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THE ROLE OF UNIVERSITIES IN ECONOMIC DEVELOPMENT OF RUSSIAN REGIONS

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This paper analyses the contribution of higher education institutions (HEI) in Russia to gross regional product (GRP) growth. We explore the relationship between higher education coverage and rates of economic growth based on longitudinal economic growth models which are pooled regression, fixed effects, and regression with simultaneous fixed and spatial effects. In addition to the influence of HEI on economic growth, the model specifications also allow an investigation of the relationship between the territory accessibility of higher education and GRP growth, and the significance of higher education in regions with different structures of GRP. The main policy outcome of the paper is that universities can be considered as fully-fledged economic agents which make positive contributions to GRP growth. The development of regional higher education systems would lead to a positive effect on regional economic development.

JEL Classification: I21, I23, I25

Keywords: higher education, economic growth, spatial effects, influence on GRP, regional economic development

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Introduction

Over the last 20 years steady growth in demand for higher education has been observed in Russia: the number of students in the 1990/91 academic year was 2.8 million and reached 5.2 million in 2014/15. Total spending on higher education both from state and private sources increased significantly as well. Higher education as a social imperative raises the question of how to justify and assess the efficiency of this spending. The issue of the impact of higher education institutions (HEI) on socio-economic development has become crucial from this perspective.

This research assumes that the positive effects of the presence of universities is reflected in the development of the regions and cities where they are located [Belenzon and Schankerman, 2013; Pinheiro et al., 2012]. From this point an attempt to assess the economic impact of higher education in Russia is complicated by the high level of socio-economic, geographical, cultural heterogeneity of the regions [Leshukov, et al. 2016].

This work analyses the contribution of HEIs as organizations to gross regional product (GRP) growth considering the peculiarities of regional socio-economic and spatial development. Our assumptions imply that the impact of HEI on regional development may be associated with (a) regional characteristics and (b) features of the HEI network. Since our goal is to estimate the overall effects of universities as economic agents, we choose GRP growth as a primary measure of higher education investment efficiency. The main proxy variable of the level of development of the higher education system ("higher education coverage") is a student population accessed by share of students in 17-25 age cohort.

The general results of the paper are as follows. First, we show that HEI can be considered as fully-fledged economic agents that contribute to GRP growth. Second, we reveal a negative relationship between the average distance from each district centre to the nearest university and GRP growth. Third, we show that higher education plays a different role in economic development in regions with different GRP structures. Finally, we show the importance of the spatial effects for modelling the economic impact of HEI.

The information base for the study is data from the Federal State Statistics Service, in particular the statistical collection "Regions of Russia" and data from the unified information system of the Ministry of Education and Science. Based on these data, a multidimensional data panel has been generated covering the period 2005-2014.

The structure of the paper is as follows. The first part describes the main approaches to the analysis of the economic impact of HEI and the research in this area. The second presents classical models of economic growth with the higher education coverage as an independent variable based on longitudinal data. The third includes analogous economic growth models but with spatial and fixed effects. The conclusion summarizes the overall results of the work and directions for further research.

Approaches to the evaluation of university influence on economic development

Today there is a large number of studies in which universities are positioned as full-fledged economic agents and analyzed in terms of economic efficiency [Hanushek E. A., 2016; Agasisti, 2011; Agasisti, Johnes, 2010]. Many studies describe a positive relationship between the development of the educational system and economic growth. Most of this research concludes that the development of education leads to economic growth. On the micro-level such evidence can be obtained through the Mincer earnings function, which in most cases shows that earnings are positively related to the level of education [Mincer, 1974; Pasacharopulos, Partinos, 2002]. On the macro-level research shows a positive relationship between national human capital and economic growth [Barro, Sala-i-Martin, 1992]. However, there could be a causality problem: it might be the case that the economic development of a country or region promotes the development of educational systems. Today there are two general hypotheses about how the institutions (including higher education) are related to economic growth. The first one is the institutional hypothesis [Kaufmann et al., 2005], which states that better institutions promote economic development. The other is the development hypothesis [Glaeser et al., 2004], which states that effective organizations tend to appear in more economically-developed countries or regions. Our initial assumption is that the institutional hypothesis holds for the Russian economy, and our methodology controls for the direction of the relationship between education and economic growth (through the instrumental variables approach). As stated above, our aim is to estimate the contribution of HEI to regional economic growth, so it is reasonable to consider approaches to the estimation of the economic impact of higher education.

An econometric estimation of production functions is widely used in research on sources of economic well-being. Traditional aggregate economic indicators such as GDP can be described by production functions, which link factors of production with output. HEI sector characteristics can be used among these factors. The use of this approach is complicated by econometric problems such as multicollinearity and endogeneity, and the selection of appropriate variables to describe the source of the impact under investigation. These problems can be overcome, however. The Solow model is the basis of the macroeconomic framework to the study of education's contribution to economic development:

$$Y = AF(K, L),$$

where Y is GDP level, F is the production function, K is capital, L is labour, A is total factor productivity – the portion of GDP unexplained by the volume of utilized capital and labour characterizing their productivity.

Contemporary theory and the empirical analysis of economic growth are based on convergence theory [Krueger, 2001; Barro, 2014]. Convergence is expressed as the dependence of economic growth on the prior level of economic development. Regions with a low initial level of economic development are usually characterized by an accelerated rate of growth due to catch-up development, while the more developed ones demonstrate decelerated rates. Convergence has also been empirically proven for Russian regions [Vakulenko, 2014].

An econometric evaluation of HEI contribution to GRP may be difficult. Regions with higher levels of productivity and education generally possess a higher level of capital. Capital expansion requires the growth of education. Therefore, econometric evaluations of the contribution of education may also cover the contribution of capital. The interrelation of human and physical capital is evened out in models of the evaluation of human capital in the total factor productivity [Oulton, 1997]. However, such models require the estimation of the total factor productivity, which is difficult due to the constraints of existing data at the regional level in Russia. All in all, the rate of economic growth rather than the GRP level is the more widespread economic indicator of interest to policy makers and researchers.

The traditional model can be rewritten for assessing the contribution to the rate of economic growth as [Johnes and Johnes, 2004]:

$$\Delta ln\left(\frac{Y}{N}\right) = \theta_0 + \theta_1 ln\left(\frac{Y_0}{N_0}\right) + \theta_2 \frac{I}{Y} + \theta_3 H,$$

where $Y$is GDP level, N is population, I is investment in capital, H is the stock of human capital (which may be considered a part of total factor productivity), Y_0 and N_0 are the initial levels of GDP and population.

For empirical evaluation, a regression equation normally also includes a set of variables such as the rule of law, the openness of the economy, the geographical characteristics of the region, fertility, inflation [Barro, 1996], and structure of the economy [Liberto, 2006]. Moreover, it needs to be taken into account that human capital is defined not only by education but also by initial abilities, family, health, and other factors [Hanushek, 2016]. The endogeneity of education variables requires using instruments in the models to explain economic growth [Barro, 1996; Mankiw, 1992; Demidova and Ivanov, 2016]. Generally, in econometric evaluation, lags of independent variables are used as such instruments.

Based on earlier studies, [Goldstein et al.,1995] enumerated eight sources of the impact of HEI on GRP, namely, knowledge creation, human capital creation, the transfer of know-how, technological innovation, capital investment, regional leadership, influence on environment, and knowledge infrastructure production. A variety of mechanisms require attention to select the relevant variables describing the impact of education. Human capital is the main focus of previous research. One of the most popular human capital indicators in the literature is the average years of schooling (of adults) of a population [Barro, 1996; Hanushek and Woessmann, 2010]. The impact of higher education cannot be separated from the effects of other levels of education with the use of this variable, however. An alternative approach is to use the percentage of the population with a particular level of education [Demidova, 2016]. A problem with this indicator is that it does not show the impact of a particular education system, as the accumulated human capital of the population could have been formed decades ago and migration can distort the interpretation. Another approach is to include the number of graduates as an explanatory variable [Gottlieb and Fogarty, 2003]. As human capital growth is not a single source of impact, a more 'comprehensive' variable or a list of different variables should be included. For the former case, it can be difficult to find such a universal indicator, while for the latter case it can be difficult to find an appropriate indicator for every source of impact. Regarding sources of impact except human capital, research-related and technology transfer variables are included usually [Sterlacchini, 2008; Goldstein and Drucker, 2006]. Valero and Reenen [2016] used the number of universities as a factor to estimate the impact of higher education on a sample of 8,128 region-year observations. For such a scale it is extremely difficult to find a solid measure with comparable values for each observation; however, this obstacle is offset by the number of regions and the period covered.

Consideration of this problem on the regional level requires taking into account that regions are not isolated, they actively interact with each other. There are several works where authors show the existence of spatial economic effects for different macroeconomic variables in Russian regions [Demidova, 2013], so we also should formulate and check the hypothesis that our sample also contains spatial effects and to adjust our methodology appropriately.

Based on the research purpose and literature review we propose the following hypothesis:

H1: Higher education coverage, which characterizes the universities as economic agents and reflects current economic performance of regional higher education system, is positively related to GRP growth rates.

The logic behind this hypothesis is that universities provide aggregate expenditures in regional economy (by their purchases, staff salaries, taxes), which results in relatively faster economic growth.

H2: The territorial accessibility of higher education is positively related to GRP growth rates.

This hypothesis reflects the fact that in regions with higher accessibility to higher education people are more likely to get higher education and, as a result, the quality of human capital is higher in these regions. It is known that quality of human capital is positively related to rates of economic growth.

H3: Higher education provides different contributions to economic development in regions with different GRP structure.

Here we assume that there are different types of regions (with different GRP structures) and in some of these regions a workforce with higher education is more in demand, while in other regions the labour market is more centred around people with vocational education due to the specific structure of GRP and the prevalence of some particular industries in regional economies.

H4: Spatial effects should be taken into account for estimation of higher education coverage impact on GRP.

This hypothesis assumes that there are spatial interactions between regions. Territories with a high level of economic development tend to have the similar neighbours. So some regions might play the role of drivers of economic development and contribute to the economic growth of other regions.

The estimation of the economic impact of HEI based on classical longitudinal data models

In order to estimate the economic impact of HEI econometrically, first of all we have to construct an economic growth model and make appropriate modifications. The list of explanatory variables in our models contains standard characteristics which are used in research devoted to regional economic growth modelling [Demidova, 2016]. The dependent variable in our models is a log of growth rates of GRP at constant prices. This indicator is the prevalent choice for research of this type [Barro, Sala-i-Martin, 1992]. The logarithmic transformation of the dependent variable is also in line with classical economic growth research and allows the squashing of the data and the simplification of the quantitative interpretation of results. GRP growth rates were corrected for population growth rates in order to obtain per capita regional economic growth rates.

For the estimation of the models the data of the Federal State Statistics Service for the period from 2005 to 2014 was collected. It is impossible to extend the panel used as some macroeconomic variables, including GRP growth rates, which are not yet available for 2015.

The estimates of the economic impact of HEI are based on the elasticity coefficients of per capita GRP growth rates by the share of students in the 17-25 age cohort. This explanatory variable is common because of the variation in the size of Russian universities is high enough: the number of the universities in each region varies, but at the same time the difference between total numbers of students in two regions can be insignificant, so the variable which reflects the number of universities can in some cases be misleading. The total number of students is not a relevant choice for the key independent variable either since Russian regions are also very heterogeneous in population. Other possible variables that indirectly reflect the scope of higher education system in the region are unjustifiably complicated and can be misleading. A special check was implemented for a clearer interpretation of the elasticity of per capita GRP growth by higher education coverage. The share of students in the age cohort was replaced by the share of the workforce with higher education. Including both these variables in the model simultaneously is not possible due to the multicollinearity problem which leads to the instability of coefficients while insignificant changes in the initial data. As a result, two different regressions were estimated. This approach was implemented in order to define the significance of higher education coverage and to reveal what factors are reflected by this variable. The verification demonstrated that the elasticity of GRP growth by the share of the workforce with higher education is higher than the elasticity of the dependent variable by higher education coverage (0.11 vs 0.05-0.07). Such results are expected since the employed population have been working and contributing to GRP (which is relatively higher than the contribution of workers without higher education), while the students are still acquiring the human capital that might contribute to GRP in the future. The chosen variable allows the isolation of the pure economic impact of the higher education system which refers to all kinds of university expenses, the spending of students from other regions and countries and so on. We suggest that higher education coverage is an optimal indicator of the current state of regional higher education systems. We do not make any quantitative prediction about economic growth associated with the number of students; this variable is used just as indicator.

The list of explanatory variables for regional growth regressions can be split into two blocks. First, special attention is given to the set of control variables reflecting the region's economic potential. Here we include the investment to GRP ratio, a dummy variable which reflects the aggregate financial results of all organizations in the region, the unemployment rate and different variables reflecting the structure of GRP: the share of commercial mineral extraction (oil, gas, ore and other commodities), the share of industries, the share of public services (education, healthcare, public administration), the share of private services (transport, communication, real estate operations, finance, leasing, hotels and restaurants, other social services). The model’s specification also includes the value of GRP in the previous period in order to take into account the scale of region’s economic activity. This modification is necessary because the initial base of the region may influence the subsequent rates of economic growth.

Hypothesis 3 states that regions with different GRP structures have different impact from higher education sector. To test this hypothesis, i.e. to define for what types of regions higher education is more important, we employ variable interaction analysis and include the products of higher education coverage with the share of commercial mineral extraction, the share of industries, the share of public services with the share of private services in GRP.

The second block of explanatory variables is centred around the relationship between the territorial accessibility of higher education and GRP growth rates (Hypothesis 2). Territorial accessibility of higher education, which can be considered an important factor of education development in such a large and heterogeneous country as Russia [Froumin, Leshukov, forthcoming], was included in the model in order to check for statistically significant effects of this variable on rates of regional economic growth. By the territorial accessibility of higher education we understand the distance from a city to the nearest university averaged by all cities in the region [Gromov, Platonova, Semenov, Pyrova, 2016]. Including this variable in the model alone reflects the economic effects not only from territorial accessibility, but also from the different social, economic and geographical features of the region. In order to make our findings correct we impose additional control variables which reflect the total area of the region in square kilometres, the share of urban citizens in the total population and the population density. The model specification contains the dummy variables for time effects. These dummies were not included for each year in the sample, but only for 2006, 2009, 2011 and 2014. This combination of dummies allows us to maximize the adjusted R-squared and corresponds to actual trends in GRP growth rates: the economic shocks in 2009 and 2014 and the acceleration of regional growth rates in 2006 and 2011.

Finally, we obtain a relatively wide list of regressors. Such an approach to model specification allows the avoidance of specification constraints of the production functions, which lead to endogeneity problems arising from a restricted list of independent variables. In particular, the endogeneity problem was considered in detail in [Hanushek, Woessmann, 2012].

The methodology of the estimation is the generalized method of moments. This approach to model identification was chosen since the method of instrumental variables was employed in order to overcome the endogeneity problem. In particular, the instrumental variables are the logarithm of total GRP in the previous period and coverage of higher education. These variables were instrumented by appropriate values of the same variables in previous period. The method of instrumental variables was employed in order to overcome the causation concern, since the direction of dependence is not obvious here: it might be the case that more economically developed regions are characterized by more developed higher education systems. The utilization of lags as instruments ensures that we analyse the correct direction of dependence. This approach also prevents the case when there is some third variable that affects economic growth and higher education coverage simultaneously.

The list of variables used and descriptive statistics are presented in the appendix. The sample used contains all Russian regions except the regions with no “parent” universities (Chukotka Autonomous Okrug, Yamalo-Nenets Autonomous Okrug); Crimea and Sevastopol since Russian Federal State Statistics service do not provide the data for these regions for periods earlier 2014; Khanty-Mansi Autonomous Okrug is treated as a part of Tumen region and Nenets Autonomous Okrug is treated as part of Archangelsk region. Some regions were dropped from the sample as outliers: Moscow, Moscow region, Saint-Petersburg, Leningrad region. These regions differ significantly from all other territories by their socio-economic characteristics. It is necessary to exclude them for validation of the sample.

The descriptive statistics presented in the appendix reveal some tendencies in the general economic and educational characteristics of Russian regions. The first important observation is that the dynamics of higher education coverage has a parabolic form with maximum level of 31.3% in 2010. Before this year a stable increase in the share of students in age cohort can be observed from 26.8% in 2005, and after 2010 it decreases to 29.6% in 2014. The dynamics of the maximal coverage of higher education approximately corresponds to the mean value dynamics. In almost all the years the maximal share of students in age cohort was observed in Tomsk, Kursk and Tumen regions (Moscow and Saint-Petersburg were excluded as outliers).

These tendencies in general correspond to the dynamics of average GRP growth per capita after controlling for the macroeconomic shocks in 2009 and 2014. Other economic variables such as unemployment rates, the share of different sectors in total GRP are relatively stable and characterized by low variation over time.

As mentioned we checked the robustness of our results by the substitution of the share of workers with higher education for higher education coverage. This modification does not significantly influence the explanatory power of our models and the general conclusions so the estimation results presented below are for the higher education coverage as a main regressor.

First a simple pooled regression model was considered in order to reveal the relationship between the log of GRP growth rates per capita and the territorial accessibility of higher education. The results of estimation are presented in Table 1.

Tab. 1. Results of pooled regression estimation.

Dependent variable – log of GRP per capita growth	
Share of students in age cohort 17-25	0.0751 * (0.0378)
Investment to GRP ratio	0.0365 (0.0302)
Dummy variable for aggregate financial results of the companies	0.2881 ** (0.1017)
Log of GRP in previous period	- 0.3932 *** (0.0324)
Territorial accesibility of higher education	- 0.0344 . (0.0201)
Population density	- 0.0043 (0.0035)
Total square of the region (log)	- 0.4665 * (0.2289)
Share of urban citizens in total population	0.1424 * (0.0721)
Unemployment rate	- 0.0870 * (0.0376)
Public services share in GRP	- 0.1109 (0.0896)
Private services share in GRP	0.2361 * (0.1049)
Commercial minerals extraction share in GRP	0.0861 * (0.0405)
Industries share in GRP	- 0.0506 (0.0432)
Dummy variable for the year 2006	0.8361 *** (0.0932)

Dummy variable for the year 2009	- 0.4874 *** (0.1023)
Dummy variable for the year 2011	0.7634 *** (0.0923)
Dummy variable for the year 2014	- 0.7320 *** (0.0632)
Product of higher education coverage and share of commercial minerals extraction in GRP	- 0.0237 . (0.0127)
Product of higher education coverage and share public services in GRP	0.0236 ** (0.0088)
Product of higher education coverage and share private services in GRP	0.0524 (0.0385)
Product of higher education coverage and share of industries in GRP	-0.0239 (0.0201)
R-squared=0.52 F-statistics=36.4*** Significance codes: 0 "***", 0.01 "**", 0.05 "*", 0.1 "." Standard errors are presented in brackets	

Based on the data from Table 1 our model can explain more than 50% of the total variation of GRP growth rates. The share of students in the total population of the age 17-25, as expected, has positive impact on GRP growth rates and is statistically significant with a p-value not exceeding 0.05. However the general results of the pooled regression estimation are that territorial accessibility is negatively related with growth rates (the higher average distance between all district centres and the nearest university, related with lower growth rates) and statistically significant with a p-value equal to 0.1, so our models predict that regions with relatively territorially accessible higher education experience faster economic growth. Two out of three control variables for territory accessibility – the log of the total area of the region and the share of urban citizens in the total population are also statistically significant (p-value not exceeding 0.05). The population density has no effect on GRP in our model probably because its effect is captured in total area of the region or in the urbanization variable.

Among the variables which reflect the economic characteristics of the regions, the investment to GRP ratio is not statistically significant, while the dummy variable for the aggregate financial result of all organizations in the region has a positive effect on growth rates. The log of GRP in the previous period (at constant prices) is negatively related to growth rates. This fact can be explained by low base effect, which proposes that low-income regions have a tendency for more rapid growth. The elasticity coefficient of GRP growth rates by the unemployment rate is statistically significant and negative, which corresponds to Ouken's law.

Dummies for time effects are significant with p-values close to 0 and have the expected signs: negative for the shocks in 2009 and 2014 and positive in 2006 and 2011.

In addition, the results allow us to make some suggestions about the significance of higher education for the regions with different GRP structures. The elasticity coefficient of GRP growth rates by the share of commercial mineral extraction in GRP is significant, while the product of higher education coverage and the share of commercial mineral extraction are also significant and negative. We suggest that for these regions professional education is a more foregrounded development factor. The elasticity of the dependent variable by the share of public services is insignificant, while its product with higher education coverage is positive and significant. It means that higher education ensures a substantial impact on regions with extensive budget and public services sector.

Next we assume the existence of region-specific development trends and introduce fixed effects to the model specification which is possible by utilizing longitudinal data. From our point of view, this approach is an optimal way to discern the unobservable heterogeneity of Russian regions. The inclusion of fixed effects in our models requires reconsidering the entire specification of the model since regressors which are characterized by low variations over time will be automatically included in the model through fixed effects because of the implementation of within-transformation. Therefore, the current approach requires us to remove territorial accessibility, total area, population density and the share of urban citizens in the total population from our specification since these variables almost do not vary in time. Other variables are the same as in the pooled regression. The results of fixed effects model estimation are presented in Table 2. For the estimation the generalized method of moments was employed to implement the method of instrumental variables. The instrumented variables are the same as in the pooled sample regression.

Tab. 2. Results of fixed effects regression estimation

Dependent variable –log of GRP per capita growth	
Share of students in age cohort 17-25	0.0704 ** (0.0271)
Investment to GRP ratio	0.0269 (0.0202)
Dummy variable for aggregate financial results of the companies	0.2892 ** (0.1071)
Log of GRP in previous period	- 0.2881 ***

	(0.0123)
Population density	- 0.0075 (0.0068)
Share of urban citizens in total population	0.1302 * (0.0658)
Unemployment rate	- 0.0673 * (0.0315)
Public services share in GRP	-0.0529 (0.0423)
Private services share in GRP	0.2182 * (0.0922)
Share of commercial minerals extraction in GRP	0.0297 * (0.0150)
Industries share in GRP	- 0.0617 (0.0598)
Dummy variable for the year 2006	0.8802 *** (0.0343)
Dummy variable for the year 2009	-0.4941 *** (0.0438)
Dummy variable for the year 2011	0.7903 *** (0.1002)
Dummy variable for the year 2014	-0.7492 *** (0.0432)
Product of higher education coverage and share of commercial minerals extraction in GRP	- 0.0238 * (0.0112)
Product of higher education coverage and share public services in GRP	0.0045 * (0.0021)
Product of higher education coverage and share private services in GRP	0.0545 (0.0495)
Product of higher education coverage and share of industries in GRP	- 0.0238 * (0.010)
R-squared=0.61 F-statistics=55.44*** Significance codes: 0 "***", 0.01 "**", 0.05 "*", 0.1 "." Standard errors are presented in brackets	

The addition of fixed effects increases the share of the explained variation of the dependent variable to more than 60% but that does not change the results or the main conclusions. The model reveals the statistically significant dependence of the log of GRP per capita growth rates on the coverage of higher education. This model also confirms the conclusions from the pooled sample regression about the economic significance of higher education depending on the GRP structure. The product of higher education coverage and the share of public services are positive and statistically significant, while the share of public services alone is not significant, and this means that the public services sector cannot operate properly without higher education. The model also suggests that specialists with higher education are less demanded in commodities-oriented regions, since the product of the share of this sector in GRP and higher education coverage is negative with a p-value not exceeding 0.05. The share of higher education in private services is as important as in other sectors of regional economy.

Models with spatial effects

The modelling of different social and economic indicators on the regional level often leads to the problem of inhomogeneity in spatial observations. First of all, it can be expressed through the non-zero spatial correlation between regression errors. A positive spatial correlation means that observations are clustered in space, i.e. similar objects are located close to each other. Negative spatial correlation means, conversely, the clustering of heterogeneous objects. This may happen for different reasons, such as clustered influence factors or the implication of spatial interactions such as flow channels or diffusion. These effects enable the proper estimation of parameters using standard econometric approaches. In particular, if the true model is:

$$y = X\beta + \rho WY + \varepsilon \ (*),$$

where Y is a vector containing dependent variable,

X is the regressors matrix,

W is the matrix of weights,

ϵ is the error vector

ρ is the spatial correlation coefficient, and

β is the vector of estimated parameters.

Then it is easy to show that the least squares method gives the following estimates:

$$\widehat{\beta_{OLS}} = \hat{\beta} + \hat{\rho}(\mathrm{X}^{\mathrm{T}}\mathrm{X})^{-1}\mathrm{X}^{\mathrm{T}}WY$$

So the OLS estimates are biased. The obvious solution to this problem is the inclusion of the dummy variables, which indicate the particular object in space, but when we have a very extensive list of points in space, it increases the number of estimated parameters dramatically. Therefore, the spatial econometrics methods to limit the number of additional estimated parameters towards the spatial correlation coefficient is required.

Anselin [1980] presented the fundamentals of spatial econometrics. In this and subsequent papers the author has shown that spatial dependence can be included in the classical regression model through two different methods, so there are two major classes of spatial econometric models. The models from the first class contain an additional regressor, which reflects the spatial lag of the dependent variable. These models are named spatial autoregression models (SAR). Models from the second class contain information about the spatial dependencies in the covariance matrix (models with spatial interactions in errors).

The specifications of all spatial models include the spatial weights matrix which contains information about the location of the spatial objects. There are many ways to introduce the spatial weights matrix. The simplest way is a matrix of the nearest neighbour, which consists of zeros and ones. Elements of this matrix take a value “1” if two regions are neighbours and “0” otherwise. Regions are designated neighbours if they have some common border or some other common feature [Viton, 2010]. The other widespread class of weights matrices are the matrices of the distances between regional centroids. The distance between two regions can be measured as a simple straight line or geodetic, such as distances by railways or airlines, which can be expressed in terms of time or length units.

These methods of spatial econometrics are more commonly used in research on unemployment [Vakukenko, 2015], [Semirikova, Demidova, 2015], migration [Sardadvar, Vakulenko, 2016], and economic growth modeling [Demidova, Ivanov, 2016].

Previous research, where authors implemented the methods of spatial econometrics for modelling macroeconomic variables based on Russian regional data, shows that there are spatial effects. In particular, in [Demidova, 2013] it was shown that the spatial correlation coefficient is statistically significant for unemployment, real wages, and GRP growth rates. Moreover, the value of the coefficient is positive for most cases, i.e. similar Russian regions are clustered in space. The initial evidence of positive spatial correlation of the current data is visually represented in Fig.1

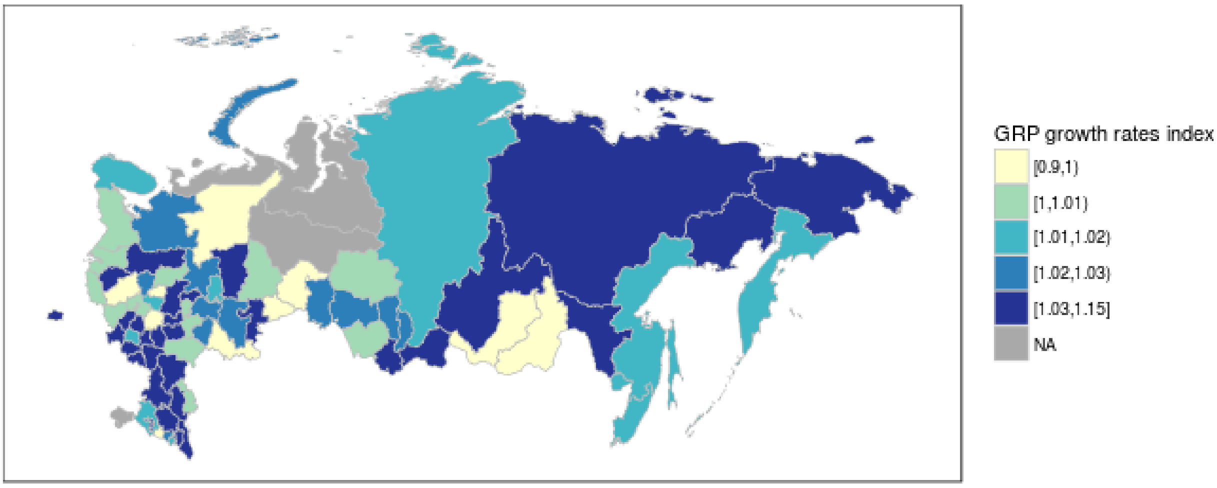

Fig. 1. Economic growth in Russian regions (GRP growth rates index)[5]. 2014

Source: Federal State Statistics Service

The fact that Russian regions are clustered in space means that fast-growing regions have similar neighbours and less economically developed regions are more likely to have a common border with slow-growing regions.

Since we deal with multidimensional data, the final step of the modelling uses a modification of the spatial model for longitudinal data which has the following specification:

$$y = \lambda(I^T W_N)y + X\beta + u,$$

where y is the vector containing the dependent variable,

I^T is the T-dimensional identity matrix,

W_N is the matrix of weights,

X is the matrix containing explanatory variables,

β is the vector of unknown parameters,

λ is the spatial dependence parameter, and

u is the error vector.

Since we deal with a panel data model, the vector of errors can be divided into two parts: the classical $\varepsilon_i \sim IID(0.\sigma_\varepsilon^2)$ and the component which reflects time-invariant spatial effects which are not correlated. So vector u can be rewritten as:

$$u = (l_t I_N)\mu + \varepsilon,$$

[5] 0.01 change is equal to 1%

where μ is the vector of individual effects, and

l_t is the identity vector

Vector u can also be specified in a different way which was proposed in [Kapoor et al., 2007] as:

$$u = \rho(I_T W_N)u + \varepsilon,$$

where

$$\varepsilon = (l_t I_N)\mu + \eta$$

These two specifications are quite similar and the main difference between them is that the specification proposed in [Kapoor et al., 2007] assumes that individual effects are also correlated in space.

The most popular approaches to the estimation of spatial models are maximum likelihood and the generalized method of moments. Since here it is also necessary to employ instrumental variables we will use the generalized method of moments [Mutl, Pfaffermayr, 2011], [Piras, 2011].

The model was estimated in R using the splm package [Millo, Piras, 2012]. The matrix of weights was taken as the inverse distances matrix. This choice is based on research where authors implement the methods of spatial econometrics. In particular, [Semirikova, Demidova, 2015] show that for Russian regional data on unemployment rates, the bias of estimates is smaller for inverse distances matrix compared to other types of matrices of weights. Our initial assumption is that this conclusion can be transferred to other macroeconomic variables such as GRP growth rates. To check this assumption we also implement a robustness check (analysis of consequences after the change of weighting matrix, Table 4).

At the initial stage modelling three different spatial specifications were considered: SEM, SAR and SAC models. These models were compared based on the Akaike information criteria, which showed that the optimal model is SAR, where spatial effects are taken into account through additional independent variable. The results of SAR model identification are presented in Table 3.

Tab. 3. Results of spatial fixed effects regression estimation

Dependent variable –log of GRP per capita growth	
Lambda	0.435 ** (0.1523)
Share of students in age cohort 17-25	0.0578 * (0.0272)
Investment to GRP ratio	0.0559 (0.0501)
Dummy variable for aggregate financial results of the companies	0.2001 * (0.0921)
Log of GRP in previous period	- 0.3140*** (0.0212)
Population density	- 0.2431 ** (0.0077)
Share of urban citizens in total population	0.0744 (0.053)
Unemployment rate	- 0.0383 * (0.0163)
Public services share in GRP	0.1597 (0.1432)
Private services share in GRP	0. 1586 (0.1197)
Share of commercial minerals extraction in GRP	0.0392 ** (0.0135)
Industries share in GRP	- 0.0288 . (0.0172)
Dummy variable for the year 2006	0.6334 *** (0.1313)
Dummy variable for the year 2009	-0.4608 *** (0.0983)
Dummy variable for the year 2011	0.9117 *** (0.1023)
Dummy variable for the year 2014	-0.5401 *** (0.0342)
Product of higher education coverage and share of commercial minerals extraction in GRP	- 0.0281 * (0.0114)
Product of higher education coverage and share public services in GRP	0.0484 * (0.0232)
Product of higher education coverage and share private	-0.0263

services in GRP	(0.0188)
Product of higher education coverage and share of industries in GRP	- 0.0269 (0.0174)
Significance codes: 0 "***", 0.01 "**", 0.05 "*", 0.1 "." Standard errors are presented in brackets	

The results of the spatial model estimation show that the spatial lag of the dependent variable is statistically significant with a p-value not exceeding 0.01, which confirms the necessity of the employment of a spatial econometrics approach for modelling. The size of the effect of higher education coverage decreases slightly compared with the simple fixed effects model, but in general the key results remain the same.

As mentioned above, it is also necessary to implement a robustness check which shows the variation of the estimated parameters depending on the type of weighting matrix in order to confirm the correctness of our choice of weighting matrix. For this purpose we used the squares matrix of inverse distances and matrices of the 1, 5 and 15 nearest neighbours. The results of the procedure are presented in Table 4.

Tab. 4. Results of robustness check

	Inverse distances matrix	**Squared inverse distances matrix**	**1 nearest neighbors**	**5 nearest neighbors**	**15 nearest neighbors**
Share of students in age cohort 17-25	0.0578 * (0.0272)	0.0544 * (0.0289)	0.0601 ** (0.0223)	0.0554 * (0.0302)	0.0588 * (0.0312)
Investment to GRP ratio	0.0559 (0.0501)	0.0323 (0.0425)	0.0432 (0.0434)	0.0643 (0.0473)	0.0734 (0.0472)
Dummy variable for aggregate financial results of the companies	0.2001 * (0.0921)	0.1981 * (0.0892)	0.1943 * (0.0899)	0.1893 * (0.0911)	0.1932 * (0.0902)
Log of GRP in previous period	- 0.3140*** (0.0212)	-0.3213 *** (0.0332)	-0.3167 *** (0.0312)	-0.3012 *** (0.0293)	-0.3242 *** (0.0298)
Population density	- 0.2431 ** (0.0077)	-0.0253 ** (0.0082)	-0.0232 * (0.0091)	-0.0262 ** (0.0089)	-0.0253 ** (0.0987)
Share of urban	0.0744	0.1022	0.0343	0.0543	0.0432

citizens in total population	(0.0534)	(0.0812)	(0.0299)	(0.0503)	(0.0399)
Unemployment rate	- 0.0383 * (0.0163)	-0.0385 * (0.0166)	-0.0356 * (0.0160)	-0.0403 * (0.0172)	-0.3412 * (0.0171)
Public services share in GRP	0.1597 (0.1432)	0.1743 (0.1283)	0.1634 (0.1028)	0.1453 (0.1057)	0.1423 (0.1185)
Private services share in GRP	0. 1586 (0.1197)	0.1712 (0.0103)	0.1643 (0.1231)	0.1642 (0.1132)	0.1442 (0.1098)
Share of commercial minerals extraction in GRP	0.0392 ** (0.0135)	0.0378 ** (0.0143)	0.0385 * (0.0157)	0.0386 * (0.0156)	0.0401 * (0.0158)
Industries share in GRP	- 0.0288 . (0.0172)	-0.0341 * (0.0172)	-0.0123 (0.0102)	-0.0185 . (0.0134)	-0.0213 * (0.0121)
Dummy variable for the year 2006	0.6334 *** (0.1313)	0.6432 *** (0.1232)	0.6834 *** (0.1343)	0.6234*** (0.1402)	0.6343 *** (0.1398)
Dummy variable for the year 2009	-0.4608 *** (0.0983)	-0.4593 *** (0.0921)	-0.5324 *** (0.1023)	-0.4693 *** (0.0932)	-0.5123 *** (0.0986)
Dummy variable for the year 2011	0.9117 *** (0.1023)	0.8912 *** (0.1058)	0.9003 *** (0.1139)	0.9121 *** (0.1032)	0.0892 *** (0.0923)
Dummy variable for the year 2014	-0.5401 *** (0.0342)	-0.5394 *** (0.0432)	-0.5543 *** (0.0534)	-0.4921 *** (0.0432)	-0.5312 *** (0.0343)
Product of higher education coverage and share of commercial minerals extraction in GRP	- 0.0281 * (0.0114)	-0.0293 * (0.0132)	-0.0273 * (0.0123)	-0.0245 * (0.0112)	-0.0298 * (0.0132)
Product of higher education coverage and share public services in GRP	0.0484 * (0.0232)	0.0453 * (0.0243)	0.0532 * (0.0223)	0.0412 * (0.0232)	0.0501 * (0.0210)
Product of higher	-0.0263	-0.0324	-0.0374	-0.0432	-0.0323

education coverage and share private services in GRP	(0.0188)	(0.0281)	(0.0293)	(0.0302)	(0.0276)
Product of higher education coverage and share of industries in GRP	- 0.0269 (0.0174)	-0.0137 (0.0129)	-0.0342 (0.0296)	-0.0234 (0.0201)	-0.0241 (0.0189)
Significance codes: 0 "***", 0.01 "**", 0.05 "*", 0.1 "." Standard errors are presented in brackets					

The results presented in Table 4 show that the estimated parameters are quite robust for changes in the matrix of weights; the differences between coefficients are very small. That procedure confirms the correctness of our approach and the reliability of our results. This allows us to conclude that the employment of spatial econometric models is necessary for modelling the economic impact of regional higher education systems and that ignoring spatial effects prevents the correct estimates of elasticity coefficients being obtained, and this conclusion should be taken into account in subsequent research in this field.

Discussion

Several conclusions can be made based on the results of our analysis. First, the estimated models reveal the positive dependence of GRP growth rates on the education proxy indicator – higher education coverage. All the models show that elasticity coefficients of GRP growth rates by higher education coverage are positive and statistically significant. Moreover, the variation of the effect is not high, the values of these elasticity coefficients do not differ significantly across the models. The effect of higher education coverage is significantly lower than the effect of the share of working population with higher education. We suppose different factors that are captured in our key explanatory variable: university spending on infrastructure and services, the expansion of employment, additional revenue from students from other countries and regions. Our proxy partially contains effects related to human capital improvement, since we assume the existence of a significant and positive correlation between higher education coverage and the quality of human capital in the region.

The pooled sample model reveals that the elasticity of GRP per capita growth rates by territorial accessibility of higher education is statistically significant (with a p-value not exceeding 0.1) and has a negative sign even after the inclusion of additional control variables which reflect the total area of the region, the density of population and the share of urban citizens in the total population. The inclusion of these controls exempts the measure of territorial accessibility from the most important factors which are not related directly to higher education systems (for example, without controls the negative elasticity of the dependent variable by the measure of territorial accessibility may reflect the fact that larger regions are likely to grow more slowly than other regions). This result is very important since it shows that not only the direct measures of the development of higher education coverage influence GRP growth rates, but the variable which restricts the increase of higher education coverage also has a negative impact on GRP growth rates.

The models allow us to make some preliminary suggestions about the importance of higher education in regions with different structures of GRP. The variable interaction analysis shows that in commodity oriented regions (with a high share of commercial mineral extraction in GRP) the level of higher education coverage is less than in other regions. A possible hypothesis for further research is that vocational education is more important for these regions. We are able to show the importance of higher education in regions with a substantial share of public services which is logical because higher education is important for most individuals employed in education, healthcare and public administration. For the private service sector higher education is as important as for other sectors of economy, and for the industrial sector the effect is ambiguous.

Finally, the modelling procedure confirms the existence of spatial effects and the necessity to use spatial econometric methodology. Spatial models show that the spatial correlation coefficient is positive and statistically significant with a p-value close to zero. This fact confirms our initial hypothesis about the clustering of similar regions in space. It means that regions are not isolated and play an important role in the development of neighbours and this fact should be taken into account when analysing the impact of universities on economic growth at the regional level.

The policy implications of this research refer mainly to issues of the development of regional networks of higher education. Our analysis suggests that universities can be considered as fully-fledged economic agents which make a positive contribution to GRP growth. The development of regional higher education systems would have a positive effect on regional economic development.

Our findings about territorial accessibility suggest that further research is needed about whether the development of higher education and the improvement of territorial accessibility would be favourable for regional economic development. We cannot estimate the effect of this policy precisely, but we claim that it would have positive consequences for regional economies.

From the perspective of policy implication, it is important that the structure of regional economies should be taken into account when implementing a restructuring policy for regional higher education systems. In particular, the merger of universities with consequent staff reduction can lead to more serious negative consequences for less-developed regions with a higher share of the public sector in GRP. Moreover, universities play a less important role in the economic development in some regions (in particular, in commodities-oriented regions), therefore it might be more important to concentrate on the development of professional education in these regions.

The results of the paper suggest directions for further research. First, the analysis of spatial effects of higher education coverage is required, especially for how the development of one regional higher education system influences the peculiarities of universities in neighbouring regions. Second, it is necessary to test our models on different sub-samples (such as western and eastern regions, federal districts) in order to make the first step towards understanding the heterogeneity of Russian regions and the role of education in their economic development. These developments will allow us to understand region-specific features in more detail and to formulate more precise policy recommendations.

References

1) Agasisti T. (2011). Performance and spending efficiency in Higher Education: a European comparison through non-parametric approaches. *Education Economics*, 19 (2), pp. 199-224
2) Agasisti T., Johnes G. (2010). Heterogeneity and the Evaluation of Efficiency: the Case of Italian Universities. *Applied Economics*, 42 (11), 1365-1375.
3) Anselin L. (1980). Estimation Methods for Spatial Autoregressive Structures. *Regional Science Dissertation and Monograph Series 8*, Field of Regional Science, Cornell University. Ithaca. N.Y.
4) Barro R. J. (2014) Convergence and Modernization. *The Economic Journal*, pp. 125 - 585.
5) Barro R. J. (1996) Determinants of Economic Growth: A Cross-Country Empirical Study. *NBER Working Paper 5698.*

6) Barro R.J., Sala-i-Martin X (1992). Convergence. *The Journal of Political Economy*, 100, 2, pp. 223-251
7) Belenzon. S., Schankerman M. (2013) Spreading the word: geography, policy and knowledge spillovers. *Review of Economics and Statistics*, 95 (3), pp. 884-903.
8) Demidova O., Ivanov D. (2016) Economic growth models with unhomogeneous spatial effects (example of Russian regions). *Economic journal of Higher school of economics*, 20(1), pp. 52-75
9) Demidova O., Ivanov D. (2016) Models of Economic Growth with Heterogenous Spatial Effects: The Case of Russian Regions. *HSE Economic Journal*, 20(1), pp. 52–75
10) Demidova O. (2013). Identification of spatial effects for the main macroeconomic indicators of Russian regions, NRU-HSE
11) Froumin I., Leshukov O. Federal - regional relationships in higher education in the Russian Federation in Federalism and higher education: a comparative study, forthcoming, 2017
12) Gottlieb P. D. (2003) Educational Attainment and Metropolitan Growth. *Economic Development Quarterly*, 17(4), pp. 325-336
13) Goldstein, H. A., Maier, G.б Luger,M. I. (1995). The university as an instrument for economic and business development: U.S. and European comparisons. In D. D. Dill & B. Sporn (Eds.), Emerging patterns of social demand and university reform: Through a glass darkly (pp. 105-133). Oxford, UK: Pergamon.
14) Goldstein H., & Drucker J. (2006) The Economic Development Impacts of Universities on Regions: Do Size and Distance Matter? *Economic Development Quarterly*, 20(1), pp. 22-43.
15) Gromov A. D., Platonova D. P., Semyonov D. S. (2016) Modern Analytics of Education Volume 8: Accessibility of Higher Education in Regions of Russia. Moscow, Russia: National Research University Higher School of Economics.
16) Glaeser E., La Porta R., Lopez-de-Silanes F., Shleifer A. (2004). Do institutions cause growth? *Cambridge, MA: Harvard University*
17) Hanushek E.. Woessmann L. (2010) How Much Do Educational Outcomes Matter in OECD Countries. *NBER Working Paper 16515*
18) Hanushek E., Woessmann L. (2012). Do better schools lead to more growth? Cognitive skills, economic outcomes and causation. *Journal of economic growth*, 17, pp. 267-321.
19) Hanushek E. A. (2016) Will more higher education improve economic growth? *Oxford Review of Economic Policy*, 32(4), pp. 538–552.

20) Johnes G., Johnes J. (2004) International Handbook on the Economics of Education. Northampton. MA: Edward Elgar Publishing Limited

21) Kapoor M., Kelejian H, Prucha I (2007). Panel Data Model with Spatially Correlated Error Components. *Journal of Econometrics*, 140(1), pp. 97–130

22) Kaufman D., Kray A., Mastruzzi M., (2005) Governance Matters IV: Governance indicators for 1996-2004. *World Bank*

23) Krueger A.B., Lindahl M. (2001). Education for Growth: Why and For Whom? *Journal of Economic Literature*, 39(4), pp. 1101-1136

24) Liberto A. D. (2008) Education and Italian regional development. *Economics of Education Review*, 27, pp. 94–107.

25) Mankiw N. G., Romer R., Weil D. N. (1992) A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 107(2), pp. 407-437.

26) Mutl J., Pfaffermayr M. (2011). The Hausman Test in a Cliff and Ord Panel Model. *Econometrics Journal*, 14, pp. 48–76.

27) Millo G., Piras G. (2012) splm: Spatial panel data models in R. *Journal of Statistical software*, 47(1), pp. 1-38

28) Mincer D. (1974). Education, experience and distribution of earnings. N.Y.: NBER press

29) Oulton, N. (1997), Total factor productivity growth and the role of externalities. *National Institute Economic Review*, 162, pp. 99–111.

30) Piras G. (2010). sphet: Spatial Models with Heteroskedastic Innovations in R. *Journal of Statistical Software*, 35(1), pp. 1–21.

31) Pasacharopulos G, Partinos H., (2002) Returns to investment in in education. *World Bank policy research working paper 2881*

32) Semirikova E., Demidova O. (2015). Analysis of regional unemployment in Russia and Germany: spatial econometric approach. *Spatial Economics*, 2, pp. 64-85

33) Sterlacchini A. (2008) R&D, higher education and regional growth: Uneven linkages among European regions, *Research Policy*, 37, pp. 1096–11.

34) Sardaver S., Vakulenko E. (2016). Interregional migration within Russia and east-west dive: evidence from spatial panel regression. *Review of Urban and Regional development studies*, 28(2), pp.123-141

35) Universities and regional development: a critical assessment of tensions and contradictions / edited by Rymulo Pinheiro. Paul Benneworth and Glen A. Jones. 2012

36) Valero A., Van Reenen J. (2016). The economic impact of universities: evidence from across the globe. *NBER working paper No. 22501*

37) Viton P. (2010). Notes on spatial econometric models. *City and regional planning 870.03*
38) Vakulenko E. (2015). Analysis of the relationship between regional labor markets in Russia using Okun's model. *Applied econometrics*. 40 (4), pp. 28-48

Appendix - Descriptive statistics

		2010	**2011**	**2012**	**2013**	**2014**
Growth rates of GRP per capita, %	Max	117.0	113.3	115.3	114.2	112.2
	Min	87.76	100.9	89.2	83.8	85.5
	Mean	104.7	105.4	105.0	102.2	98.6
	St. deviation	7.43	5.1	5.8	6.1	4.7
Share of students in age cohort 17-25, %	Max	52.4	51.0	50.5	50.4	46.6
	Min	12.93	13.1	14.4	14.3	14.8
	Mean	31.33	31.1	30.9	30.3	29.6
	St. deviation	7.24	8.5	8.2	8.3	8.1
Investment to GRP ratio, %	Max	71.25	64.4	58.4	57.4	43.9
	Min	15.39	15.1	15.5	16.0	16.16
	Mean	29.21	30.0	29.1	28.7	25.6
	St. deviation	10.13	10.4	9.5	7.6	6.7
Share of urban citizens in total population, %	Max	95.50	95.7	95.8	95.3	95.4
	Min	27.70	28.7	28.9	29.0	29.2
	Mean	68.26	68.4	68.5	68.6	68.7
	St. deviation	12.62	12.6	12.6	12.6	12.6
Dummy variable for aggregate financial results of the companies	Max	1.00	1.0	1.0	1	1
	Min	0.00	0.0	0.0	0	0
	Mean	0.83	0.8	0.9	0.77	0.56
	St. deviation	0.38	0.4	0.3	0.4	0.5
Log of GRP in previous period	Max	14.48	14.5	14.7	14.8	14.8
	Min	9.38	9.4	9.6	9.7	9.7
	Mean	11.68	11.7	11.9	11.9	11.9
	St.	0.99	1.0	1.0	1.0	1.0

	deviation					
Unemployment rate,%	Max	49.7	48.1	47.7	43.7	29.8
	Min	4.50	4.3	3.4	2.9	3
	Mean	9.51	8.5	7.4	7.1	6.6
	St. deviation	6.68	6.2	5.9	5.5	4.07
Public services share in GRP,%	Max	45.70	47.1	48.7	50.1	48.6
	Min	5.40	5.5	5.7	5.9	6.1
	Mean	17.17	16.7	18.2	19.3	18.9
	St. deviation	7.14	7.2	7.5	7.8	7.5
Private services share in GRP,%	Max	32.10	35.2	38.1	38.6	39.0
	Min	11.50	10.3	10.2	11.0	10.2
	Mean	20.47	20.2	20.7	20.8	20.5
	St. deviation	5.01	5.0	5.3	5.4	5.4
Commercial minerals extraction share in GRP,%	Max	59.30	60.6	61.5	61.1	65.7
	Min	0.00	0.0	0.0	0	0
	Mean	7.97	8.7	8.4	8.1	8.0
	St. deviation	12.52	13.2	13.0	12.9	13.1
Industries share in GRP,%	Max	40.90	40.8	39.8	43.7	41.3
	Min	2.00	2.0	2.0	2.9	1.2
	Mean	17.81	18.1	17.7	17.1	17.3
	St. deviation	9.80	10.4	10.2	5.5	10.2
Density of population , people/ squared kilometer	Max	115.28	119.4	122.8	125.8	128.9
	Min	0.31	0.3	0.3	0.3	0.31
	Mean	27.93	28.0	28.0	28.0	28.1
	St. deviation	24.67	24.9	25.2	25.4	25.6
Growth rates of GRP per capita,%	Max	112.7	115.2	126.3	115.8	110.5
	Min	91.4	95.9	98.4	88.4	67.7
	Mean	108.5	115.2	112.0	106.9	92.4
	St. deviation	7.3	6.7	10.3	6.9	8.2

Share of students in age cohort 17-25,%	Max	40.3	48.8	50.4	52.0	52.6
	Min	11.4	11.8	11.8	10.8	11.7
	Mean	26.8	28.3	29.0	29.4	31.0
	St. deviation	7.0	6.9	7.1	7.3	7.5
Investment to GRP ratio,%	Max	91.6	82.8	86.0	76.0	76.0
	Min	11.1	13.0	12.4	15.7	14.1
	Mean	24.3	25.1	29.2	31.2	29.3
	St. deviation	11.2	10.7	10.3	9.5	12.8
Share of urban citizens in total population,%	Max	94.4	94.8	95.0	95.3	95.6
	Min	26.0	26.1	26.2	26.4	26.6
	Mean	67.5	67.5	67.7	67.6	67.7
	St. deviation	12.5	12.5	12.5	12.5	12.4
Dummy variable for aggregate financial results of the companies (1-positive, 0-otherwise)	Max	1.0	1.0	1.0	1.0	1.0
	Min	0.0	0.0	0.0	0.0	0.0
	Mean	0.9	0.9	1.0	0.8	0.8
	St. deviation	0.3	0.3	0.2	0.4	0.4
Log of GRP in previous period	Max	14.3	14.6	14.6	14.6	14.7
	Min	8.8	8.9	9.0	9.4	9.5
	Mean	11.4	11.5	11.6	11.7	11.8
	St. deviation	1.0	1.1	1.0	1.0	1.0
Unemployment rate,%	Max	64.9	66.9	53.0	55.0	52.9
	Min	4.0	2.7	2.5	2.4	4.8
	Mean	9.4	9.7	8.3	8.7	10.4
	St. deviation	7.5	9.7	7.8	7.0	6.3
Public services share in GRP,%	Max	39.2	45.9	46.0	53.5	50.4
	Min	3.6	4.3	4.8	5.2	6.0
	Mean	14.3	16.5	16.7	17.4	19.3
	St. deviation	6.4	7.4	7.5	8.3	7.4
Private services	Max	36.3	36.2	35.7	35.0	32.7

share in GRP,%	Min	6.8	9.6	10.4	10.6	10.5
	Mean	20.4	20.4	20.0	19.9	20.6
	St. deviation	5.9	5.8	6.0	5.8	5.2
Commercial minerals extraction share in GRP,%	Max	59.9	57.9	55.6	52.9	55.7
	Min	0.0	0.0	0.0	0.0	0.0
	Mean	8.0	7.4	7.4	7.4	6.9
	St. deviation	12.1	11.5	11.9	11.7	11.5
Industries share in GRP,%	Max	55.4	55.6	52.4	52.9	42.6
	Min	0.5	0.8	1.6	1.6	1.9
	Mean	19.5	19.3	19.4	19.1	16.5
	St. deviation	11.6	11.7	11.4	11.4	9.2
Density of population, people/ squared kilometer	Max	135.3	136.9	138.6	141.1	143.6
	Min	0.3	0.3	0.3	0.3	0.3
	Mean	28.4	28.3	28.3	28.3	28.3
	St. deviation	25.5	25.6	25.7	25.9	26.1

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