Economic growth of Russian regions: an econometric study of spatial interaction

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Motivation

Purpose of the study:

- to **reveal the crucial spatial factors** affecting growth of Russian regions;
- to measure **interregional spatial correlation** of growth indicators;
- to estimate impact of spatial externalities on regional growth and distribution of economic activities across Russian regions.

Russia

СЕВЕРНЫЙ ЛЕДОВИТЫЙ ОКЕАН
Норвежское море
Баренцево море
Карское море
Море Лаптевых
Восточно-сибирское море
Берингово море
Охотское море
Японское море
Балтийское море
Каспийское море
НОРВЕГИЯ
ШВЕЦИЯ
ФИНЛЯНДИЯ
ЭСТОНИЯ
ЛАТВИЯ
ЛИТВА
БЕЛОРУССИЯ
КАЗАХСТАН
МОНГОЛИЯ
КИТАЙ
ЯПОНИЯ
ГРУЗИЯ
АРМЕНИЯ
АЗЕРБАЙДЖАН
Республика Саха
(Якутия)
Москва
Красноярский
край
Амурская обл.
Хабаровский край
Томская обл.
Иркутская обл.
Бурятия
Читинская обл.
Камчатская обл.
Магаданская обл.
Чукотский а.о.
Корякский а.о.
Таймырский
(Долгано-Ненецкий) АО
Эвенкийский АО
Ямало-Ненецкий АО
Ханты-Мансийский АО
Архангельская обл.
Республика Коми
Ненецкий АО
Новосибирская обл.
Алтайский край
Омская обл.
Тюменская обл.
Свердловская обл.
Приморский край
Сахалинская обл.
Якутск
Тура
Дудинка
Магадан
Палана
Анадырь
Петропавловск-Камчатский
Хабаровск
Владивосток
Южно-Сахалинск
Благовещенск
Биробиджан
Чита
Улан-Удэ
Иркутск
Красноярск
Томск
Новосибирск
Омск
Барнаул
Кемерово
Абакан
Кызыл
Горно-Алтайск
Тюмень
Екатеринбург
Челябинск
Курган
Уфа
Оренбург
Пермь
Самара
Саратов
Волгоград
Астрахань
Ростов-на-Дону
Краснодар
Ставрополь
Элиста
Махачкала
Мурманск
Архангельск
Салехард
Нарьян-Мар
Сыктывкар
Киров
Казань
Ижевск
Санкт-Петербург
Петрозаводск
Псков
Новгород
Калининград
Вологда
Ярославль
Тверь
Смоленск
Брянск
Калуга
Тула
Орел
Курск
Белгород
Воронеж
Тамбов
Липецк
Рязань
Владимир
Иваново
Кострома
Нижний Новгород
Чебоксары
Йошкар-Ола
Саранск
Пенза
Ульяновск

Desirable data

Why to use panel data?

- one can include year dummies (crisis years);
- stationarity of distribution of income across Russian regions is questionable.

Problem with regional level data:

- some regions have huge territory, but are almost empty;
- Moscow and Saint-Petersburg are cities with federal status $\Rightarrow$ urban-level data would be preferable.

Empirical papers on Russian data

Buccellato T. (2007):

- conditional convergence, data: 1999-2004

Carluer F. (2010):

- convergence clubs, data: 1985–1999

Solanko L. (2003):

- conditional convergence, data: 1992–2001

Kolomak E., Zverev D. (2010):

- conditional convergence, data: 1995–2006

Lugovoy O. et al. (2007):

- conditional convergence, data: 1998–2004

Research questions

Question 1.
Are spatial externalities at work? If yes, are they rather positive or negative?

Question 2.
Is it true that urbanization is associated with the regional growth? Do Russian agglomerations matter?

Question 3.
Do cross-sectional and dynamic market size variations impact on economic performance of the Russian regions?

Data description

79 Russian regions (Chechen Republic is excluded; composite regions – Tyumen and Arkhangelsk oblasts – are considered as single regions).
Years: 1996–2010.
Sources:

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

Methodology

Barro regression

$$\frac{1}{T}\ln\frac{y_{Ti}}{y_{0i}} = \alpha + \beta \ln y_{0i} + c' X_i + \varepsilon_i,$$

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

Spatial versions of convergence equation

Conditional convergence equation. Spatial error model (SEM), (Anselin, Hudak, 1992)

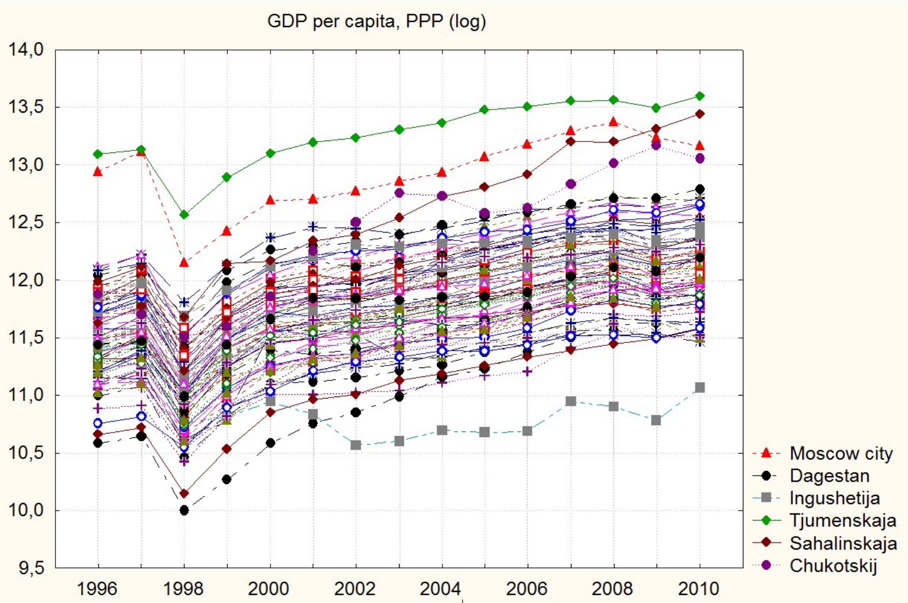
$$\frac{1}{T}\ln\frac{y_{(t+1),i}}{y_{ti}} = \alpha + \beta \ln y_{ti} + c'X_{ti} + u_{ti},$$

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

where

- W – a matrix of spatial weights,
- λ – a spatial autoregressive parameter,
- ε_{ti} – a vector of homoskedastic and uncorrelated errors.

Real GDP per capita corrected by the PPP, 2010 prices (log)



Russia

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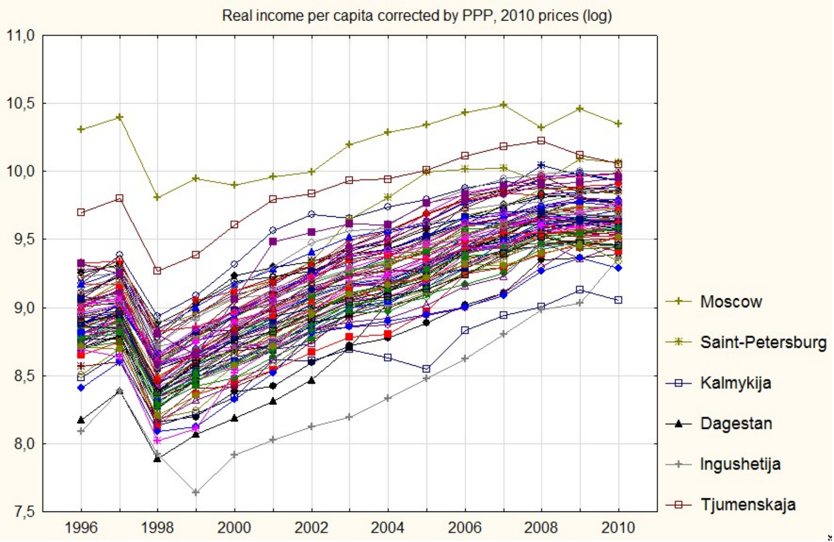
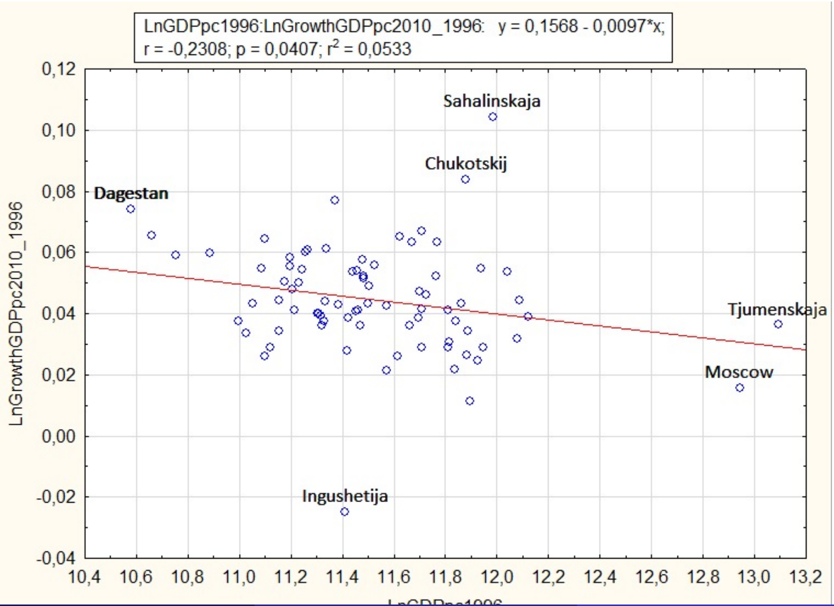
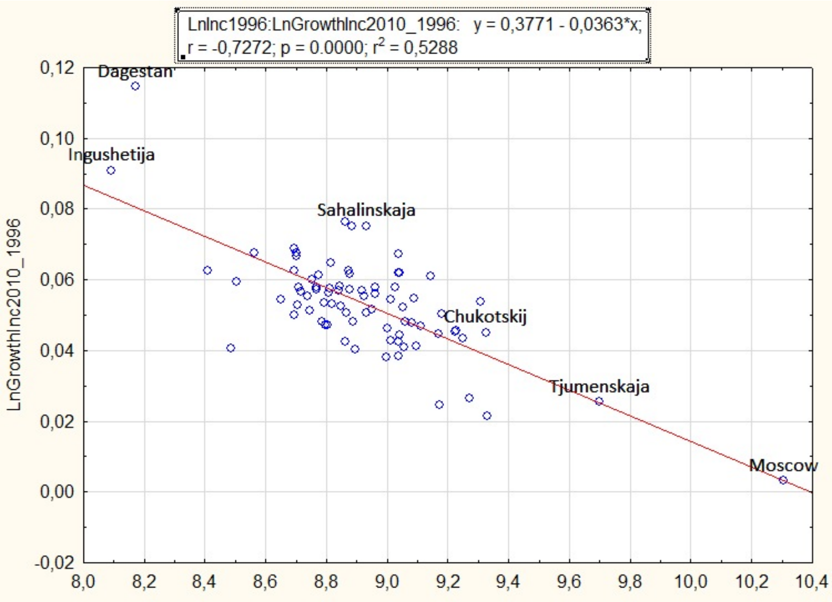
Income per capita corrected by the PPP, 2010 prices (log)



GDP per capita



Income per capita



Estimating spatial externalities

Methods:

- to add regional dummies in regression models:
  - for regions with high or low growth rates;
  - border dummy (for regions bordering with foreign countries);
  - sea dummy (for regions with a navigable non-freezing sea port);
- to plot regional spatial interaction using matrix of weights; to measure spatial interaction of regions by means of spatial autocorrelation (Moran's I).

Spatial autocorrelation

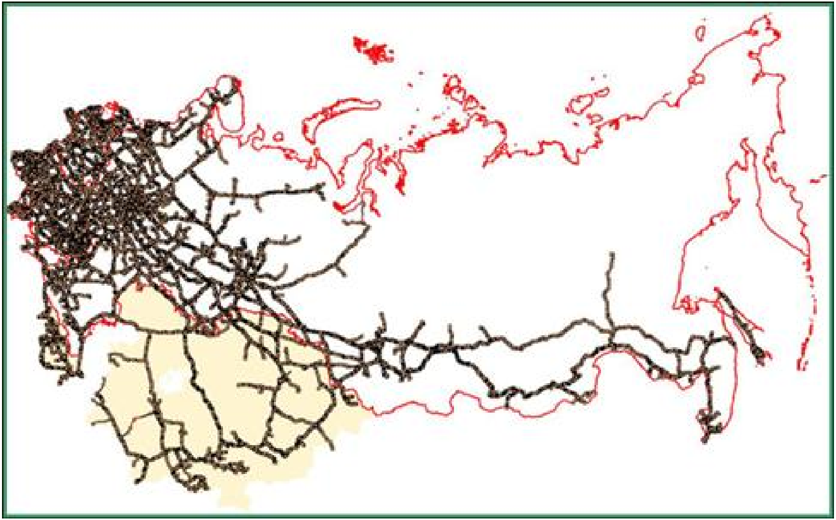
Moran's I:

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_i (y_i - \bar{y})^2}$$

Different types of spatial matrices w_{ij}:

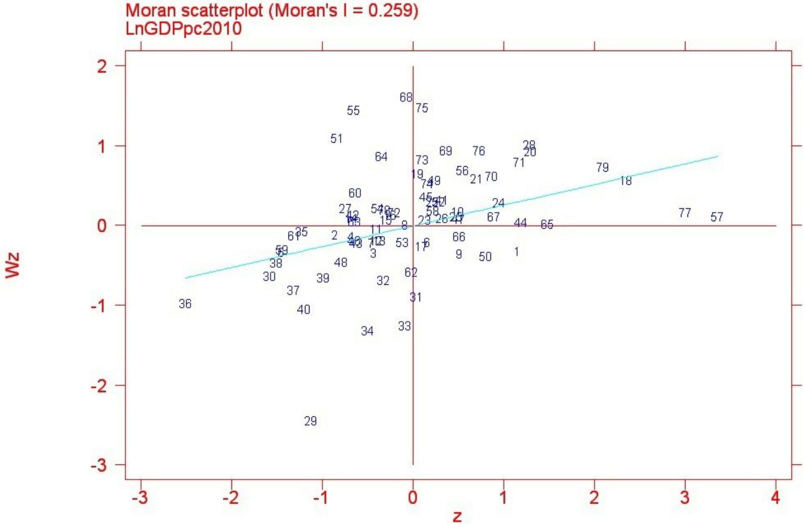
- matrix of neighbors ($w_{ij} = 1$, if regions i and j have a common border, $w_{ij} = 0$, otherwise)
- Kaliningrad-modified matrix of neighbors
- Moscow-modified matrix of neighbors
- inverse distance matrix ($w_{ij} = \frac{1}{dist_{ij}^{\gamma}}$), $dist_{ij}$ – railway distance between regional centers i and j (1000 km)

Russian railway system



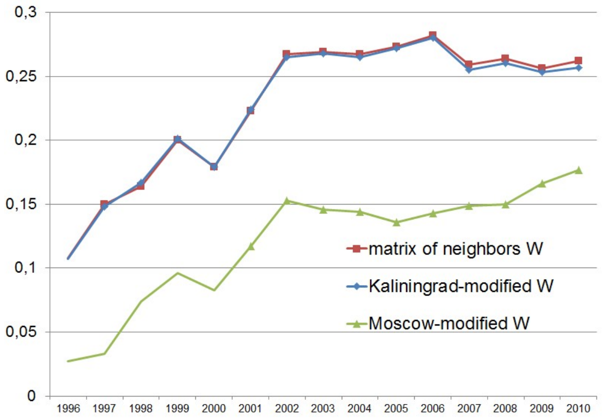
Moran's scatterplot

Variable: **GDP per capita 2010 (log).**
W – matrix of neighbors. N=79.



Moran's I. Role of neighbors

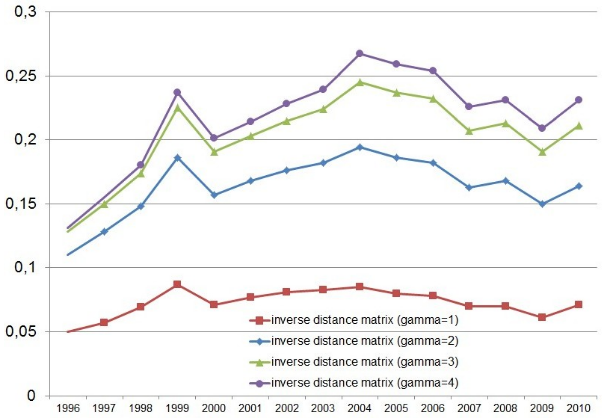
Moran's I for: **GDP per capita PPP (log).** Years: 1996–2010. N=79.



Marked (dotted) values are significant at 5% level.

Moran's I. Role of distance

Moran's I for: **GDP per capita PPP (log).** Years: 1996–2010. N=79.



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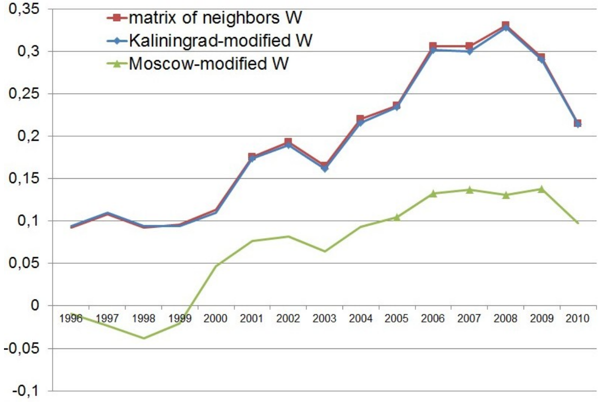

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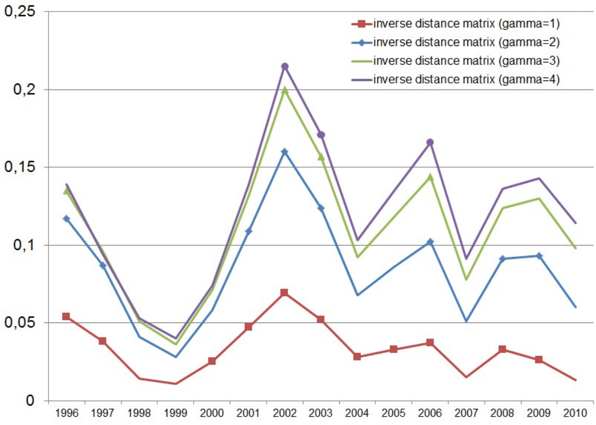

Marked (dotted) values are significant at 5% level.

The role of transportation system. SEM

Variables	Dependent variable: $\frac{1}{14}\ln\frac{GRPpc_{2010}}{GRPpc_{1996}}$		
	(1)	(2)	(3)
$constant$	0,205*** (0,055)	0,209*** (0,037)	0,212*** (0,036)
$\ln GRPpc_{1996}$	-0,014* (0,004)	-0,014*** (0,003)	-0,015*** (0,003)
$dummySakhalin$	–	0,064*** (0,011)	0,064*** (0,011)
$dummyChukotka$	–	0,039*** (0,011)	0,046*** (0,012)
$dummyDagestan$	–	0,016 (0,012)	0,016 (0,011)
$dummyIngushetia$	–	-0,068*** (0,011)	-0,067*** (0,000)
$\ln RailWayDensity$	–	–	0,0007* (0,0004)
Variance ratio	0,108	0,509	0,519
Speed of convergence, %	1,53	1,58	1,65
Half-level convergence, years	45,2	43,8	42,1

The role of transportation system. SEM

	(1)	(2)	(3)
Variance ratio	0,108	0,509	0,519
Squared corr.	0,053	0,526	0,526
Sigma	0,02	0,01	0,01
Log likelihood	211,54	239,73	241,15
λ	0,370* (0,193)	0,426** (0,188)	0,497** (0,176)
Wald test of λ =0: $\chi^2(1)$	3,675 (p=0,055)	5,171 (p=0,023)	8,010 (p=0,005)
Likelihood ratio test of λ =0: $\chi^2(1)$	3,236 (p=0,072)	4,405 (p=0,036)	6,197 (p=0,013)
Lagrange multiplier test of λ =0: $\chi^2(1)$	2,438 (p=0,118)	3,285 (0,070)	4,416 (p=0,036)

Panel data

Dependent variable: $\ln \frac{GDPpc_{t+1}}{GDPpc_t}$	**(1)**	**(2)**
constant	-0.940*** (0.083)	0.663*** (0.006)
$\ln GDPpc_t$	0.083*** (0.111)	-0.048*** (0.007)
Dummy for crisis years (1998, 2008)	no	yes
R^2 within	0.1169	0.7236
R^2 between	0.0165	0.0165
R^2 overall	0.0477	0.7057
Speed of convergence. %		5.64
Half-level convergence. years		12.3

Estimating the impact of agglomerations

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

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

- y_{ti} – GRP-by-industry per capita,
- $X_{ti} = (Aggl_{ti}, H_{ti}, Innov_{ti}, Edu_{ti}, MP_{ti})'$ – a vector of control variables;
  - $Aggl_{ti}$ – agglomeration indicator of the i-th region at time t ;
  - H_{ti} – indicator of sectoral diversity (Herfindhal-Hirshman index);
  - $Innov_{ti}$ – measure of own innovative activity;
  - Edu_{ti} – share of skilled workers;
  - $MP_{ti} = \sum_{j \neq i} \frac{GDPind_{t_{ij}}}{Dist_{ij}}$ – real market potential, $Dist_{ij}$ – distance between regional centers.

Estimating the impact of population

$$\frac{1}{T}\ln\frac{y_{(t+1),i}}{y_{ti}} = a + b\ln y_{ti} + c_1 \ln MarketSize_{ti} + c_2 \ln Migration_{ti} + u_{ti},$$

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

$$MarketSize_{ti} = \Omega_i + v_{ti},$$

$$v_{t+1,i} = \rho v_{ti} + \xi_{t+1,i},\ 0 \leq \rho < 1,$$

- $MarketSize$ – population, Ω_i – a stable target size, v_{ti} – a possibly persistent random shock, ξ_i – iid random shocks,
- $Migration_{ti}$ – in-migration.

Determinants for Russian in-migration (Yu.Andrienko, S. Guriev, 2003):

- initial personal income in the region i ;
- big cities;
- resource potential;
- climate;
- public goods,

The role of population growth. SEM

Spatial error model (inverse distance matrix) Variables	Dependent variable: $\frac{1}{14}\ln\frac{Income_{2010}}{Income_{1996}}$				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
constant	0.463*** (0.024)	0.458*** (0.024)	0.393*** (0.031)	.460*** (0.023)	0.401*** (0.031)
$\ln Income_{1996}$	-0.036*** (0.004)	-0.035*** (0.004)	-0.024*** (0.004)	-0.035*** (0.003)	-0.026*** (0.005)
LnPopulationGrowth	–	.281** (0.136)	.518*** (0.177)	–	–
LnLaborGrowth	–	–	–	0.406*** (0.132)	0.374*** (0.133)
dummyMoskva	–	–	-0.027** (0.011)	–	-0.019* (0.011)
dummyTumen	–	–	-0.017* (0.009)	–	-0.011 (0.009)
dummyChukotka	–	–	0.016* (0.009)	–	0.009 (0.008)
dummySakhalin	–	–	0.027*** (0.008)	–	0.022*** (0.008)
dummyDagestan	–	–	0.029*** (0.009)	–	0.032*** (0.009)
dummyIngushetia	–	–	-0.0006 (0.009)	–	0.008 (0.008)
Variance ratio	0.511	0.509	0.716	0.611	0.718
Speed of convergence. %	5.01	4.81	2.92	4.81	3.23
Half-level convergence. years	13.8	14.4	23.7	14.4	21.4

The role of population growth. SEM

	(1)	(2)	(3)	(4)	(5)
Variance ratio	0.511	0.561	0.716	0.611	0.718
Squared corr.	0.529	0.552	0.673	0.581	0.682
Sigma	0.01	0.01	0.01	0.01	0.01
Log likelihood	252.98	255.054	268.77	257.41	268.47
λ	0.268* (0.159)	0.28* (0.16)	.35** (0.15)	.245 (0.164)	.255 (0.16)
Wald test of $\lambda=0$: $\chi^2(1)$	2.821 (p=0.093)	3.028 (p=0.082)	5.282 (p=0.022)	2.237 (p=0.135)	2.498 (p=0.114)
Likelihood ratio test of $\lambda=0$: $\chi^2(1)$	2.626 (p=0.105)	2.795 (p=0.095)	4.486 (p=0.034)	2.076 (p=0.150)	2.293 (p=0.130)
Lagrange multiplier test of $\lambda=0$: $\chi^2(1)$	2.438 (p=0.118)	2.338 (0.126)	3.463 (p=0.063)	1.682 (p=0.195)	1.877 (p=0.171)

Endogeneity of Market Size

As market size is clearly endogenous it should be instrumented.
Instruments:

- data of population census in Russian Empire in 1897,
- data of population census in USSR (1926, 1937, 1939, 1959, 1970, 1979, 1989),
- data of population census in Russian Federation (2002, 2010).

Conclusions

Spatial externalities exist.

Russian regions interactions highly depend on accessibilitiy of railways system. 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 plans

- Russian regions are highly heterogeneous, so it's reasonable to get access to more disaggregate data in order to redo the estimates, which may allow to catch the desirable effects in a more subtle way.

Thank you for your attention!