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The Effect of Human Capital on the Output of Slovak Urban Regions

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Abstract

Cities play a key role in the creation of the national product. Most of the population is located in cities, which leads to intensive economic activity. At present, two main topics are being discussed in the academic environment. One focuses on the importance of different size categories of cities in the economic system of countries. The second focuses on the importance of individual production factors in the creation of economic output of cities. This article deals with measuring the effects of production factors on the economic output of urban regions (also referred in this article as cities) in Slovakia. The analysis of 78 urban regions of Slovakia showed that the human capital factor has the largest effect on the production of their total output. Results from the subsequent analysis on the comparison of the impact of production factors between different size categories of urban regions largely confirmed the main result. However, the measured effects of individual production factors for different size categories of urban regions brought interesting differences.

Keywords

Human Capital, Economic Output, Urban Regions, Urban Size, Slovakia

JEL Classification

R10, R12

Introduction

The perception and position of cities (or urban regions) in the economic system of countries has received much attention in recent years, both in academia and in international institutions. The main reason for the increased interest of cities in the world lies mainly in the growing urbanization, which has been taking place in an intensive form for last few decades. According to the United Nations (UN), this trend will continue in the near future (UN 2008; 2014). Because the majority of the population and firms are located in cities, cities contribute a significant share to the creation of the total economic output of countries. In the context of urban economic performance, the city size factor plays a specific role. The advantages of large cities result mainly from the fact, that they bring together a larger number of actors on their territory. These actors derive agglomeration benefits from being located in close proximity. That enables cities to achieve a high level of production and continue to grow. In large cities, all production factors tend to accumulate. A large workforce is located in local labour markets, a number of localized companies have a huge amount of capital, universities, together with attractive jobs and the quality of facilities, attract human capital. Furthermore, highly educated people along with innovative companies help to nurture the technological progress. The combination of these factors thus creates larger and larger production.

The topic of cities of different sizes and their different roles in the economic system of countries is still relevant for today. An article by Dijkstra, Garcilaz and McCann (2013) points out that at the turn of the millennium, growth and concentration of population as well as economic growth in Europe's largest cities have slowed down. While the population and total product has been increasing in the last decades of the 20th century, especially in the largest European cities, this has not been the case since the late 1990s and the beginning of the new millennium. An article by Parkinson, Meegan and Karech (2015) discussed the fact that secondary cities can also, contribute to the economic performance of national economies across European countries. Based on an analysis of the economic performance of 150 cities in 31 European countries, the authors pointed out that not only capital cities play an important role in the economies of countries, but also secondary and smaller cities can play an important role. From analysing the data during the last economic recession, the authors recommend that national governments should invest more in secondary and smaller cities. This advice was supported by the argument, that according to their results, those countries that did invest in smaller cities before the economic recession, managed the economic crisis better than countries that focused only on supporting major (largest) cities. In addition, Italian economists Camagni, Capello and Caragliu (2015) provided an answer to the question, why some smaller cities in Europe outnumbered large ones in terms of economic growth. In their study, they pointed on the differences in the functions of secondary (in terms of population) and smaller cities. The authors pointed out that smaller cities took advantage of the geographical proximity of large cities and used their specific functions. As some examples, they

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argue that in recent years, a lot of smaller cities have reached international transport corridors, accessed international trade markets, or developed partnerships with other cities. These causes then significantly helped them to boost their economic growth.

Regarding the explanation and measurement of the economic performance of cities, during the last decades have academics used several indicators. A common indicator by which urban researchers measured the economic "strength" of cities and estimated their growth, was by the development of employment. For example, Simon (1998), Simon and Nardinelli (1996; 2002) or Ciccone and Hall (1996) have used in their studies employment growth as an indicator of economic growth. Researchers also measured the economic superiority of cities compared to other territories through the level of average wages of workers. A standardly used indicator for explaining the economic growth of countries and regions is the gross domestic product (GDP). Although for explaining the economic growth of cities it is used in a lesser extent of literature due to the limited availability of statistical data. For example, Florida et al. (Florida, Mellander and Stolarick, 2016) used the GDP indicator in their outputs to monitor the GDP of metropolitan regions in the USA. Glaeser compared the GDP indicator in the largest cities across the countries in United States (US) (Glaeser 2011), or Parkinson et al. (Parkins, Meegan and Karecha, 2015) investigated the development of the GDP indicator between major and smaller urban regions in Europe.

To sum up, from this short literature review of cities and their position in the economic system it is clear, that it is a broad research topic and it is studied and analysed especially in the western countries of Europe and in the US. From the point of view of a more detailed study of cities in the environment of the countries of Central and Eastern Europe, and especially in Slovakia, it is a research area that has not yet been examined in more depth. Therefore, this article deals with the economic output of urban regions in Slovakia and the influence of production factors on their total output. In this article, emphasis is placed on the impact of human capital in cities on the economic output of urban regions. The sub-objective is to examine whether there are differences in the impact of human capital between different size categories of urban regions. The importance of the factor of human capital in urban economy is discussed in more detail in the following chapter.

Literature Review

Human capital is considered by many researchers and studies to be the most crucial factor in the economic success of cities. An educated, highly qualified workforce, which is concentrated in a small space, gives an excellent precondition for the creation of agglomeration effects. All actors located in a given area benefit from these effects. Many researchers have addressed these effects in several studies. For example, Glaeser and Ressenger (2010) addressed the agglomeration effects and supply of the educated urban population in their work. In their article, they state that agglomeration effects are more noticeable in cities with a larger supply of human capital than in cities with a smaller number of educated people. From an analysis of studies and articles, Duranton and Puga (2014) pointed out that it is important for cities and their faster economic growth to accumulate as much human capital as possible along with the support of the development of small businesses and the focus on diversity of work activities. Regarding the relationship between human capital and the growth of the city, many authors also pointed to various approaches that have most often appeared in the empirical literature. For example, in studies by Glaeser, Scheinkman and Shleifer (1995), Simon and Nardinelli (1996) or Simon (1998), authors estimated regressions in which the dependent variable representing the urban growth was a change in population or employment (expressed in logarithms) and the independent variables were different forms of human capital along with a set of independent, control variables. For the human capital variable, other various indicators were used. Commonly used indicator was the median number of years of education of the population. Another one was the percentages of the population with the number of years of education (both in Glaeser, Scheinkman and Shleifer, 1995). Simon and Nardinelli (1996) used as a proxy for human capital the number of specialist workers. In more recent studies, the indicator of the share of the university-educated population is very often used. This indicator is more accurate and has stronger effects. For example, it was used by Simon and Nardinelli (2002) or by Glaeser et al. (2004). Researchers also pointed to the causality between the effects of human capital and urban growth. An instrumental (exogenous) variable used by Glaeser et al. (2004), or by Moretti (2004), was the year in which a college or a university in the city was founded. Glaeser et al. (2004) and Shapiro (2006) founded out in their studies that instrumenting human capital in cities by the presence of universities (measured by the year of school establishment) is a causal effect of increasing education levels on urban growth. They also found out that this leads to higher coefficients than previously reported data.

Since the early 1990s, several regional economists and geographers have been researching human capital on the economic performance of cities in much more detail. Among the first, was Rauch (1993), who focused on the human capital in American cities and its impact on overall factor productivity. He used employee wages and real estate prices as dependent variables, respectively the average level of rent. The independent variable was the average level of education (expressed in the average number of years that a city dweller spent in education). The author tried to control this variable by the presence of universities and research centres in cities. Specifically, the author used data on the amount of funding resources that universities and research centres received from public sources. The author assumed that cities in which these institutions were located, have generated a larger amount

of human capital, compared to other cities in which such institutions were not located. However, after adding these variables to the econometric model, they were statistically insignificant and negative (similar results were obtained by the author after transforming the variables into so-called categorical variables, as well as in the case of values in logarithms). Rauch in his article also examined the role of social characteristics of the population (such as gender, marital status, or race) as well as the role of various categorical variables capturing the regional dimension or the climatic environment. To estimate the impact of education on the overall productivity of production factors in cities, the author used a regression method with cross-sectional data. A sample of 237 US cities (SMSA - Standard metropolitan statistical area) with data from the 1980 Census. His main result was, that an increase of overall productivity by adding an additional year of education were 2.8%. Lucas (1988) tried to find an answer to a similar question, but with a regression method based on time series. By modelling the relationship between the level of education and productivity growth between countries, from the data for 1909 to 1957, Lucas concluded that an additional year of education increases overall productivity by 3.2%. Therefore, these two studies showed that an increase in human capital by one unit (an increase in education by 1 year) will increase the total productivity of the territory by approximately 3%.

The relationship between urban characteristics (educational structure) and urban growth (expressed in terms of income growth and population) between 1960 and 1990 was also discussed by a group of American economists led by Edward Glaeser (Glaeser, Scheinkman and Shleifer, 1995). The sample consisted of 203 US sites (SMSA). The main findings were that income growth and population growth were interrelated and both types of growth had a positive relationship with the initial level of education, a negative relationship with the initial level of unemployment and a negative relationship with the initial share of employment in the manufacturing sector. These relationships applied to cities (smaller administrative units) and SMSA (larger administrative units). The analysed data also showed that government spending was not correlated with urban growth and government debt were positively correlated with later economic growth. Similarly, Eaton and Eckstein (1997) analysed the relationships between urban population growth and human capital accumulation. According to their model, cities with a larger population will, despite the possibility of free migration, achieve a higher supply of human capital, higher wages and higher real estate prices in the future. They conducted research in the 20 largest cities in France and Japan. In another research, the effects of human capital on the economic growth of cities in the United States, as well as the effects of human capital on the economic performance of their cores and peripheral areas, were discussed by Florida et al. (2016). They provided an analysis with on a sample of 380 U.S. metropolitan regions. The main results of this article showed that the distribution of human capital in space plays an important role in the economic performance of cities. The main finding of these researchers was that human capital located in peripheral areas has a greater impact on the economic growth of metropolitan regions (measured by workers' incomes and real estate prices) than human capital located in their centres. Moreover, when comparing city size categories, they found that human capital in the largest cities has a greater effect than human capital in other city size categories. In another work (Duranton and Puga, 2014), authors pointed out on the links between human capital and business. The authors assumed that entrepreneurs are more concentrated among educated workers and thus in cities with a larger educational base (represented by a larger share of educated population). According to them, cities with a larger educational base are also more enterprising cities. At the same time, these cities are also places, where more new businesses are being set up and where existing companies are growing faster. According to the authors, one of the main reasons why this phenomenon occurs is that more educated cities, i.e. more educated workers, are more productive (as claimed by Rauch, 1993).

However, higher productivity is not the only possible source of human capital for urban growth. This may also be because more educated cities provide better benefits to the population and because cities are also attractive to workers from other cities, especially for the more educated. Although Glaeser et al. (2004) along with Shapiro (2006) provided only modest evidence that various benefits have an impact on the attraction of educated population. Diamond (2013) pointed out on her analysis of American cities on the relationship between benefit development and the divergence in labour market structure according to skills. According to her findings, in cities with a wider range of benefits, there are more intellectually demanding jobs, while in cities with a smaller volume of benefits, average demanding jobs are concentrated. Furthermore, Venhorst (2017) dealt with the production and consumption spill-over effects of human capital in cities. On a sample of 287 Dutch cities, he examined the relationship between the ability of cities to attract recent university graduates to local labour markets, as well as the change in the structure of skills (respectively qualifications) in terms of consumption caused by the influx of graduates in cities. From the point of view of changes in labour markets, his analysis showed a strong positive relationship between the influx of university graduates and the increase in the share of knowledge-intensive and research jobs in cities. From the point of view of the change in the structure of qualifications, it turned out that the immigrant population with a university degree has a positive impact on creating new services and products that employ workers with secondary and lower education. Simply put, according to his findings, production spill-over effects are more common among highly skilled workers, while consumer spill-overs occur between highly skilled and less skilled workers.

Simon (1998) also addressed the relationship between human capital and employment growth in metropolitan

regions. His research also confirmed that cities with higher average levels of human capital should expect higher employment growth. He also pointed to spill-overs effects between cities within the metropolitan area. The growth of employment in one city was positively linked to human capital from another city, but within the relevant metropolitan area. A similar relationship between the growth of the university-educated population and the growth of employment in American cities has been observed by Shapiro (2006). The author tested 3 possible explanations to answer the question: Why cities with a larger supply of human capital achieve higher employment growth? The first explanation was in the lack of a variable that would explain the specific nature of the territory that would be correlated with both human capital and employment growth (although a number of studies with a large number of variables pointed to a positive relationship between human capital and urban employment growth). The second explanation was that residents with high human capital are looking for areas where the quality of life is growing. And the third explanation was that the university-educated population generates large local productivity growths that arise when searching for the labour market (for example, through knowledge leaks or through monetary externalities). His analysis showed that the growth of the city generates two thirds of the growth of human capital and one third of the growth in the quality of life of the inhabitants. The monitored indicators were wages and real estate prices. The conclusion of his work was the finding that the element of human capital in the growth of the city is manifested not only through leaks of knowledge, as many authors argue (based on the work of Alfred Marshall or Jane Jacobs), but that it also significantly improves the quality of life represented by higher real estate prices. Recent articles that were dealing with the topic of economic growth of cities with human capital are provided in Table 1.

Table 1. Overview of studies which modelled the impact of human capital on the output of cities.

Definition of a city	Indicator for human capital	Indicator for economic output	Observed time period	Used methods	Conclusions
237 SMSA (Standard Metropolitan Statistical Area)	1. average number of years of education	1. average wage per hour	1980	Cross-section OLS regression	The effect of an additional year of average education on the overall productivity factor is 2.8 percent.
203 SMSA (Standard Metropolitan Statistical Area)	1. median number of years of education	1. income per capita	1960-1990	Panel regressions with fixed effects and cross-section OLS regressions	Income and population growth are positively linked to the initial level of education.
79 English and Welsh cities	1. share of workers - professionals	1. annual population growth	1861-1961	Cross-section OLS regression	Cities with a larger share of workers - professionals achieved higher growth.
39 French urban areas, 40 Japanese urban areas	1. average number of years of education	1. average nominal wage of an employee	for French urban areas 1876-1990, for Japanese urban areas 1925-1985	Cross-section OLS regression	Cities (urban areas) with larger populations will achieve higher shares of human capital, higher wages and higher rents in the future.
313 SMSA (Standard Metropolitan Statistical Area)	1. share of population with secondary and tertiary education 2. share of population with tertiary education	1. employment (number of employees)	1940-1986	Cross-section OLS regression	Cities with higher levels of human capital achieve higher employment growth.
SMSA (Standard Metropolitan Statistical Area)	1. average number of years of education 2. number of years of work experience	1. average wage per hour	1990	Cross-section OLS regression	The inequality of border product in cities is caused by the spillover effect.
315 SMSA (Standard Metropolitan Statistical Area)	1. share of population with tertiary education	1. employment	1900-1990	Panel regressions with fixed effects and cross-section OLS regressions	The initial level of human capital played an important role in urban growth. Cities with higher levels of human capital have grown faster.
304 SMSA (Standard Metropolitan Statistical Area)	1. share of the population with tertiary education 2. number of patents per employee	1. average wage per hour	1990	Cross-section OLS regression	The inequality of the marginal product in cities is caused by the spillover effect.
SMSA (Standard Metropolitan Statistical Area)	1. share of population with secondary and tertiary education	1. employment	1940-1990	Panel regressions with fixed effects and cross-section OLS regressions	Two thirds of the growth is due to the effect of human capital due to increased productivity, the other part is due to the growth of quality of life.
SMSA (Standard Metropolitan Statistical Area)	1. share of population with tertiary education	1. median household income	2000	Cross-section OLS regression	Agglomeration effects (wage growth) are stronger in cities with higher skill levels.
85 Spanish urban areas	1. share of the population with tertiary education 2. share of employees with knowledge-intensive employment 3. number of years of work experience	1. average wage	2004-2009	Panel regressions with fixed effects	Workers in big cities earn more because of the learning by working effect.
218 SMSA (Standard Metropolitan Statistical Area)	1. employment by educational attainment 2. share of tertiary educated population	1. employment	1980-2000	Panel regressions with fixed effects and cross-section OLS regressions	Cities with a wider range of benefits provide more intellectually demanding jobs than cities with a narrow range of benefits. These cities provide less benefits.
380 SMSA (Standard Metropolitan Statistical Area)	1. share of population with tertiary education	1. average wage	2010	Cross-section OLS regression	Human capital located in peripheral areas has a greater impact on urban economic growth than human capital in centers. In addition, human capital in the largest cities has a greater effect than in smaller cities.
287 Dutch cities	1. share of population with tertiary education	1. employment by skill level	1998-2008	Panel regressions with fixed effects	Production effects predominate among highly skilled workers, while consumption effects predominate among less skilled workers.

No.	Author(s) (year of publication)	Research question
1.	Ruch J. E. (1993)	How large is the impact of an additional year of average education on the overall factor of productivity in cities?
2.	Glaeser E. L. et al. (1995)	What economic forces explain the urban growth in US cities?
3.	Simon C. J., Nardinelli C. (1996)	Do cities with a higher share of workers - professionals achieve higher growth?
4.	Eaton J., Eckstein Z. (1997)	How will the relationship between urban growth and human capital accumulation develop in the future?
5.	Simon C. J. (1998)	Do cities with higher levels of human capital achieve higher employment growth?
6.	Glaeser E. L., Maré D. C. (2001)	Why is the marginal product in cities 30% higher than in other areas?
7.	Simon C. J., Nardinelli C. (2002)	What has caused to some of American cities to grow more than others in the last 100 years?
8.	Glaeser E. L., Saiz A. (2004)	Why are more skilled cities achieving higher growth?
9.	Shapiro J. M. (2006)	What is the relationship between the concentration of skilled residents in the metropolitan area and growth in quality of life?
10.	Glaeser E. L., Ressenger M. G. (2009)	Are metropolitan areas with higher skill levels more productive than metropolitan areas with lower skills?
11.	Duranton G., Puga D. (2014)	Why do workers in big cities earn higher wages than in smaller cities?
12.	Diamond R. (2013)	What is the relationship between the concentration of workers according to their skill level and the development of benefits in urban areas?
13.	Florida R. et. al. (2016)	What role does spatially distributed human capital play in the economic performance of cities?
14.	Venhorst V. (2017)	What type of spillover effects outweigh effects of human capital in cities? Productive spillover effects or consumer spillover effects?

Source: Authors´own

Methods

The subject of research were 78 Slovak urban regions, which were defined by Rafaj (2018). Based on the population, the author classified urban regions into 4 size categories - large urban regions with a population greater than 100,000 inhabitants (a total of 9 urban regions), medium-large urban regions with a population between 50,001 to 100,000 inhabitants (18 urban regions), medium-small urban regions with a population between 20,001 to 50,000 inhabitants (26 urban regions) and small urban regions with a population less than 20,000 inhabitants (25 urban regions).

Both estimations (1. Estimation of the impact of production factors on the total product of Slovak urban regions; 2. Estimation of the impact of production factors between individual size categories) were based on econometric models from American economists Gregory N. Mankiw, David Romer and David N. Weil (1992). It is an extended Cobb-Douglas production function with the following form:

$$Y_{(t)} = K_{(t)}^{\alpha} * H_{(t)}^{\beta} * (A_{(t)}L_{(t)})^{1-\alpha-\beta} \quad (1)$$

where

Y_t – the dependent variable (a GDP per capita indicator) at time t
K_t – factor of capital
L_t – factor of labour
A_t – level of technological progress
H_t – factor of human capital
α, β – elasticity coefficients
t – time (the observed year)

Both models are based on OLS regression analyses with panel data for the years 2000, 2005, 2010 and 2016. The dependent variable (Y) is GDP per capita and independent variables are the share of employees per capita (L), the share of total assets per capita (K) and the share of university graduates (H). Data were collected from several sources. Data for human capital for observations 2000 and 2010 are from the Population and Housing Census (Census) 2001 and Census 2011. Data from Censuses 2001 and 2011 are publicly available at webpages of the Statistical Office of the Slovak Republic. Values for years 2005 and 2016 were obtained by statistical method of linear interpolation and linear extrapolation of values from 2001 and 2011. Socio-economic data necessary to calculate the GDP of all urban regions, as well as data on the number of employees and total assets, were from firms that employ 20 or more employees. The number of firms from which the processed data were aggregated differed in every observed year. In 2000, the sample consisted from 6495 firms. In 2005, the sample consisted from 6301 firms, in 2010 it consisted from 6593 firms and in 2016 the sample consisted from 8382 firms. These data are confident and were obtained from the Statistical Office of Slovak Republic under the contract no. ZML-6-18 / 2017-600. Data on the number of inhabitants come from publicly accessible statistics of the Statistical Office of the Slovak Republic.

All variables in the function are expressed in logarithmic form due to the problem of uneven data distribution. The functional notation of the model for estimating the impact of production factors for all urban regions therefore has the following form:

$$\log Y_t = \beta_{0_t} + \beta_1 \log L_t + \beta_2 \log K_t + \beta_3 \log H_t + \varepsilon_t \quad (2)$$

where

Y, K, L, H, t – variables from the previous equation (1)
log – the common logarithm
B_0, B_1, B_2, B_3 – coefficients of interest
ε – the residue

The functional notation of the model for estimating the impact of production factors between individual size categories of urban regions has the following form:

$$\log Y_{it} = \beta_{0_{it}} + \beta_1 \log L_{it} + \beta_2 \log K_{it} + \beta_3 \log H_{it} + \varepsilon_{it} \quad (3)$$

where

Y, K, L, H, t, log, $B_0, B_1, B_2, B_3, \varepsilon$ – variables from the previous equation (2)
i – a specific size group of urban regions

Data for GDP were calculated by the production method of GDP calculation. The calculation of this method is the sum of all final products and services that have been produced and provided in the territory of a given region for a certain period. It is calculated as the difference between the sum of the value added of each production stage of all sectors, together with paid taxes on production and the volume of subsidies and subsidies granted for production. The calculation of GDP by the production method takes the following form of notation:

GDP = Gross value added + taxes on production and imports + grants and subsidies on production (4)

where

GDP – gross domestic product
Gross value added – the value of output of all firms minus the value of their intermediate consumption
taxes on production and imports – the value of all compulsory, unrequited payments charged by general government in respect of the production and importation of goods and services, the employment of labour, the ownership or use of land, buildings or other assets that all firms used in production
grants and subsidies on production – the value of all payments provided by the general government to all firms on the production

Based on the accessed statistical data by the Statistical Office of the Slovak Republic, the following entry was used to calculate the GDP of individual urban regions:

GDP = Gross value added + income taxes + grants and subsidies on production (5)

where

GDP, Gross value added, grants and subsidies on production – variables from the previous equation (4)
Income taxes – taxes charged by general government on the earnings of all firms

Production tax data have been replaced by income taxes due to the unavailability of data. For more value-added data from confidential data for firms with 20 or more employees, they include revenues and sales for revenues of all firms. Therefore, replacing the product tax indicator with an income tax indicator seemed to be an acceptable choice.

Results

Based on the assumption of a model in which the observation objects (urban regions) did not change over time, OLS regression with panel data and fixed effects was used. The results of the Hausman test confirmed the correctness of using this type of regression. There was a significant correlation between the monitored indicators, but this was due to the fact that, except for the human capital indicator, all other indicators come from the same source - industry reports for firms with 20 or more employees. Thus, the development of the indicators of GDP, labour, and capital are closely related to each other, since they were calculated from the same source. The potential problem of multicollinearity was tested using the VIF (variation inflation factors) method. The VIF test values using the variables in the natural form were less than 5 (mean value 3.47), which means that there was no multicollinearity between the indicators.

The results from the first regression are provided in Table 2. A total of 78 urban regions were observed over 4 time periods, but the total number of observations was 311, as 2016 data for one urban region were not available. The total significance of the model (R-sq overall value) is 0.8327, which means that the observed relationship of independent variables explains the dependent variable to 83%. The remaining 17% does not explain the chosen econometric model. The results of the regression also show that all independent variables (production factors per

capita) are statistically significant (p values are less than 0.001) and all of them have a positive effect on the dependent variable (GDP per capita). Moreover, results show that the human capital factor had the greatest impact on the GDP indicator per capita in all urban regions. The processed data show that by increasing the human capital factor by 1% will increase GDP per capita by 0.82%. Thus, if the share of the university-educated population in the urban region were to increase by 1%, the total product of the region would increase by 0.82%. Furthermore, according to results, capital had the second largest impact on the level of product of urban regions. By increasing capital per capita by 1%, the product per capita of the urban region will increase by 0.52%. And finally, the labour factor had the lowest, but not negligible, impact. By increasing the labour factor (share of employees per capita) in the urban region by 1%, GDP per capita will increase by 0.41%.

Table 2. Fixed-effects regression results for all urban regions.[1]

All urban regions							
Fixed-effects (within) regression					Number of obs	=	311
Group variable: Codes					Number of groups	=	78
R-sq:	within	=	0.7697		Obs per group: min	=	3
	between	=	0.8558		: avg	=	4.0
	overal	=	0.8327		: max	=	4
					F (3, 230)	=	256.21
					Prob > F	=	0.0000

	Coef.	Std. Err.	T	P > | t |	[95% Conf.	Interval]
log L	.4132158	.0499632	8.27	0.000	.3147717	.51166
log K	.5154161	.0516805	9.97	0.000	.4135884	.6172438
log H	.815292	.0638928	12.76	0.000	.6894019	.941182
_cons	2.478263	.2730705	9.08	0.000	1.940223	3.016302
sigma_u	.113475532					
sigma_e	.112116977					
rho	.59070829	(fraction of variance due to u_i)				

F test that all u_i = 0: F (77, 230) = 5.14 Prob > F = 0.0000

Source: Authors´own

From the comparison of the results of fixed-effects regressions for individual size category of urban regions it is clear, that all independent variables have a positive effect on the GDP per capita indicator. The data also show that apart from the factor of labour in the categories of large and medium-large urban regions, all factors are statistically significant. According to results their p values are lower than 0.001. In the category of large urban regions, the human capital factor had the greatest impact on the GDP per capita indicator. Increasing the share of university-educated inhabitants in the region of this size category by 1% will increase the total product per capita in the region by 0.85%. The effect of the factor of human capital factor in this category has a similar effect on the indicator GDP per capita as it has in the analysis of all urban regions. However, results for the category of large urban regions need to be taken with some distance, because they are based only on 36 observations. To confirm this result, it would be necessary to examine this relationship by a larger number of observations. In the group of medium-small urban regions, the largest impact on the GDP per capita indicator had the factor of capital. Increasing the share of capital per capita by 1% the total product per capita in medium-small urban regions will increase by 0.63%. The value of GDP per capita in the group of medium-large urban regions was similarly strongly influenced by capital and human capital factors. The human capital factor had a slightly greater impact on the monitored indicator. An increase of 1% will increase the total product per capita in this category by 0.65%, while an increase of 1% in the factor of capital per capita will increase the total product per capita by 0.63%. In the category of small urban regions, the human capital factor had the highest impact on GDP per capita. Increasing the share of the university-educated population in this category by 1% will increase GDP per capita approximately by 0.90%. All results of fixed-effects regressions for every individual size category of urban regions are provided in Table 3.

[1] Note: Standard errors in parentheses. *, ** and *** denote significance level at 0.10, 0.05 and 0.01 respectively.

Table 3. Fixed-effects regression results for individual size categories of urban regions.[2]

	(1) Large urban regions	(2) Medium-large urban regions	(3) Medium-small urban regions	(4) Small urban regions
	log HDP per capita	log HDP per capita	log HDP per capita	log HDP per capita
log L	0.0234	0.0358	0.408***	0.497***
	(0.818)	(0.792)	(0.000)	(0.000)
log K	0.439***	0.629***	0.650***	0.421***
	(0.001)	(0.000)	(0.000)	(0.000)
log H	0.846***	0.560***	0.653***	0.898***
	(0.000)	(0.000)	(0.000)	(0.000)
_cons	2.462***	1.404*	1.832***	3.005***
	(0.001)	(0.011)	(0.000)	(0.000)
N	36	72	104	99
R-sq	0.909	0.842	0.873	0.669
F	79.57	90.90	171.4	47.87
df_m	11	20	28	27
df_r	24	51	75	71

Source: Authors´own

The results of the regressions from Table 3 also show that production factors had different effects on the GDP per capita indicator on different categories. Human capital had the highest impact in small urban regions. The labour factor was statistically significant only in medium-small and small urban regions. However, in comparison between these two categories, it had a larger impact on the GDP per capita indicator in the category of small urban regions. While with a 1% increase in the factor of labour in the category of small urban regions, GDP per capita would increase by less than 0.50%. With the same increase in the category of medium-small urban regions, the total product per capita would increase only by 0.40%. And finally, the factor of capital has the largest impact on the category of medium-small urban regions. Increasing the factor by 1% would increase the GDP per capita indicator by 0.65%.

Discussion

From the results of the analysis of the impact of production factors on the total product it is clear, that among the monitored production factors, human capital has the largest impact on total product in all urban regions. This means, that our findings are consistent with the results and conclusions of the works of Berry and Glaeser (2005), Glaeser (2011), or Moretti (2004; 2012). This means, that the economic "strength" of cities is mainly driven by the large stock of smart and very well-educated people and not by large stock of capital (e.g., machines) or a high rate of employment. This conclusion was also confirmed by our case of Slovak urban regions (cities). Therefore, in order to have a successful city, it is reasonable for public authorities to attract and maintain smart and well-educated people in their cities. Moreover, from our findings of the analysis of the impact of human capital on the total product between different size categories of cities it is clear, that the largest impact has human capital in small cities. This result is in contrary with the findings of foreign studies, e.g., from Berry and Glaeser (2005) or from Florida, Mellander and Stolarick (2016). According to findings from foreign studies, the largest impact of the factor of human capital on the economic output can be seen in the largest cities. The difference of our results and the results of foreign studies could be caused by the statistical effect of small numbers. Studies by Berry and Glaeser (2005) or Florida, Mellander and Stolarick (2016) have analysed more observations, than we did. In addition, these foreign studies were analysing US statistical metropolitan areas (SMAS) with a minimum population of 250,000 inhabitants, but in our study, we analysed much smaller cities.

The author of this contribution is well aware of two major shortages of his analysis. First, in both models were used data for only one indicator as the factor of human capital. In both models, the indicator of human capital was represented by the share of tertiary educated inhabitants. The author of this contribution admits that for a deeper and more detailed analysis it would be useful to monitor other indicators of human capital, such as by the average years of schooling (as proposed by Rauch, 1993), or by the median number of years of education (Glaeser et al. 1995), by number of years of work experiences (Glaeser and Maré, 2001) or by the share of employees with knowledge-intensive employment (Duranton and Puga, 2013). Unfortunately, due to data limitations it was not possible to elaborate an analysis with these other indicators. Therefore, the only possible indicator to use was the

[2] Note: Standard errors in parentheses. *, ** and *** denote significance level at 0.10, 0.05 and 0.01 respectively.

share of tertiary educated people. The second shortage is related to the lack of real data for the indicator of human capital for observed years of 2005 and 2016. Data for the indicator of human capital were collected from the Censuses 2001 and 2011, and these collections of data are provided only once per 10 years. Therefore, the author decided to use the statistical method of interpolation and extrapolation of data from Censuses 2001 and 2011 to obtain data for 2005 and 2016.

This contribution therefore serves as an argument for a public discussion on the support of attracting and maintaining smart, well-educated people into cities.

Conclusion

The main aim of this article was to estimate the impact of production factors on the total output of Slovak urban regions (Slovak cities). The results of the analysis confirmed the key role of the factor of human capital on the economic output of Slovak cities. From the comparison of effects for different size categories of urban regions it is clear, that human capital has the largest impact on the total output in smaller cities. But these results have to be taken with some caution, because of non-standard data were used in the analysis. Thus, based on the results of this analysis, regional and local public policy makers should primarily focus on supporting the attraction and maintenance of human capital in their territories. As it is known from the vast body of foreign literature, public authorities should focus their interest into public support on local amenities, because they play a great importance to the university-educated people in their decision on their choice of localisation.

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