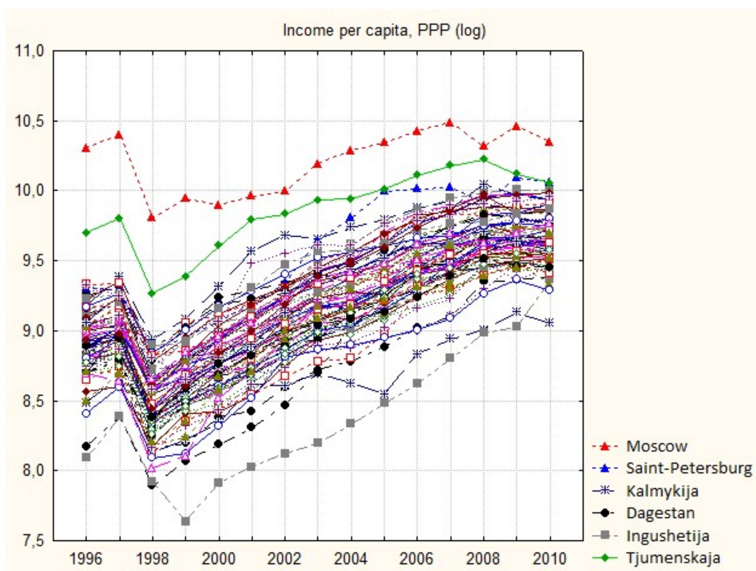

Fig. 4. Dynamics of per capita income (log), 1996–2010.

Comparision of outliers in Fig. 2 and Fig. 4 allows to figure out that Sakhalin and Chukotka cannot be considered as well-developped regions. Their high per capita GDP is explained by the fact that headquarters of some resource companies are located there, and the regions look rich due to high local tax revenues.

Scatterplot for per capita income and annual growth rates is given in Fig. 5, 1996–2010.

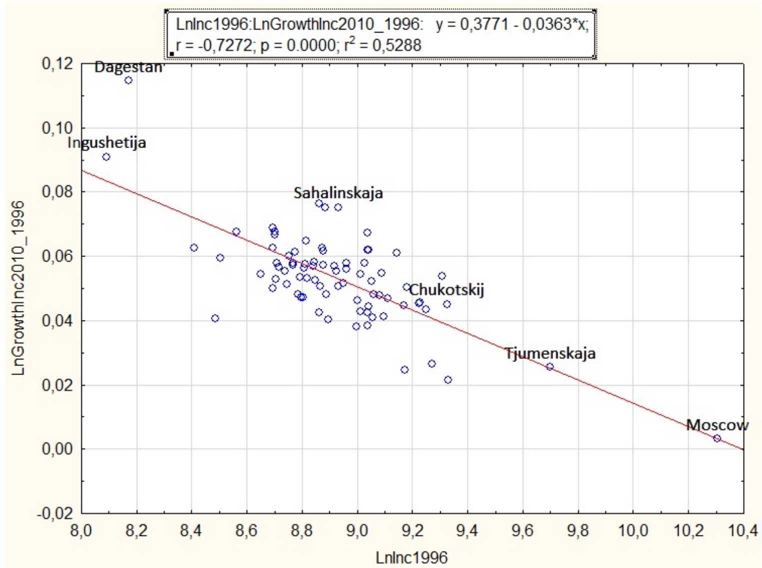

Fig. 5. Scatterplot for log of real per capita income in 1996 and log of average annual per capita income growth rate in 1996–2010.

The last scatterplot reveals strong beta-convergence by per capita income across Russian regions. As for sigma-convergence, it also seems to be present in the data, which becomes clear if we omit the outliers mentioned above (see Fig. 6–7 below).

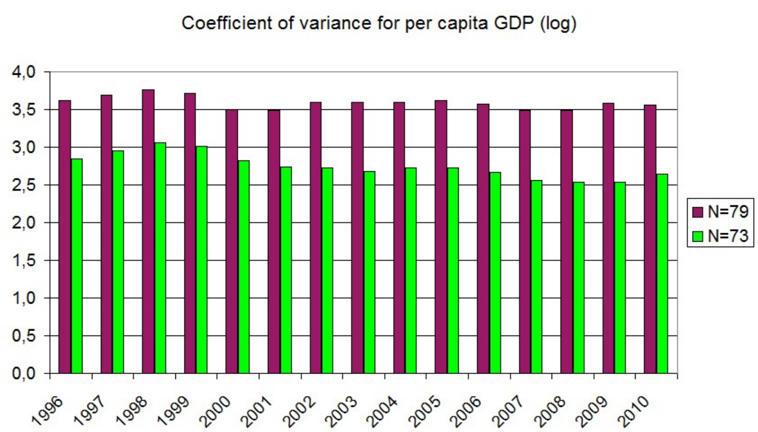

Fig. 6. Dynamics of coefficient of variance for log of per capita GDP, 1996–2010.

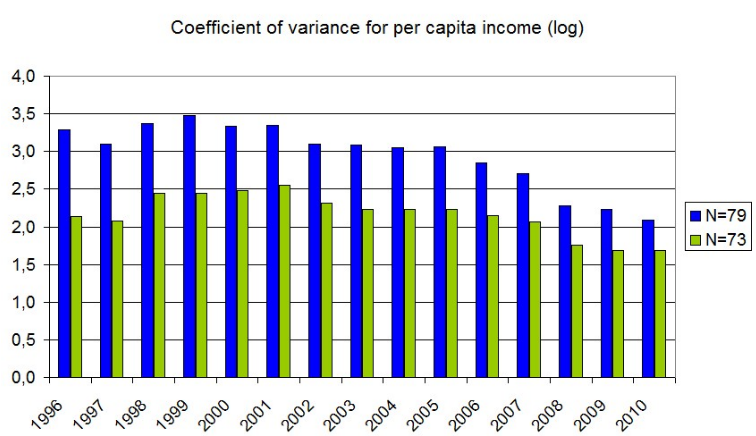

Fig. 7. Dynamics of coefficient of variance for log of per capita GDP, 1996–2010.

Spatial interaction between regional economies.

I calculate Moran's I for testing hypothesis about spatial autocorrelation of GDP per capita with different spatial matrices W:

1) matrix of neighbors, its elements $w_{ij} = 1$ if regions i and j have a common border, $i \neq j$, and $w_{ij} = 0$ otherwize;

2) Kaliningrad-modified neighbors matrix. Kaliningrad oblast is separated from other Russian regions by foreign countries, so it has no common borders with others. I modified mathrix of neighbors as if Kaliningrad region is contiguous to Pskov region;

3) Moscow-modified neighbors matrix. This matrix is constructed as if each region interacts directly with the capital – Moscow city:

$$w_{ij} = \begin{cases} 1, & \text{if either } i \text{ or } j \text{ is Moscow city,} \\ 1, & \text{if } i \text{ and } j \text{ have a common border,} \\ 0 & \text{otherwize} \end{cases}$$

Elements $w_{ij} = 1$ if regions i and j have a common border, $w_{ij} = 1$ if i or j – Moscow city, $i \neq j$, and $w_{ij} = 0$ otherwize;

4) inverse distance matrix, defined as follows:

$$w_{ij} = \frac{1}{d_{ij}^{\gamma}}, \; i \neq j$$

where d_{ij} is distance between regional centers i and j, γ is a paraemter, $\gamma \in \{1, 2, 3, 4\}$. We set $w_{ii} \equiv 0$ by definition.

Dynamics of Moran's I for per capita GDP (log) is shown in Fig. 8, dotted values are significant at 5%.

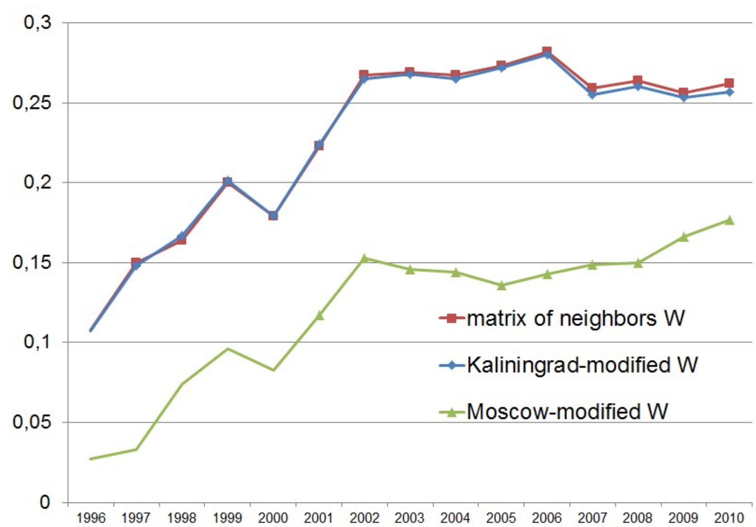

Fig. 8. Dynamics of Moran's I for log of per capita GDP.

One can see that the role of capital city in regional interaction in Russia during last several years has become stronger.

Income dispersion accross regions supports the same conjecture (Fig. 9).

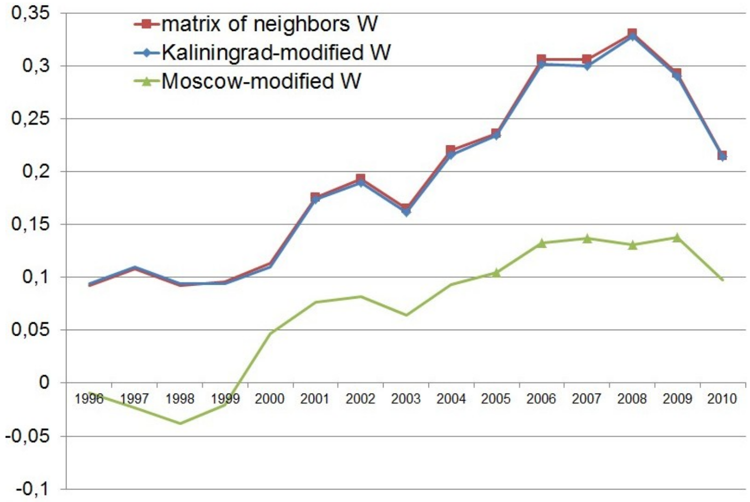

Fig. 9. Dynamics of Moran's I for log of per capita income.

I calculate Moran's I with 4 values of γ in inverse distance matrix, $\gamma = 1, 2, 3, 4$. The higher γ, the higher Moran's I (Fig. 10 and Fig. 11). The higher γ the more similar dynamics of Moran's I under inverse distance matrix to dynamics of Moran's I under contiguity matrix (Fig.10 and Fig. 8). Hence, there is a "cutoff"-distance in regional interaction.

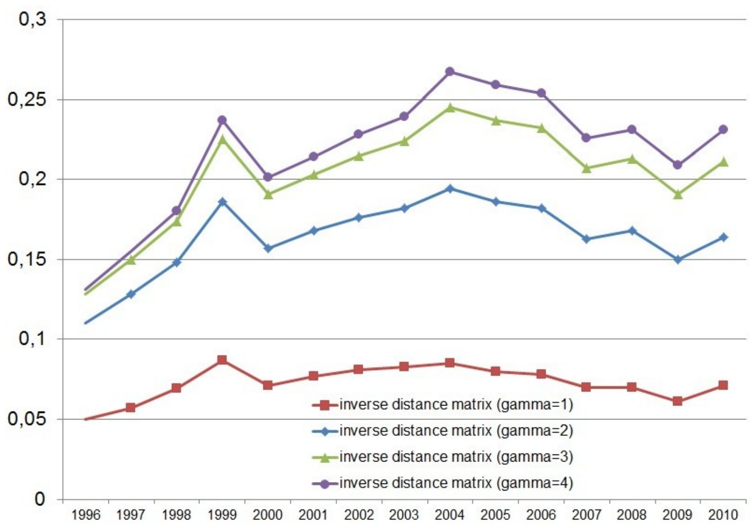

Fig. 10. Dynamics of Moran's I for log of per capita GDP.

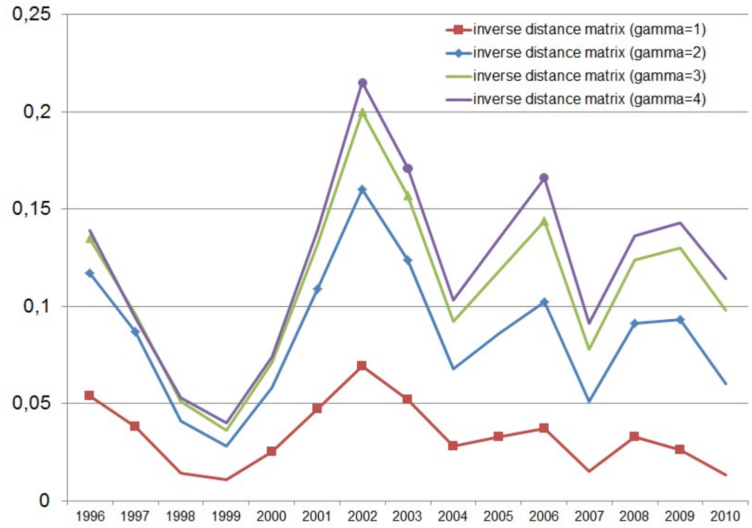

Fig. 11. Dynamics of Moran's I for log of per capita income.

SEM estimates.

Diagnostic tests reveal significant spatial dependence in errors and lags in OLS regression, so spatial issues in estimating Barro regressions is required.

In the first stage, I find that regional dummies are significant, from which I infer that these regions are really specific. I use dummy variables for the regions with specific growth paths and estimate SEM for two key indicators: per capita GDP and per capita income, spatial matrix – Kaliningrad-modified (Table 1 and Table 2).

Table 1. SEM estimates

Variables	(1)	(2)
	dep. var.: **p.c.GDP**	dep. var.: **p.c.GDP**
constant	0,193*** (0,055)	0,221*** (0,039)
$logY_{t_0}$	–0,013*** (0,004)	–0,014***(0,003)
dummySakhalin	–	0,063*** (0,012)
dummyChukotka	–	0,068*** (0,013)
dummyIngushetia	–	–0,067*** (0,011)
dummyDagestan	–	0,016 (0,012)
Variance ratio	0,092	0,496
Squared corr.	0,053	0,526
Sigma	0,02	0,01
Log likelihood	211,74	239,16
λ	0,266* (0,134)	0,291* (0,15)
Wald test of λ =0	3,960 (*p*=0,047)	3,642 (*p*=0,056)
Likelihood ratio test of λ =0	3,643 (*p*=0,056)	3,263 (*p*=0,071)
Lagrange multiplier test of λ =0	4,122 (*p*=0,042)	2,726 (*p*=0,099)
number of observations	79	79
speed of convergence, %	1,43	1,56
half-level of convergence, years	48,3	44,5

Notes. Standard errors are in paranthesis; if not indicated, *p* means *p*-level. *, **, *** mean signicant at 10 percent, 5 percent, and 1 percent.

Table 2. SEM estimates

Variables	(3)	(4)
	dep. var.: **p.c.income**	dep. var.: **p.c.income**
constant	0,389*** (0,036)	0,332***(0,038)
$logY_{t_0}$	–0,037*** (0,004)	–0,031***(0,004)
dummySakhalin	–	0,023***(0,009)
dummyChukotka	–	0,006(0,009)
dummyIngushetia	–	0,013(0,009)
dummyDagestan	–	0,038***(0,010)
Variance ratio	0,572	0,660
Squared corr.	0,529	0,647
Sigma	0,01	0,01
Log likelihood	252,16	263,16
λ	0,158 (0,157)	0,061 (0,173)
Wald test of λ =0	1,011 (p=0,315)	0,126 (p=0,723)
Likelihood ratio test of λ =0	0,984 (p=0,321)	0,124 (p=0,724)
Lagrange multiplier test of λ =0	0,900 (p=0,343)	0,097 (p=0,755)
number of observations	79	79
speed of convergence, %	5,21	4,07
half-level of convergence, years	13,3	17,0

Notes. Standard errors are in paranthesis; if not indicated, p means p-level. *, **, *** mean signicant at 10 percent, 5 percent, and 1 percent.

Both key indicators show absolute beta-convergence across Russian regions. Adding regional dummies makes convergence stronger.

Tyumen region and Moscow city dummies are not included into SEM, because they occur insignificant (the richest regions display lower growth rates, it maintains beta-convergence idea).

Does location matter?

Moscow-modified matrix of spatial weights describes spatial interaction of Russian regions and it takes into consideration specificity of transport systems of Russia (Fig. 11). The railway system looks like a hub-and-spoke network with Moscow city as a hub.

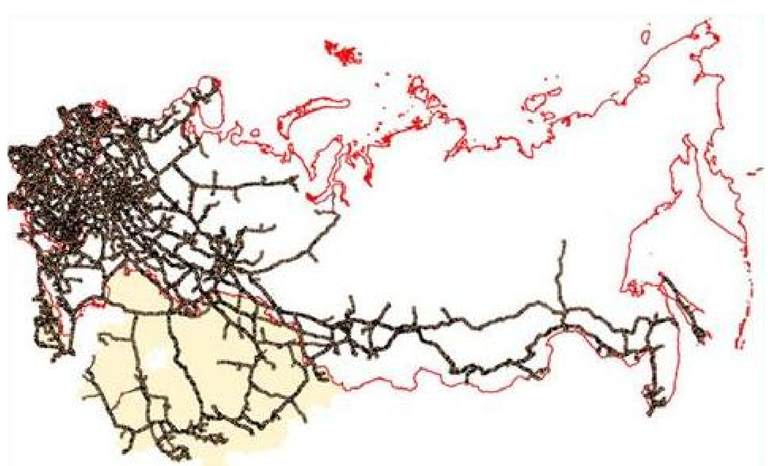

Fig. 11. Railway system of Russia (source: http://www.esti-map.ru).

So I estimate SEM (3) with regional dummies and with an indicator of accessibility to the railway system of Russia (density of railways). The structure of Russian railways has not changed very much since the Soviet period (time-based variance is non-significant), so the variable "railway density" cannot be used in panel version of SEM because of insignificance of its annual deviation. I use the density of regional railway system in 1995 as unchanged variable, which may be considered as a geographic factor for regional growth.

Results are in the Table 3 (data: cross-section, years: 1999–2010, method: maximum likelihood).

Table 3

variables	**dep. var.: real p.c. GDP**
constant	0,202*** (0,041)
lnY_{t_0}	-0,012*** (0,004)
$dummySakhalin$	0,057*** (0,012)
$dummyChukotka$	0,076*** (0,013)
$dummyDagestan$	0,046*** (0,013)
$dummyIngushetia$	–0,054*** (0,012)
$log(RailWayDensity_{1995})$	0,003** (0,001)
Variance ratio	0,541
Squared corr.	0,525
Sigma	0,01
Log likelihood	233,61
λ	0,395** (0,177)
Wald test of λ =0	5,002 (p=0,025)
Likelihood ratio test of λ =0	4,281(p=0,039)
Lagrange multiplier test of λ =0	3,597 (p=0,058)
number of observations	79
speed of convergence, %	1,34
half-level of convergence, years	51,6

Notes. Standard errors are in paranthesis; if not indicated, p means p-level. *, **, *** mean signicant at 10 percent, 5 percent, and 1 percent.

Variable "railway density" is positive and significant. The same result can be obtained if we take another initial year. Thus accessibility of railway is a crucial factor of location quality.[1]

Concluding remarks

Spatial externalities seem to be present in the data. Russian regions interactions highly depend on accessibility of transport system.

[1] I also tested location factors such as accessibility to sea ports and to foreign markets. Coefficients by the sea dummy and the dummy of a common border with foreign country are also positive and significant.

Interaction almost disappears while distance between regions becomes large.

Regions with an advantageous geographic position (e.g. bordering foreign countries, having sea-ports) grow faster.

There are regions with specific growth paths: Moscow city, Tyumen oblast, Sakhalin oblast, Chukotka AO, Dagestan Republic, Ingushetia Republic.

Further work

At the first stage, I estimate SEM corresponding to the 2nd hypothesis on cross-section data without instrumenting variables. Preliminary results show that there is beta-convergence of Russian cities.

I plan to test formulated hypotheses by means of estimation of SEM on panel data.

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