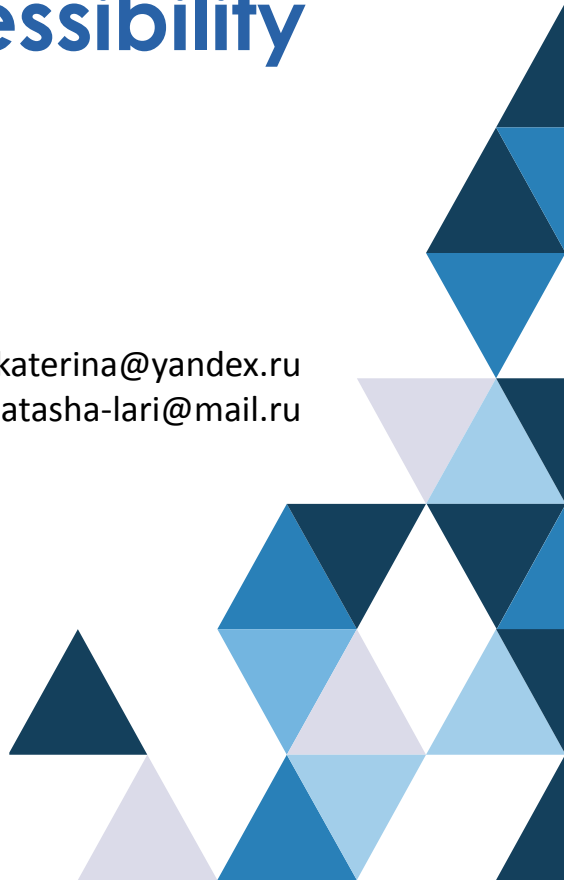




# Spatial analysis of the higher education accessibility

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# MOTIVATION

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- Cesi & Paolini (2011) developed a theoretical model predicting that geographical distance is a strong deterrent to university participation and choice;
- Agasisti & Dal Bianco (2007) suggest that when a student moves, chooses a university located in an area with good socio-economic conditions;
- Alm and Winters(2009) confirm the key role of distance in the choice of where to study;
- Gabdrakhmanov (2019) talks about a decline in university enrollment in Russia
- Sa Florax & Rietveld (2004), Spiess & Wrohlich (2010), Denzler and Wolter (2011), Gibbons & Vignoles (2012), Verboven & Kelchtermans (2010) stress that geographical proximity has a key role in the enrollment probability along with the students ability and school background;

# MOTIVATION

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- Increase in fees or distance (that means a more territorially concentrated higher educational system) will reduce the enrollment rate (Pigini & Staffolani - 2013);
- Public expenditure per tertiary student bears a negative association with tertiary enrollment ratios, whereas GDP per capita and public spending on education as a percentage of GDP both have a positive effect on tertiary enrollment (Yang & McCall - 2014);
- Gromov et al. (2016) distinguish three groups of factors determining the availability of education: distance, financial component and the number of places of admission ;
- Assessment of the spatial differentiation of Russian regions by the accessibility of higher education remains unexplored.

# Research question and hypothesis

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## RESEARCH QUESTION:

- ✓ Is there a spatial dependence on the studied indicator – the number of students accepted per 10 thousand of population?
  - ✓ Is there a  $\beta$ -convergence (convergence) of the growth rate of the studied indicator?

## HYPOTHESIS:

The number of places of admission to the university is a key determinant for higher education accessibility

# OBJECTIVES:

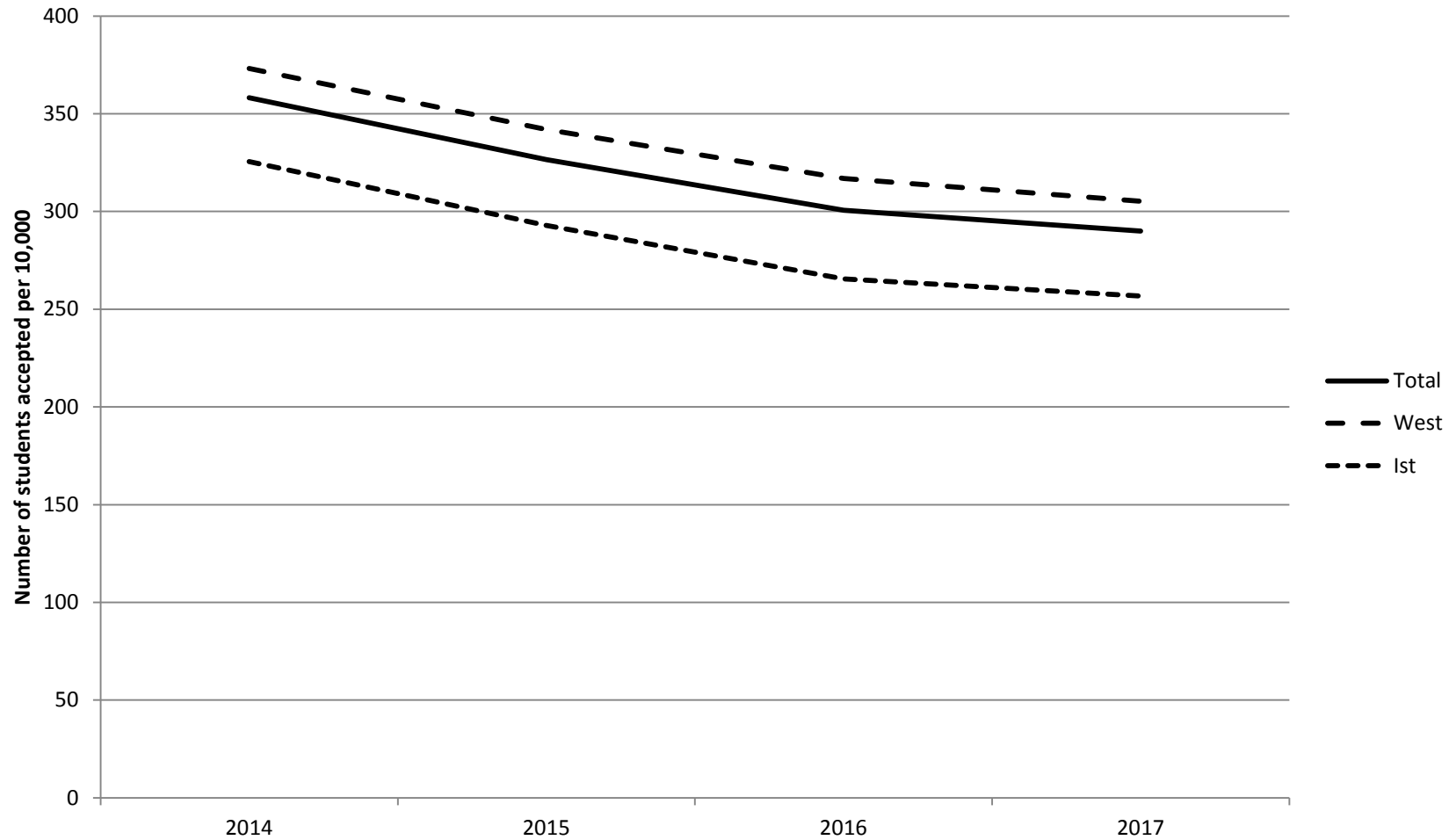
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- Estimation of Russian regions spatial correlation by the level of higher education accessibility;
- Assessment of the  $\beta$ -convergence of the average growth rate of the number of accepted students per 10 thousand population
- Identification of short-term and long-term spatial effects and determinants of higher education accessibility in the regions

## The period of research and data:

- 2014-2017.
- 78 regions of the Russian Federation.
- Federal State Statistics Service.
- Monitoring the information society development in the Russian Federation.
- Regions of Russia. Socio-economic indicators.

# Dynamics of the average number of accepted students in the regions



# VARIABLES

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Variables	Mean	St. D.	Min	Median	Max
The number of accepted students per 10 thousand of population	254,407	96,600	44,106	248,252	571,863
The average rate of decline in the number of students accepted per 10 thousand of population by 2014	0,775	0,098	0,439	0,786	0,945
Availability ratio as the ratio of the number of admission places in universities to the number of school graduates	159,015	70,843	37,500	145,206	400,905
The coefficient of financial affordability as a ratio of tuition to per capita income in the region	1,159	0,463	0,125	1,232	2,612
The indicator of territorial accessibility as the minimum distance from the regional center of the region to the nearest settlement with a university, km	105,321	92,231	8,000	69,500	474,000

# METHODOLOGY: Moran and Gini indices

$$I(X) = \frac{N}{\sum_{i,j} w_{ij}} \cdot \frac{\sum_{i,j} w_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

$$C = \frac{(n-1) \sum_{i=1}^n \sum_{j=1}^n w_{ij} (X_i - X_j)^2}{2W \sum_{i=1}^n (X_i - \bar{X})^2}$$

$$I_{Li} = N \cdot \frac{(X_i - \bar{X}) \sum_i w_{ij} (X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

N - the number of regions

$\bar{X}$  - average value of an indicator

X - average rate of growth (decrease) in the number of students accepted per 10 thousands of population relative to 2014

$w_{ij}$  - elements of the boundary matrix of weights

W indicates the amount for all  $w_{ij}$



# METHODOLOGY

## Conditional $\beta$ -convergence models

**OLS**

$$\ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + \beta \ln(y_{i,t}) + \gamma X_{i,t} + \varepsilon_{it}$$

**SDM**

$$\ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + \beta \ln(y_{i,t}) + \gamma X_{i,t} + \rho W \ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) + W \ln(y_{i,t}) \theta_1 + W X_{i,t} \theta_2 + \varepsilon_{it}$$

**SAR**

$$\ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + \beta \ln(y_{i,t}) + \gamma X_{i,t} + \rho W \ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) + \varepsilon_{it}$$

**SDEM**

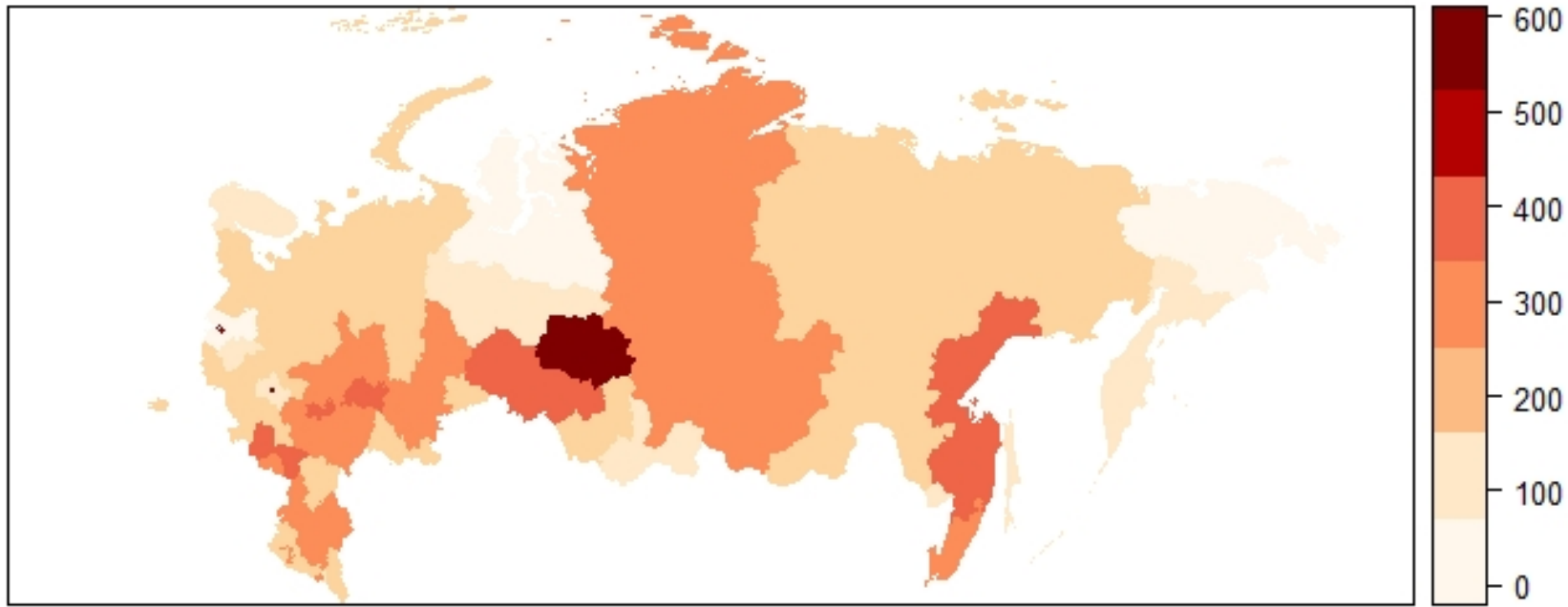
$$\ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + \beta \ln(y_{i,t}) + \gamma X_{i,t} + W \ln(y_{i,t}) \theta_1 + W X_{i,t} \theta_2 + \lambda W u_{i,t} + \varepsilon_{it}$$

**SEM**

$$\ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + \beta \ln(y_{i,t}) + \gamma X_{i,t} + \lambda W u_{i,t} + \varepsilon_{it}$$

**SAC**

$$\ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + \beta \ln(y_{i,t}) + \gamma X_{i,t} + \rho W \ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) + \lambda W u_{i,t} + \varepsilon_{it}$$



Cartogram of the number of students accepted per 10 thousands of population in the regions of Russia in 2017

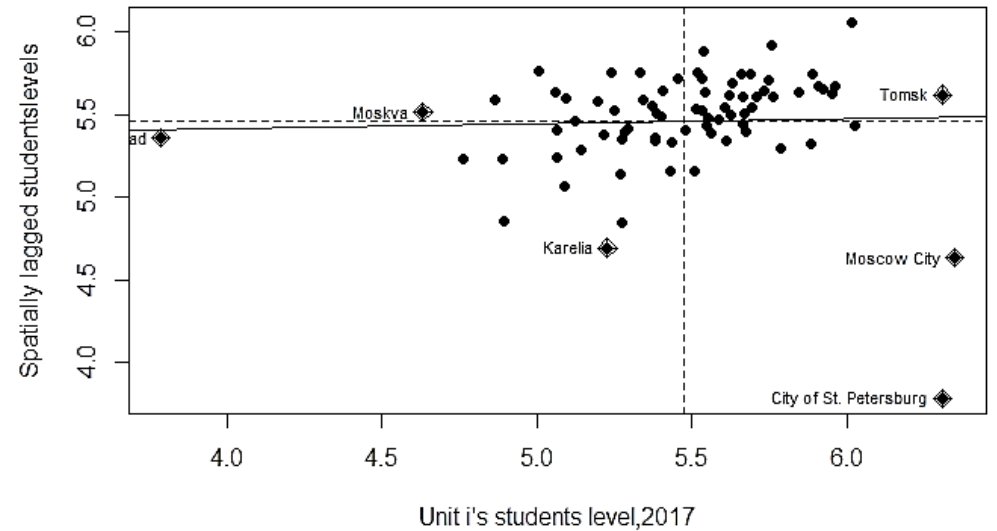
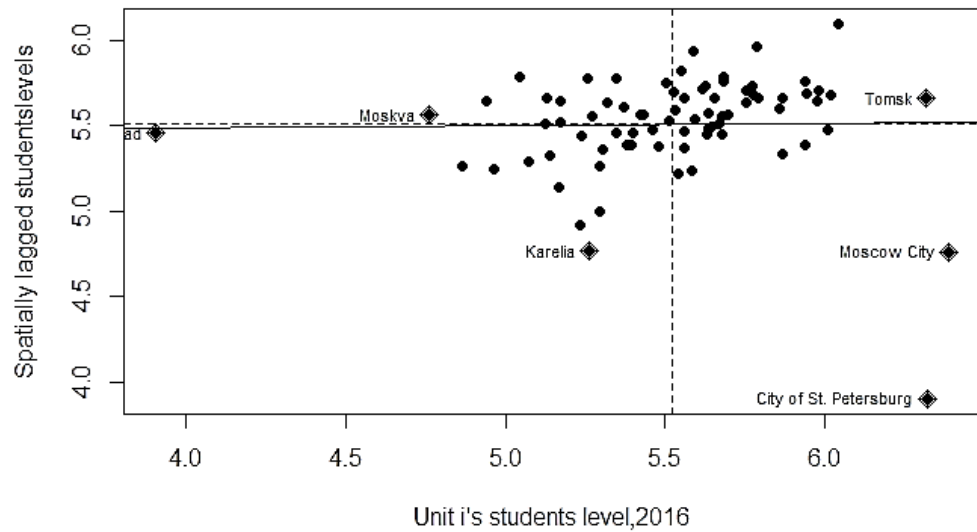
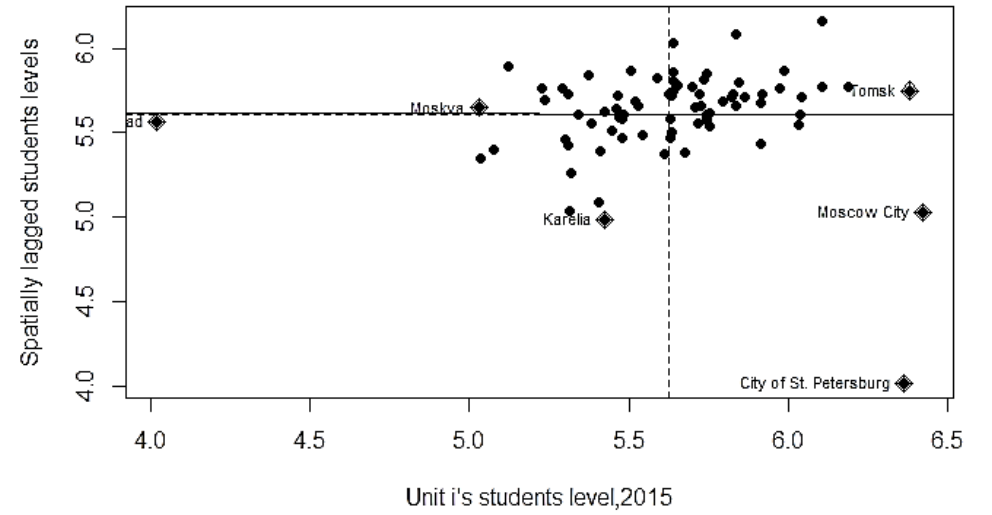
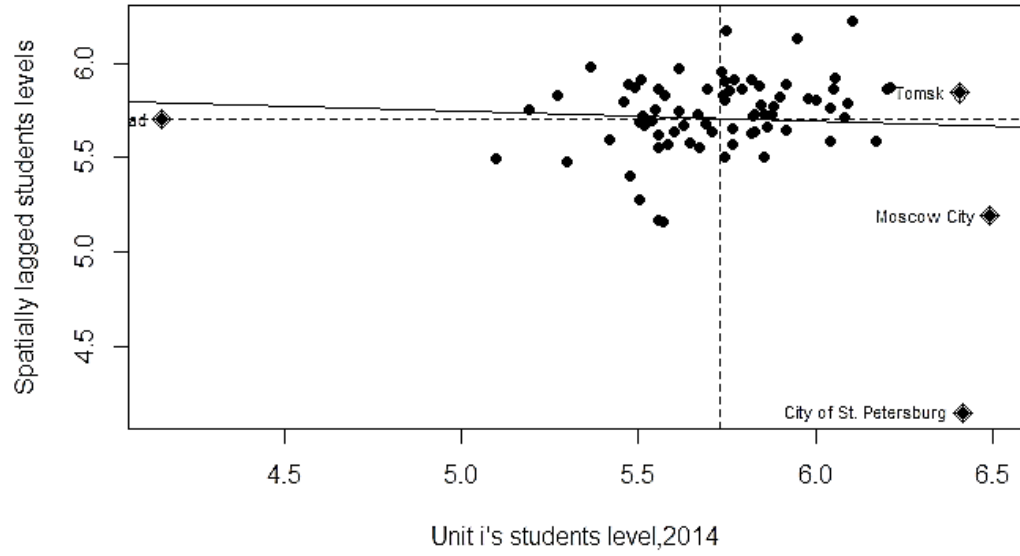


Cartogram of the local Moran index of the number of students accepted per 10 thousands of population in the regions of Russia in 2017

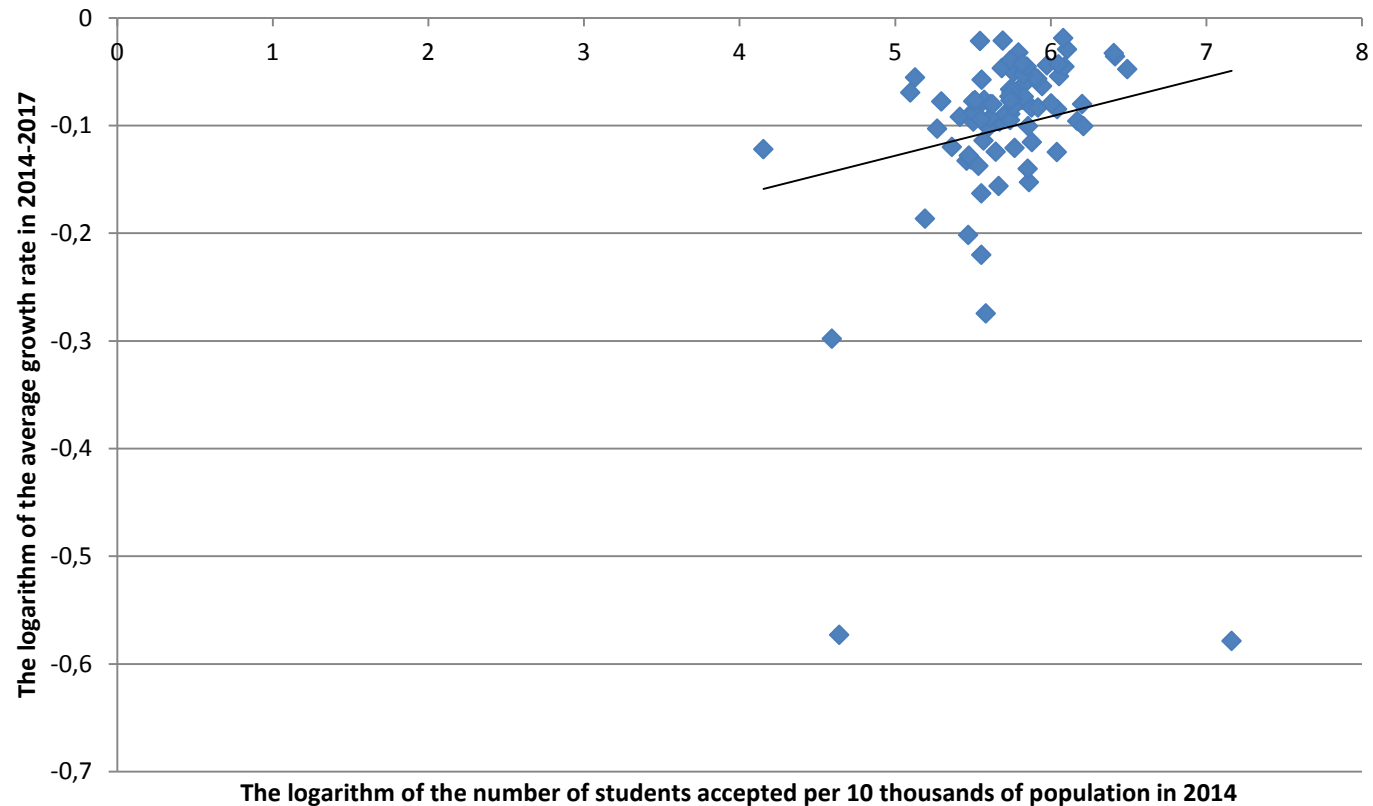
# RESULTS

Indicator	2014	2015	2016	2017
<b>Boundary Weight Matrix</b>				
Global Moran Index	-0.026	0.013	0.024	0.033
Giri Global Index	0.970	0.920	0.892	0.882*
<b>Inverse Distance Weighting Matrix</b>				
Global Moran Index	-1.298e-02	-1.298e-02	-1.298e-02	-1.298e-02
Giri Global Index	1	1	1	1

# RESULTS: Moran Charts



# RESULTS: Unconditional $\beta$ -convergence is absent



## Assessment results of conditional $\beta$ -convergence models of the number of students accepted per 10 thousands of population, identification of long-term spatial effects (boundary weight matrix)

Regressors	SAR_RE	SEM_RE	SDM_RE	SDEM_RE
Intercept	5.9993e-02	3.8218e-02	-1.4335e-01	-1.4586e-01
ln(stud)	-4.7066e-02*	-4.6468e-02*	-4.2929e-02*	-4.2792e-02*
dist	8.7044e-05	7.1466e-05	1.4067e-04*	1.4071e-04*
finans	3.4031e-02***	3.4246e-02***	1.5845e-02	1.6005e-02
size	5.0858e-04***	5.1290e-04***	5.1270e-04***	5.1265e-04***
sw	2.2825e-03	1.4154e-03	2.2498e-03	2.0961e-03
lambda		0.18302		0.026879
rho	0.195588*		0.014520	-0.0042979
Slag_stud			2.1347e-02	2.1011e-02
Slag_dist			-8.9225e-05	-8.9907e-05
Slag_finans			5.7545e-02***	5.7727e-02***
Slag_size			2.2409e-05	3.2105e-05
Slag_sw			-3.6755e-03	-3.5750e-03
AIC	-897.0318	-893.7015	-910.581	-910.5847
Hausman test (p-value)	0.01806	0.004655	4.41e-05	5.767e-09
n	234	234	234	234

**Assessment results of conditional  $\beta$ -convergence models of the number of students accepted per 10 thousands of population, identification of long-term spatial effects (boundary weight matrix)**

Regressors	SAR_FE	SEM_FE	SDM_FE	SDEM_FE
finans	0.04858586***	0.05299460***	2.6712e-03	-0.02073563
size	0.00038477**	0.00039919**	3.8337e-04**	0.00036003*
lambda		0.095605		-0.62233***
rho	0.155503*		0.049981	0.54051***
Slag_finans			8.1436e-02***	0.06406955**
Slag_size			-9.5489e-05	-0.00020329
AIC	-1156.457		-1168.403	
n	234	234	234	234

## Assessment results of conditional $\beta$ -convergence models of the number of students accepted per 10 thousands of population, identification of long-term spatial effects (Inverse distance weighting matrix)

Regressors	SAR_RE	SEM_RE	SDM_RE	SDEM_RE
Intercept	4.5847e-02	3.4255e-03	-1.2808e+00*	-1.1846e+00*
ln(stud)	-3.6579e-02	-3.7399e-02	-3.5417e-02	-3.6656e-02
dist	6.3941e-05	5.2717e-05	1.1122e-04	1.1066e-04
finans	2.5140e-02**	2.0225e-02*	1.2878e-02	1.0282e-02
size	5.0090e-04***	5.0789e-04***	5.9643e-04***	6.0843e-04***
sw	-5.7397e-04	1.5277e-03	9.9219e-03	1.0115e-02
lambda		0.61096***		-0.61687
rho	0.51376***		-0.17840	0.18580
Slag_stud			2.1658e-01*	2.1442e-01*
Slag_dist			-2.5619e-04	-2.5590e-04
Slag_finans			1.3231e-01***	9.4567e-02***
Slag_size			-4.8472e-04	-4.8643e-04*
Slag_sw			-5.8982e-02	-5.8341e-02
AIC	-904.9551	-903.7889	-916.7369	-918.1037
Hausman test (p-value)	0.1383	0.04249	1	0.000462
n	234	234	234	234



## Short-term marginal effects according to the SDEM model (2017)

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Regressors	Direct	Indirect	Total
ln(stud)	-0.0455852787**	-0.0019628076	-4.754809e-02**
dist	0.0001334955**	-0.0001532988**	-1.980333e-05
finans	0.0088347272	0.0073923617	1.622709e-02
size	0.0005020212***	0.0002997334**	8.017546e-04***
sw	-0.0071186220	-0.0082571720	-1.537579e-02

## Long-term marginal effects according to the SDEM\_RE model (Inverse distance weighting matrix)

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Regressors	Direct	Indirect	Total
ln(stud)	-0.0539388556	8.917835e-03	-0.0450210204
dist	0.0001628364	-2.692212e-05	0.0001359143
finans	0.0151302827	-2.501524e-03	0.0126287582
size	0.0008952857	-1.480196e-04	0.0007472661
sw	0.0148843890	-2.460870e-03	0.0124235187
Slag_stud	0.3155212993	-5.216586e-02	0.2633554365
Slag_dist	-0.0003765475	6.225546e-05	-0.0003142920
Slag_finans	0.1391529783	-2.300648e-02	0.1161464961
Slag_size	-0.0007157753	1.183408e-04	-0.0005974345
Slag_sw	-0.0858471399	1.419331e-02	-0.0716538346

## Long-term marginal effects according to the SDM\_RE model (weighted boundary matrix)

Регрессоры	Direct	Indirect	Total
ln(stud)	-4.360743e-02	4.622914e-05	-4.356120e-02**
dist	1.428906e-04	-1.514813e-07	1.427391e-04**
finans	1.609568e-02	-1.706337e-05	1.607862e-02
size	5.208017e-04*	-5.521128e-07	5.202496e-04***
sw	2.285386e-03	-2.422785e-06	2.282963e-03
Slag_stud	2.168419e-02	-2.298787e-05	2.166120e-02
Slag_dist	-9.063585e-05	9.608496e-08	-9.053977e-05
Slag_finans	5.845489e-02*	-6.196926e-05	5.839293e-02***
Slag_size	2.276321e-05	-2.413175e-08	2.273908e-05
Slag_sw	-3.733563e-03	3.958029e-06	-3.729605e-03

# RESULTS

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- ✓ Unconditional  $\beta$ -convergence is not detected;
- ✓ The conditional  $\beta$ -convergence of the average growth rate of the number of accepted students per 10 thousand population was revealed;
- ✓ Local spatial clusters of regions were discovered by the number of students accepted, the centers of attraction of which are federal universities;
- ✓ Positive short-term and long-term spatial marginal effects, positive autocorrelation of the dependent variable and negative correlation of the external random shock were revealed;
- ✓ All models confirmed the positive impact of the indicator of availability of admission places on the growth rate of the accepted number of students in the regions;

# RESULTS

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- ✓ The positive impact of territorial accessibility and its spatial lag on the growth rate of the number of accepted students was confirmed;
- ✓ The negative impact on other regions of the territorial accessibility of higher education in this region, the positive impact of financial accessibility in this region and in other regions were revealed.