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Evolution of the Spatial Models of the Economic Growth in the Analysis of Urbanization in Russian Regions

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Abstract: The researchers analyzed the evolution of models of economic growth with the spatial factor. Based on panel data shows the influence of the geographic factor including urbanization and economic potential for the growth of the differences in labor productivity in the cities of Russian regions. The researchers found that urbanization affects the growth of labor productivity in the cities with the power of 13% is higher than the Western European and close to Eastern European and Asian trends. On the spatial model of conditional beta-convergence shows that the less-developed and urbanized regions of Russia closer together among themselves on productivity under the influence of urbanization and Moran's index explains convergence only between them while the most developed regions diverge from the rest. The Russian regions are growing disparities in the level of urbanization due to excessive agglomeration of several cores, who take inputs from the entire periphery.

Key words: Spatial models, economic growth, labor market, regional convergence, Russia

INTRODUCTION

Regional studies of the factors and conditions of long-run economic growth underwent several stages of methodological formation. The traditional regional economic growth is analyzed using the same methods as the national growth. Since 1970s, econometric methods has been widely used in the regional development studies. By the end of 1980s, econometrics with the new IT opportunities overcame its one-sidedness. A new access to the instruments of multidimensional analysis became the main impulse for the development of unique concepts urgent at the regional and municipal levels and less important at the global one. The new economic geography, starting with Krugman's works includes spatial (geographic) indices as factors of economic growth. From the middle of 2000s such researches are widely spread in economic sciences, especially in the analysis of EU countries (NUTS I-III, etc.). But the comparative analysis of the results of different scholars is incomplete and the models themselves need to be adapted, factors to be tested for each particular case. The instruments of modeling mainly include modern interpretations of production functions with integrated spatial lags and effects. As a rule, these econometric models include panel data. The models based on spatial data became more frequently applied since the beginning of 2010s. They provide visualization of the spatial effects, urbanization included and are more adaptive, ready for meta-analysis. The advantages of GIS-models are especially obvious at the local (municipal) level. GIS-models in the analysis of the local conditions of the economic growth are rarely applied in Russia. Nevertheless, the value of each research of the regional urbanization is great, especially while elaborating the development programs of the territories, budget and social policies. In the given study, we'll analyze the spatial effects of urbanization for the regional productivity of labor as the main source of long-term economic growth. The instruments of analysis will be the production functions, realized through regression models of the panel data and beta-convergence models.

Concentration and diversity of resources in cities and agglomerations create opportunities for using scale effects, huge market and combination of different production factors. However, under certain conditions rapid urbanization involves negative consequences. The mix of benefits and expenses of the urbanization processes varies across countries.

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MATERIALS AND METHODS

Jacobs (1969) suggested the idea of cities as resources of economic growth, since that time this hypothesis has been tested with different data. The review done by Rosenthal and Strange (2004), allowed concluding, that doubling of the town size increases labor production by 3-8% in different countries. The study of publications by the other researchers showed that for China, Japan, Switzerland the index of efficiency is less than for USA and France (Melo *et al*., 2009). Nakamura, assessing Japan, concluded that if the city population increased twice, productivity would increase by 3.4% (Nakamura, 1985; Ciccone and Hall, 1996) found a positive effect of the influence of population density on the productivity in the USA, they consider that doubling of the city population will lead to a 6% growth of productivity. According to Ciccone, the results of the calculation for France, Germany, Italy, Spain and Great Britain testified that the two-fold increase of a city population would result in the productivity growth of 4-5% (Ciccone and Jarocinski, 2010).

The results of the similar studies for the Eastern Europe and Central Asia prove that the agglomeration effect in those geographical areas is much stronger than in OECD countries. Bekes and Harasztosi (2013) estimated the data for Hungarian enterprises from 1992-2003 and concluded that in case of doubling of the city size the efficiency of the production factors will rise by 16%.

The research of urbanization in Russia has been developing since the end of 1990s but primarily it was devoted to the problems of irrational distribution of production factors and seldom to the issues of the consequences of urbanization for production, migration, employment (Kolomak, 2011; Vakulenko, 2013; Demidova and Signorelli, 2011).

According to the pioneer research of Qwah, economic growth is accompanied by effects of convergence, when the countries with worse starting position grow faster. However, these regularities inside the country often involve the rise of regional differentiations, divergence which is conditioned among all by the spatial factor. It is described in the works by De La Angel (2000). This divergence may have several directions but it's always connected with the effects of urbanization and agglomeration (Ciccone, 2002).

In theory if we consider the size of the town as an endogenous value which is established as a result of interaction of economic agents we may distinguish two groups of factors, determining the economic return and economic growth:

- Positive effects of urbanization
- Restrictions of urbanization

The interaction of these two factors against the backdrop of a constant city growth may be presented as the influence curve describing the dependence of the effects of urbanization on the size of the city in the shape of the "downward facing parabola". Furthermore, the number of the mentioned above factors are fixed and equal for all cities in the frames of the particular country economy, while the others may vary significantly as in space and in time (for example expenses of transport communications). Thus, every region may have its own type of the dependence of urbanization effects and the average size of the cities.

In traditional models of agglomeration effects, we see such endogenous factors as assets (basic capital) and labor resources. It is presumed that regional labor stocks are fixed and immobile, so that we eliminate one possible source of agglomeration (Balwin and Marin, 2004). It is a major attribute for Russian regions rather than for European countries. Under conditions of low mobility of labor resources and capital, a long-run equilibrium balance of the national economy is unattainable task but many equilibrium balances at the local level are formed through the local agglomeration and Core-Periphery relations. Multiple equilibriums inside the regional groups may involve a dramatic inequality between them which leads to unstable economic growth of the country.

The mentioned above considerations prove that firstly, there are arguments pros and cons of the positive impact of urbanization on the economic development and secondly, the structure of urbanization and sizes of city settlements really matter because of the significant role of agglomeration effects.

It is a rule to use as a basic theoretical model a production function, $Q = AF(F, L)$ expanded due to the properties of urbanization level and its structure:

$$Q = AF(K,L,U,S)$$

Where:

A = Labor productivity
K = Production capital
L = Labor resources
U = Urbanization level
S = Indicator of agglomeration potential of the city settlements

As urbanization level, we take the indicator of the share of city population as index of its ability to generate agglomeration effects we use the indicator of an average size of the city in the region Urbanization effects analysis presupposes a number of statistic calculations to check hypotheses and assess the urbanization models. Further, we present the econometric modeling algorithm:

preparation of the input data for elimination of possible externalities: inflation, difference of the real cost of the assets in regional cities between the levels of economic activity and number of employees from the production function. This stage will be fulfilled while collecting and preparing the statistical data. Testing of hypotheses on the absence of the spatial effects of labor productivity and production function factors. In case of deviation of hypotheses, one may speak about accumulation effects:

- Assessment of the spatial autocorrelation. Significant autocorrelations will testify the accumulation direction and types of relations between regions (cities)
- Comparison of labor production sensitivity to the distance between cities and regions
- Describing the form of the spatial (geographical) distribution of the factors of the production function for choosing its type in the regression equation
- Testing of hypotheses on urbanization and estimation of directions, force and significance of repressors' impact. Creating a spatial regressive model of urbanization impact on labor productivity
- Decomposition of the form of indicators distribution in time in order to obtain the intervals without structural shocks, that enables to measure the spatial effect at the stationary rows
- Adjustment of the spatial regression models according to sub-periods based on the panel data
- Analysis of the spatial convergence or divergence of the regions in the city labor production

Data sources: The research includes 75 Russian regions. The period under study covers 2005-2013 years. Statistical data necessary for research includes the following primary indicators. Gross regional product (Q) by the types of economic activity for all regions under study. We excluded gross value added cost in agriculture and fish-breeding from the GRP. Many researchers consider these types of activity as not significant for the city population and distorting urbanization indicators. Besides, the exclusion of the inflation component demanded to re-estimate the remaining part of GRP in fixed prices. For this, we employed the indices of physical volume of particular economic activity types. As a result, we obtained the annual value GRP for the city settlements (Q') in constant prices of 2013 year, 2013 was chosen for the relevant interpretation. Depreciated cost of the fixed assets (K) is the most accurate index of the cost of capital used in production. It is shown in constant prices of 2013 year to eliminate the price differences. Indices of industrial and construction products were used to recalculate the prices. Russian regions vary greatly in economic potential, sizes of territory and production revenue. In order to eliminate the scale correlation and to Q' and K per capita of the urban settlement

The number of employed in the cities of Russia is L. Labor productivity of the urban population (A') is determined as the relation between GRP of the urban population and number of the employed population in the cities $A' = Q'/L$.

Number of the urban population (U) and the share of the urban citizens (S) in the population of the region are necessary indicators of urbanization. Number of cities and urban settlements in each region as the indicator was used to calculate the value of the factor U.

Distance between the capitals of the regions determined by the length of the railways communication. The factor of neighboring is important for the economic growth pace. Many researches establish the spatial dependence based on distance, as far as it is the most accurate criterion in comparison with the number of "neighbors" and the length of the state borders (Fischer and Wang, 2011).

RESULTS AND DISCUSSION

Analysis of agglomeration effects: The form of distribution of the regions according to A' in the absence of spatial effects must be approximately normal. On this basis, we can formulate the main hypothesis:

- H_0: agglomeration effects are absent and urban indicators of the regions are submitted to the normal distribution

To prove this hypothesis, let's use the diagram of smoothed frequency density distribution of the Russian regions according to the urban labor production (by Gauss. Figure 1 presents the regional agglomeration effects according to labor productivity in the cities. On the X axis there are values of labor productivity in cities of some Russian regions A', calculated in comparison of the national average, that's why the curves on the right shifts from 1.00 reflect frequencies of the regions with more than average productivity, on the left side shifts from 1.00-with lower than average productivity. On the Y-axis, there are frequencies of the regions-with exceeding of the expected frequency and lowering it. The crossing of the middle (equal to 1 from the point of normality of the tested distribution) is marked at the diagram by straight lines.

It turned out that there is a great concentration of the regions with a low labor productivity of the urban population. The labor productivity range from 20-50%

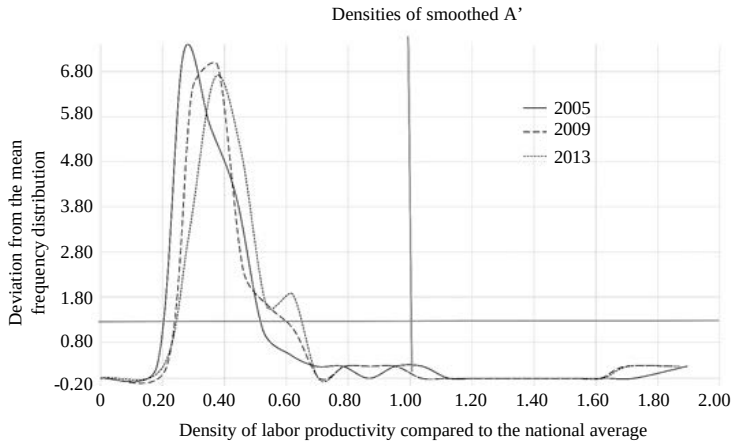

Fig. 1: Spatial agglomeration effects according to labor productivity (A') in the cities of the Russian regions: before crisis (2005), crisis (2009) and after crisis (2013)

includes maximum number of the regions, the ultimate values of the regional concentration tend to decrease in time and labor productivity levels off. In other words, labor productivity in 2005 year was more localized than in crisis year of 2009, let alone 2013 year and its levels were very far from the national average. Deviation of the modal productivity during 2005-2013 years was about 15%-the peak shifted from 24-38%. The mentioned years were not selected randomly. The visual analysis of the production levels of the urban labor showed that 2009 year was the peak-with the lowering pace A', this period embraces 2008-2010 years. We divided the period under study into several sub-periods: before crisis (2005-2007), crisis (2008-2010) and post-crisis. Further, we conduct our analyze following that particular decomposition of the time series.

Analysis of the spatial autocorrelations: Estimation of the presence and degree of spatial autocorrelation presupposes the testing of the null hypothesis.

- H_0: spatial effects for labor productivity of urban population in Russian regions are absent

Accepting this hypothesis means that labor productivity of 75 analyzed regions will not be significantly different despite the geographical distances between them. The alternative hypothesis tells that spatial effect exists. It should be noted that modern literature on spatial statistics and econometrics is devoted mainly to different tests of spatial autocorrelation. Nowadays there are many elaborated tests to establish the spatial autocorrelation, such as Moran's indices, Geary coefficient. We have tested various types of the matrix of spatial effects matrix of geographical neighboring, matrix of reverse distances, matrix of reverse squares of distances (gravitation), matrix of exponential distances and gravitation matrix of economic potential.

As a result two types were selected: matrix of reverse distances. Three-step method) and gravitation matrix of the economic potential (economic potential weights). In the second case two types were compared separately-at first-gross regional product in the regional cities-Q', then-number of employed in the cities-UE, divided by the square of the length of the transport lines of communication between the cities. Further indices are calculated for different threshold values-excluding the excessive distance which makes geographic weights insufficient. We based on the most spread criteria in the regional researches-distance quartiles. As a result, we got important spatial autocorrelations based on the Moran index and Geary coefficient for 2005, 2009 and 2013 years.

Hypothesis of the absence of the spatial autocorrelation is rejected. Moran index matters even in applying of a simple. Three-steps approach and in suspended matrix of weight coefficients.

Table 1 shows values of Moran's and Geary indices under different threshold criteria. We consecutively applied all quartiles: Q1-Q4. Judging by the negative values of the weighed Moran's index there is a negative spatial autocorrelation which implies that there is a competition between the Russian regions. It means that equilibrium in neighboring regions is not reached on the basis of cooperative development but there is a shifting of all production resources to more prospering cities from less prospering cities. The decrease of the Moran's index indicates the limited capabilities to use the external resources to increase the labor productivity.

Table 1: Comparison of indicators of spatial autocorrelation under various weight matrix and threshold values for labor productivity in Russian regions during 2005-2013 years

Years	Spatial autocorrelation indicator	Quartile 1	Quartile 4
2005	Moran's I, Three-step method	0.0422	0.0367
	Moran's I, Economic potential weights	-0.2447	-0.2202
	Moran's I, Economic potential weights	-0.5348	-0.4113
	Geary coeff., UE	1.3107	1.3379
2009	Moran's I, Three-step method	0.0528	0.0466
	Moran's I, Economic potential weights	-0.2102	-0.1900
	Moran's I, Economic potential weights	-0.4332	-0.3423
	Geary coeff., UE	1.0539	1.0759
2013	Moran's I, Three-step method	0.0528	0.0466
	Moran's I, Economic potential weights	-0.2102	-0.1900
	Moran's I, Economic potential weights	-0.3520	-0.3254
	Geary coeff., UE	1.0539	1.0759

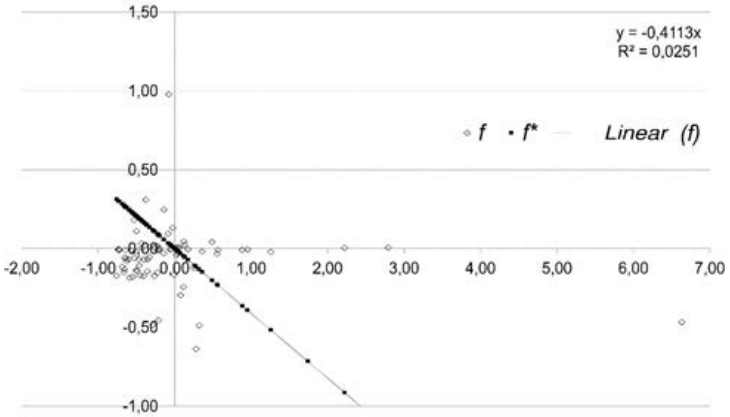

Fig. 2: Moran's diagram for urban labor productivity in Russian regions during 2005 year, quartile Q4

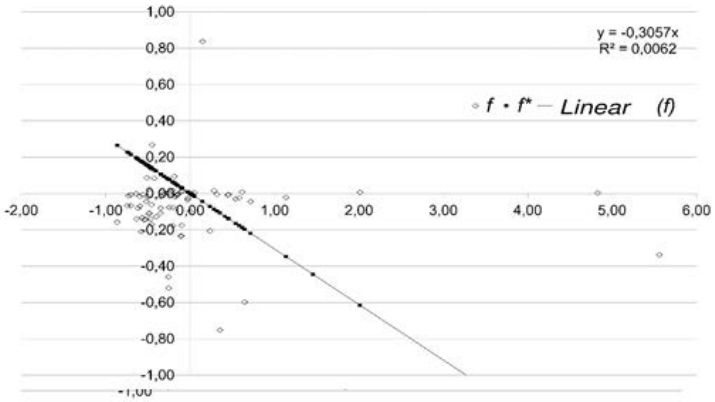

Fig. 3: Moran's diagram for urban labor productivity in Russian regions during 2013 year, quartile Q4

Analyzing the differences due to various threshold values (quartiles Q1, Q2, Q4) we may conclude that there is a high mobility between the neighboring cities but weak decrease of agglomeration effect. The attraction of urbanization in some regions with the biggest cities exceeds expenses of long distances.

While choosing the distance matrix, we took into account the charts of distribution describing not only the existence or significance of the spatial autocorrelation but also the groups of the regions with a mutual influence. The improved version of the Moran's Diagram is a dispersion diagram containing four quadrants: High-High (HH), High-Low (HL), Low-High (LH), Low-Low (LL) (Fig. 2 and 3). Moran's diagram of quartiles slightly varies but what about significant shifts for the given period at the Q4 level? We should see all possible combinations of distances and learn what regions are connected closer distant or neighboring, prosperous or not, effective or

Table 2: Significance of regression models under subperiods

Years	Multiple R	Multiple R^2	F(4, 220)	p-level	St. Err.
2005-2007	0.9481	0.8989	488.8	0.000	127.6
2008-2010	0.9492	0.9009	500.2	0.000	138.5
2011-2013	0.9453	0.8936	461.9	0.000	153.4

Table 3: Parameters of regression for the urban labor productivity in Russian regions and significance of the factors

Years	Values	Beta	SE	B	t (220)	p-level
2005-2007	Intercept			-351.9	-2.2	0.026
	2005-07_K	0.965	0.023	1.4	42.6	0.000
	2005-07_U	0.306	0.142	10.1	2.2	0.033
	2005-07_U*U	-0.297	0.143	-735.2	-2.1	0.039
	2005-07_S/MQ1	0.152	0.022	3.1	6.9	0.000
2008-2010	Intercept			-402.2	-2.3	0.021
	2008-10_K	0.971	0.022	1.2	43.2	0.000
	2008-10_U	0.354	0.143	12.7	2.5	0.014
	2008-10_U*U	-0.363	0.144	-978.6	-2.5	0.013
	2008-10_ S/MQ1	0.127	0.022	2.8	5.8	0.000
2011-2013	Intercept			-616.7	-3.2	0.002
	2011-13_K	0.971	0.023	1.2	41.7	0.000
	2011-13_U	0.507	0.151	19.6	3.4	0.001
	2011-13_U*U	-0.522	0.152	-1506.0	-3.4	0.001
	2011-13_ S/MQ1	0.135	0.023	3.2	5.9	0.000

not. Concentration of regions is maximal in quadrant LL in the bottom left and also some concentration of spots is observed in the top left quadrant. There is no regularity in the other quadrants. Trends-beginning from 2005 till 2013 the density of the regions in the bottom left quadrant is decreasing but their number is increasing, regions in the other quadrants are not grouped and may be considered as separate occurrence. Economic result from the Moran's diagrams is that the regions with a low productivity of urban labor are surrounded by the similar regions with low indicators, some of the leaders regions are surrounded by insufficient number of neighbors with low labor productivity. Clusters in the traditional meaning with a core of leading regions, promoting the productivity growth in the neighboring periphery don't exist. Consequently, there may be the variant of redundant urbanization where extremely high resource concentration on the one hand and "economic desert" from the other hand lead to unstable trend of national development in the long-term perspective.

Analysis of the spatial regression for labor productivity including the subperiods: In order to define the form of correlation and parameters of urbanization, we built the diagrams of pair correlation between labor productivity in towns from one side and the average size and share of the urban population-from the other side. Correlation between productivity and agglomeration effect is close to linear and with the urbanization level-is non-linear. It is in favor of specification of the model of linear and quadratic dependence that approves in general the situation in Kolomak Carvalho and Harvey. Therefore, we evaluate the following functional model form as following:

$$A' = \alpha + bK + c_1U + c_2U^2 + dS + M + \varepsilon$$

Where:

A' = Labor productivity of the employed urban population,

M = Variable of the fixed regional effect, taken from the spatial Moran's matrix

It turned out that S and M factors have common influence on the urban labor productivity and the most precise impact is observed under combination of factors, when the agglomeration effect including the distances between cities looks like this $\Sigma S/M_{Q_1}$.

The tested hypotheses are:

- H_1: urbanization generates labor productivity growth in Russia. This hypothesis presupposes that coefficient c_1 is positive and statistically significant
- H_2: positive impact of urbanization on labor productivity in Russia is decreasing and at a certain level it starts impeding the development. It results from this hypothesis that coefficient c_2 is negative and statistically significant
- H_3: large cities are characterized by higher productivity and create positive externality for the development of the territory in general. To support this hypothesis we need to have coefficient d positive and statistically significant. The results of estimations are presented in Tables 2 and 3

The best results are obtained for the model with a sensitive threshold value to the distances between the cities at the level of the first quartile Q1. It means that agglomeration effect in different regions is limited by the distance between the towns, not exceeding the quarter of the maximum and further the influence of the economic

Table 4: Intercepts of spatial beta-convergence model of Russian regions on urban labor productivity

Factors	Beta	SE	B	St. Err.	t (70)	p-level
Intercept	-	-	-0.999	0.804	-1.243	0.218
ln(A'0)	-0.774	0.201	-0.237	0.062	-3.851	0.000
ln(K0)	0.625	0.202	0.165	0.053	3.092	0.002
ln(U0)	0.801	0.319	0.507	0.202	2.512	0.014
U02	-0.770	0.324	-0.606	0.255	-2.376	0.020

Multiple R = 0.4925; Multiple R^2 = 0.2425; Corr. R^2 = 0.1993; F(4,70) = 5.6046; p-level = 0.0005; St.Err. = 0.1133

potential on the labour productivity becomes insignificant. All three hypotheses presented by models under subperiodshave very high values of determination and are well-grounded and non-mixed. Its hould be noted that the role of geographical factor is a bit higher during crisis.

The results of modeling prove that aggregated intercept is growing in spite of the world financial crisis in 2008-2010 and economic growth that testifies a real economic growth of the regions (in fixed prices). Dependency on the fluctuation of the real capital-labor ratio K (as we use the depreciated cost of the fixed assets per capita) is also rising but in post-crisis period there is a slowing down of growth of the given influence.

Regression coefficient c_1 for the degree of urbanization in all models is rapidly increasing, so the elasticity of labor production of the share of the urban population has increased by 1.5. Hypothesis 1 is fair; urbanization stimulates the growth of labor productivity in Russia. Positive influence of urbanization on labor productivity in some Russian regions is falling and at a certain point turns into the factor impeding the development. Hypothesis 2 is accepted which implies the decrease of the positive impact of the urbanization on the productivity in Russia in case of an excessive urbanization.

If the distance between capitals is less than the distance of the first quartile, spatial dependence of labor productivity on the concentration of economic resources becomes stronger than the agglomeration effect.

Comparing the coefficients of the spatial regression with the results of domestic and foreign scholars, we draw a conclusion of the existence of urbanization effect which is more remarkable in the majority of European Union countries than in Asia and Eastern Europe. Urbanization effect is more obvious before crisis (15.2% influence on labor productivity), during crisis it falls to 12.7% and not fully recovered after crisis 13.5%.

Analysisof conditional beta-convergence: Testing results of the spatial beta-convergence model of Russian regions are presented in Table 4. The model is significant under the Fisher's criteria and coefficients correspond to Student's criteria. The describing capacity of the model is quite sufficient which is supported by the coefficient of determination (R^2).

The strongest influence on the similarity of the regions has the level of urbanization. The higher the urbanisation level the lower is the convergence rate. The basic level of capital-labor ratio of the regions has a negative correlation. Spatial convergence model allows us to conclude that regions with similar and low levels of urban labor productivity draw together more quickly. The lower urbanization of the neighboring regions the lower their starting levels of productivity are but more similar is the pace of its growth in the cities of the subjects of Russian Federation. This is one of the key effects of urbanization which is supported by the value of Moran's index and concentration of the regions in quadrant LL.

CONCLUSION

The growth of regional flows of production resources, caused by urbanization was obvious in a pre-crisis period. Later urbanization remains an incentive for urban labor productivity growth only in frames of cooperation of underdeveloped regions. The regions neighboring with great agglomerations are inclined to depletion of resources because of their outflow. Characteristics of the regional allocation influence greatly on labor productivity and bring disproportions of the regional development in favor of excessive urbanization of the part of regions, leaving the rest of the mass on the low level. The economic potential of agglomeration plays an important role for the economic development. Urbanization has two directions: it speeds up the growth of urban labor productivity in backward regions and causes their convergence. Better starting conditions in some cities may impede mutually beneficial cooperation. The shift to another GIS-model allows to improve the analysis of urbanization role in economic development. At present, the usage of those type of models is limited because of the lack of the statistical data. Visualization of the map allows including in the analysis not only the factor of distance between regions but also the density of communication links, infrastructure development, the convenience of resources transfer, environmental factors. Undoubtedly, econometric analysis supported by these models is of great importance for monitoring territory development equilibrium.

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