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CROSS-COUNTRY INCOME DIFFERENCES: EMERGING ECONOMIES

Case Study

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Steady state;
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JEL Classification
O47, E2, E13

Abstract

The purpose of this article is to analyze why there are very large differences in income per capita (or output per worker) across countries today and to examine whether countries with same characteristics will develop in the same time and will grow fast enough to reduce the income gap between themselves. The empirical study analyzes the income evolution of six countries over the period 1995-2016: Romania, Poland, Hungary, Croatia, Czech Republic and Bulgaria. Several models are estimated in order to test the „unconditional convergence" and „conditional convergence". The second type of convergence is tested based on Solow model, which includes investments in physical capital and population growth (increased with technological growth and capital depreciation rate) and based on Augmented Solow model, which adds human capital.

INTRODUCTION

The phenomenon of convergence was studied at the beginning using Solow predictions (1956). He considered that countries having same characteristics will reach same steady-state level. Mankiw, Romerand Weil (1992) argued that Solow's prediction refers to convergence speed and the convergence of one country to its own steady-state level. Since Solow model considers that the main factors influencing economic growth are population growth, technologic progress and investment rate, Mankiw, Romerand Weil (1992) wanted to emphasize the importance of human capital factor, therefore he had conducted analyzes which show that convergence speed is higher for the models which consider human capital variables.

There are two types of convergence described by the economic literature:

- unconditional convergence (named also absolute or beta convergence) – countries with different characteristics tend to reach same steady-state level, this means that poor countries will growth faster than rich countries in order to catch-up and to diminish the income gap
- conditional convergence (named also sigma convergence) – countries with same characteristics tend to reach same steady-state level on long-term. These characteristics are seen as variables which are conditioning the income steady-state level.

The aim of this article is to examine whether countries with same characteristics will develop in the same time and whether they will grow fast enough to reduce the income gap between themselves. The empirical study analyses the income evolution of six countries over the period 1995-2016: Romania (ROU), Poland (POL), Hungary (HUN), Croatia (HRV), Czech Republic (CZE) and Bulgaria (BGR). All countries are European Union's members which didn't adopt yet euro currency. The data is collected from The World Bank database. Period analyzed was restricted by the data availability for Poland and Croatia, which is missing before 1995 for some variables included in the analyses and by the data availability only till 2016 for the variables used as proxy for educational and healthy status.

This article focuses on economies' estimations out of steady state. First, it is ignored the fact that countries differ in saving rates, population and technological growth rates and afterwards these differences are considered.

Paper is structured as follows: section 2 summarizes the theoretical literature, section 3 presents the analysis of the cross-country economy evolution of the six countries over the period 1995-2016, section 4 estimates the economies out of their steady-state level and section 5 concludes the findings of the study.

LITERATURE REVIEW

Economic growth has been studied for a long time by economists using different countries, growth models and econometric methods. All these analyses try to identify and to explain the factors that determine the economic growth. There are very large differences in income per capita and output per worker across countries today. According to Acemoglu (2007, ch.1), distribution of Gross Domestic Product (GDP) per capita is relevant for the welfare of the population, however if focus is on the productive capacity of countries, output per worker (GDP per worker) should be analyzed.

Robert Solow (1956) is among the first one who analyzed the determinants of the economic growth by defining the neoclassical production function. The model considers that the growth per capita income is determined by saving rate, population growth and technological progress. The dynamic of population growth and technical progress are considered exogenous; therefore the steady state is determined by the saving rate. With other words, the increase of the saving rate has a positive influent into the growth rate per capita income, however Solow has showed that persistent growth comes from technical progress and not from savings. Mankiw, Romerand Weil (1992) included human capital as another important factor that determines income.

Both models address the question of whether low-income countries tend to grow faster than rich countries, therefore the income gap between these two types of countries becomes smaller over the time. Weil (2013, p.87) defines the convergence as being "the process by which a country's per worker output will grow or shrink from some initial position toward the steady-state level". The steady state is the moment when capital per worker, k, is stable (the change in k is zero). Solow model considers that the convergence will be noticed for countries with similar characteristics (physical and human capital investment rates, population and technological growth rates). Romer concludes from his model, that it is not possible that poor economies grow fast and reduce the gap between them and the advanced economies. The income level in rich countries increase also due to the constant returns to capital, as stated by Rebelo (1991) or due to returns to knowledge, as showed by Romer (1990), therefore the income gap between countries will always exist.

The convergence property can be represented by the Solow model equation divided by k, (equation 1):

$$\frac{\dot{k}}{k} = s \cdot \frac{f(k)}{k} - (n + g + q) \qquad (1)$$

where, $k = K/L$ is physical capital per unit of effective labor (K is capital input and L is labor

input), $\dot{k}$ is a capital stock per unit of effective labor over time, s is saving rate, *f(k)* = $k^{\alpha}$is the production function, *n* is labor input change over time because of the population growth, g is depreciation rate of the capital input and q is the technological progress.

The average product of capital ($\frac{f(k)}{k}$) decreases as the capital increases. With the sum $(n + g + q)$ being constant, a country can register higher growth rate of capital and income per capita if it is far away from its income steady-state level (Jones, 2002, ch.3).

Barro (1992) stated that economies with a lower initial level of capita and income per capita tends to grow faster than economies with higher initial level of capital and income per capita (equation 2).

$$\frac{k}{k} = s \cdot \frac{k^{\alpha}}{k} = s \cdot k^{\alpha-1} \qquad (2)$$

Acemoglu (2007) and Barro and Sala-i-Martin (2004) discussed about two types of convergences: "unconditional convergence" and "conditional convergence". According to "unconditional convergence" of income per capita (or per worker) "the income gap between two countries increases or decreases irrespective of these countries characteristics (e.g. institutions, policies, technology or even investments)". According to "conditional convergence", countries are different from point of view of investment rates, population and technological growth rates and, therefore, have different steady-states points.

"Conditional convergence" is captured by "Barro growth regression" (equation 3):

$$g_{t,t-1} = \beta \cdot lny_{t-1} + \alpha \cdot X_{t-1} + \varepsilon_t \qquad (3)$$

where, $g_{t,t-1}$ is the annual growth rate between dates t-1 and t, y_{t-1} is output per worker (or income per capita) at date t-1, X_{t-1} is the vector of variables that condition the regression and $\varepsilon_t$is the error term. Variables included are considered determinants of stead-state income growth.

One question addressed in many studies is which factors should be included in vector of variables X_{t-1}. With other words, which factors correlate with the economic growth.

Barro and Sala-i-Martin (2004) estimate β to be approximately equal with -0,02, which indicates that the income gap between countries with same human capital skills have been reduced over the time. Same value is estimated by MRW (Mankiw, Romerand Weil).

By excluding the vector of variables X_{t-1}, we obtain "unconditional convergence" (equation 5):

$$g_{t,t-1} \cong lny_t - lny_{t-1} = \beta \cdot lny_{t-1} + \varepsilon_t \qquad (4)$$

$$lny_t \cong (1 + \beta) \cdot lny_{t-1} + \varepsilon_t \qquad (5)$$

The neoclassical model states that convergence will be observed only among countries that have similar steady-state level, while, in an endogenous AK model, the convergence is never observed, due to the constant returns in capital and, thus, in income per capita. The level of investments is always higher than the depreciation rate (Koutun and Karabona, 2013).

ANALYSES OF CROSS-COUNTRY'S ECONOMY EVOLUTION

The cross-country economy evolution analyses use the model realized by Acemoglu, "Introduction in modern economic growth" (2007, ch.1). This article focuses on Romania, Poland, Hungary, Croatia, Czech Republic and Bulgaria.

High income levels reflect high standards of living. Economic growth might increase the level of consumption, the level of education and health. However, when comparing rich countries with less-developed ones, are big differences in the quality of life, standards of living and health.

Figures 1 and 2 present the differences and the relationship between GDP per person employed in 2016 and consumption per population of age 15 and older in 2016 and life expectancy at birth in 2016. It can be noticed that the differences between GDP per person employed is strongly related with the differences in consumption and health (measured by the life expectancy at birth). Therefore, the countries that are producing more are also consuming more. Similarly, cross-country differences in health are visible. From the group of countries analysis, Czech Republic is the one with the highest living standard and welfare and Bulgaria is the poorest one.

It is important to understand why some countries are richer than the others. However, it should be considered that a country being rich it doesn't mean that total population leaving in this country have a high living standard and welfare.

Figure 3 shows the evolution of GDP per capita for all six countries analyzed over the period 1995-2017. Czech Republic is a richer country compared to Bulgaria because it has registered a constant growth during the period analyzed, even though Bulgaria has also grown. Till economic crisis (2007), Czech Republic and Hungary are in the top, during the economic crisis period (2008-2010) Poland is the only one that has been continued to growth and after economic crisis period (starting with 2010) all six countries have been registered growth.

It can be noticed that the income per capita gap was existing since the begin of the period analyzed, but it doesn't help us in understanding the causes of these differences. We can see that Poland was the

third poor country in 1995, however it is the second rich country in 2017.

It can be easier to analyze which country has grown more than the others in figure 4. Countries placed around the 45° line didn't change too much during the period analyzed. In this case β is approximately equal to zero (see equation 5). The ones that change most are Bulgaria, Romania and Czech Republic.Based on the economic theory where is mentioned that countries with low initial income levels tend to grow faster, it is expected that income from 1995 is negatively related to the growth in income over the period analyzed. Figure 5 shows a strong negative relationship between average growth rate over the period 1995 and 2006 and GDP per person employed in 1995. This may happen due to the homogeneity of the six countries included in the analyze, therefore "unconditional convergence" is present.

Countries analyzed tend to converge to the same steady-state level of income per worked in the long run. Also, they have similar population growth rate and capital depreciation rate. The result presented in figure 5 confirms the finding of other authors, saying that the convergence is easier to be observed among similar countries.

One question addressed in many studies is what factors correlate with the economic growth. Some of these factors are those presented by Basic Solow model and Augmented Solow model: investments in physical capital and human capital and population growth. Gross capital per GDP is used as proxy for physical capital and school life expectancy for tertiary level per population of age 15 and older as proxy for human capital. Figures 6 and 7 represent that the relationship between average growth rate of GDP per person employed and average investment growth rate and average years of schooling per population of age 15 and older. Both relationships are positive.

Czech Republic is the country which has the higher level of gross capital per GDP followed by Romania and Hungary, however the impact on income growth is different. Most probably there are other factors which had a stronger impact, since Romania is the one that registered the higher grow.

Based on the relationship between income growth and human capital (figure 7), Poland and Romania are still on the top of the list as being the countries which have invested the most in the human capital, however Croatia has invested the least.

Countries which had grown faster during the period analyzed are those which had invested more in physical and human capital.

ESTIMATION OF ECONOMIES OUT OF THEIR STEADY STATE

For estimating the economies out of their steady state, it is used multivariable regression analysis. The database source is The World Bankand variables are processed in Eviews. All of them are expressed in logarithm. Table 1 shows the variables' notations used in the regression analysis.

Since, annual data is used, it is not needed to analyze the series in terms of seasonality, therefore the existence of unit roots is checked using Augmented Dickey Fuller (ADF) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. When tests' results indicate that variables are not stationary, they have been integrated of the first order. The null hypothesis of the ADF test characterizes the series as non-stationary or unit root process. This hypothesis is accepted if p-value associated to the statistic of the test is higher than 5%.

The main equation used is based on Augment Solow Model (MRW,1992). Equation 6 assumes that all countries are at their steady-state point.

$$\ln y_i^*(t) = lnA_i(0) + \frac{\alpha}{1-\alpha-\beta}\ln\left(s_{k,i}^*\right) + \frac{\beta}{1-\alpha-\beta}\ln\left(s_{h,i}^*\right) - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n_i + g + q) + \varepsilon_i \quad (6)$$

where, $A_i(0)$ is the initial level of technology, α and β are the returns to physical and human capital, $s_{k,i}$ and $s_{h,i}$ are the part of income invested in physical and human capital and ε_i is the error term.

The Solow growth model predicts that countries will converge to different steady-state levels considering that they have different determinants of their steady-state: accumulation of the human and physical capital and population growth. This is the definition of the "conditional convergence" phenomenon (equation7, according to MRW model,1992).

$$\ln\left(\frac{y_i(t)}{y_i(0)}\right) = (1-e^{-\rho t})\left(\frac{\alpha}{1-\alpha-\beta}\ln\left(s_{k,i}^*\right) + \frac{\beta}{1-\alpha-\beta}\ln\left(s_{h,i}^*\right) - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n_i+g+q)\right) - (1-e^{-\rho t})\ln\left(y_i(0)\right) + \varepsilon_i \quad (7)$$

where, $\rho = (n_i + g + q)(1-\alpha-\beta)$. Convergence rate ρ is reflecting the speed of convergence to steady state.

First, it is analyzed the cross-country economies assuming that they are characterized by the unconditional convergence, afterwards it is assumed that the economies are out of their steady-state level considering also that countries differ in saving rates, population and technological growth rates (conditional convergence without and with human capital).

According to neoclassical Solow model, a country reaches a higher steady-state level of income per capita when it has a higher saving rate and a lower rate of the sum of population, technological growth and capital depreciation rate.
Table 2 presents the results of the unconditional convergence. This model is assuming that there are no differences between countries' characteristics. The coefficient of the initial level of GDP per person employed is significantly negative, R-squared is 50% and convergence rate ρ is 0,02 (as estimated by MRV, 1992). All these indicate a tendency toward convergence for the countries included in the analysis.
Table 3 illustrates the results of the conditional convergence as presented by Solow model, considering the differences in saving rates, population and technological growth rates (conditional convergence without human capital). Factors included in the estimations are investments in physical capital and population growth rate (increased with 0,05 as proxy for technological growth and capital depreciation rate). Coefficients of the three factors included are negative or positive, exactly as presented in the economic theory. R-squared is 30% and convergence rate ρ is 0,012. The speed toward convergence is a bit lower, however tendency exists.
Table 4 presents the results estimated based on equation 7, which adds a new factor as being different between countries (model introduced by MRV, 1992). The new factor is investments in human capital. Coefficients of the four factors included are negative or positive, exactly as presented in the economic theory. R-squared is 43% and convergence rate ρ is 0,014. The speed toward convergence is still low. This new variable has increased the convergence rate.

CONCLUSIONS

The article studies the presents of the convergence across countries: Romania (ROU), Poland (POL), Hungary (HUN), Croatia (HRV), Czech Republic (CZE) and Bulgaria (BGR), over the period 1995-2016. Several models are estimated in order to test the „unconditional convergence" and „conditional convergence". The second type of convergence is tested using a Solow model, which includes investments in physical capital and population growth (increased with technological growth and capital depreciation rate) and using the MRW model, which adds human capital to the Solow model.
Both types of convergences are observed in the group of countries analyzed. The unconditional convergence is more present than conditional convergence due to the fact the coefficient of the initial income per worker is stronger significantly negative: -0,41 in the unconditional convergence test compared with 0,23 in the conditional convergence without human capital test and 0,26 in the conditional convergence with human capital test.
The convergence rate, which represents the speed of convergence to steady state, is higher in the unconditional convergence test, 0,025 compared with 0,012 in the conditional convergence without human capital test and 0,014 in the conditional convergence with human capital test.
It was found that countries tend to converge faster to their steady states under the conditions of the Augmented Solow model compared with conditions of the Basic Solow model. Some results were identified by Mankiw, Romerand Weil (1992) where it was shown that Augmented Solow model can explain much of the cross-country income variance through the variance of physical capital, human capital and population growth.
The reason of R-squared around 50% in all models estimated can be explained by the absence of other variables which were not considered by the models. For future analyzes, more variables could be included and other proxy for human capital could be considered.
The results show that higher investments in human capital determine the shrink of the income gap between countries. A deeper analysis could be conducted in studying the population growth rate. For most of the countries included in this article, the rate is negative, meaning that the population is aging, therefore could explain why investments in human capital and output are lower for some of them.

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TABLES & FIGURES

Table No. 1
Variables notations used in the regression analysis

Notations	*Variables*
$\ln(Y_i1995)$; $\ln(Y_i2016)$	Natural log of GDP per person employed (constant 2011 PPP $) in 1995 and 2016
$(\ln(Y_{i,t})-\ln(Y_i1995))$	Natural log of the average amount of the difference between GDP per person employed (constant 2011 PPP $) over the period 1995-2016 and GDP per person employed (constant 2011 PPP $) in 1995
$\ln(s_{k,i})$	Natural log of the average amount over the period 1995-2016 of the GDP invested in physical capital. The proxy chosen is Gross capital formation per GDP (constant 2011 PPP $)
$\ln(s_{h,i})$	Natural log of the average amount over the period 1995-2016 for the GDP invested in human capital. The proxy chosen is the percentage of population of age 15 and older in school life expectancy, tertiary, both sexes (years)
$\ln(n_i+0,05)$	Natural log of average growth rate of the population of age 15 and older increased with 0,05 (amount which is used in several articles for sum of depreciation and technological growth rates)

Table No. 2
Unconditional convergence

Dependent Variable: log difference of GDP per person employed 1995-2016
Included observations: 6

Variable	*Coefficient*	*Std. Error*
C	4,559185	2,099265
Ln (Y_i1995)	-0,410507	0,203617
R-squared	0,504004	
S.E. of regression	0,130822	
Implied ρ	0,025166	

Source: authors' estimations based on The World Bank database

Table No. 3
Conditional convergence without human capital

Dependent Variable: log difference of GDP per person employed 1995-2016
Included observations: 6

Variable	*Coefficient*	*Std. Error*
Ln (Y_i1995)	-0,238275	0,23961
Ln ($s_{k,i}$)	0,360548	0,74195
Ln (n_i + 0,05)	-0,538090	0,52828
R-squared	0,300350	
S.E. of regression	0,179412	
Implied ρ	0,012960	

Source: authors' estimations based on The World Bank database

Table No. 4
Conditional convergence with human capital

Dependent Variable: log difference of GDP per person employed 1995-2016

Included observations: 6

Variable	*Coefficient*	*Std. Error*
Ln (Y_i1995)	-0,260474	0,266534
Ln ($s_{k,i}$)	0,180608	0,860856
Ln (n_i + 0,05)	-0,450406	0,597319
Ln ($s_{h,i}$)	0,070367	0,103580
R-squared	0,4315290	
S.E. of regression	0,1980670	
Implied ρ	0,0143688	

Source: authors' estimations based on The World Bank database

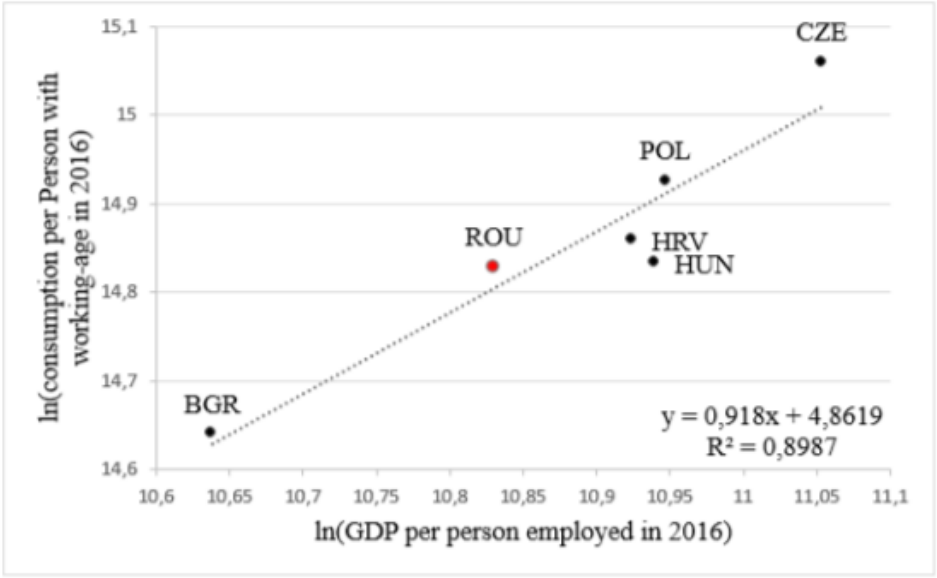

Figure No. 1
GDP per person employed and Consumption per populationof age15 and older, 2016
Source: authors' estimations based on The World Bank database

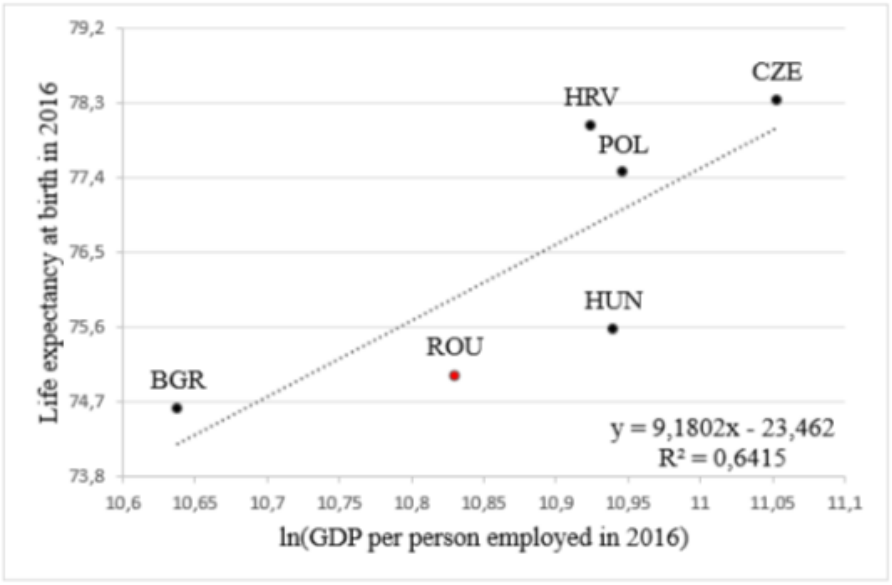

Figure No. 2
GDP per person employed and Life expectancy at birth, 2016
Source: authors' estimations based on The World Bank database

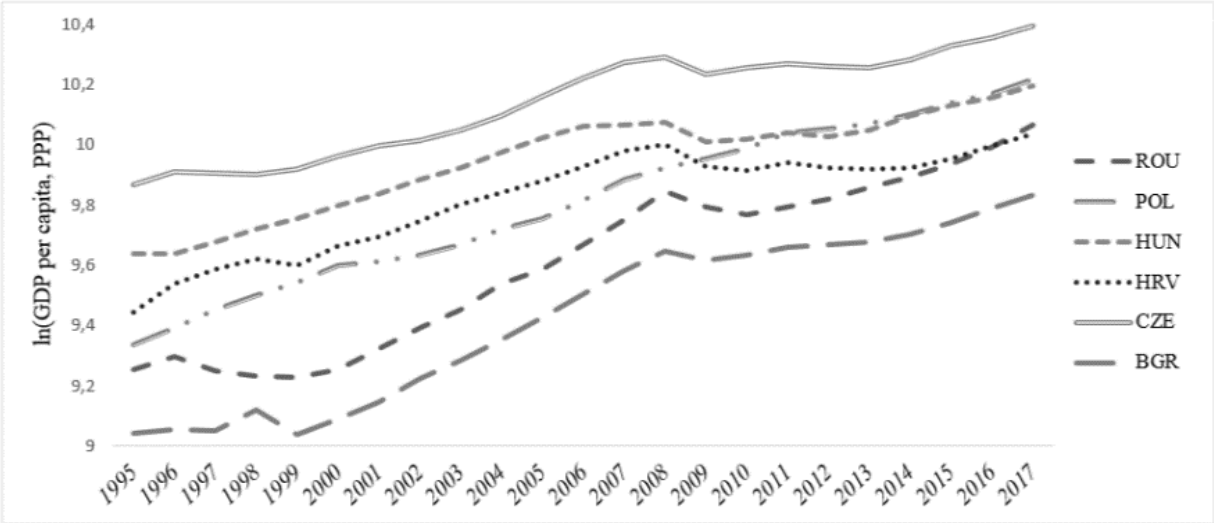

Figure No. 3
The evolution of GDP per capita, 1995-2017
Source: authors' estimations based on The World Bank database

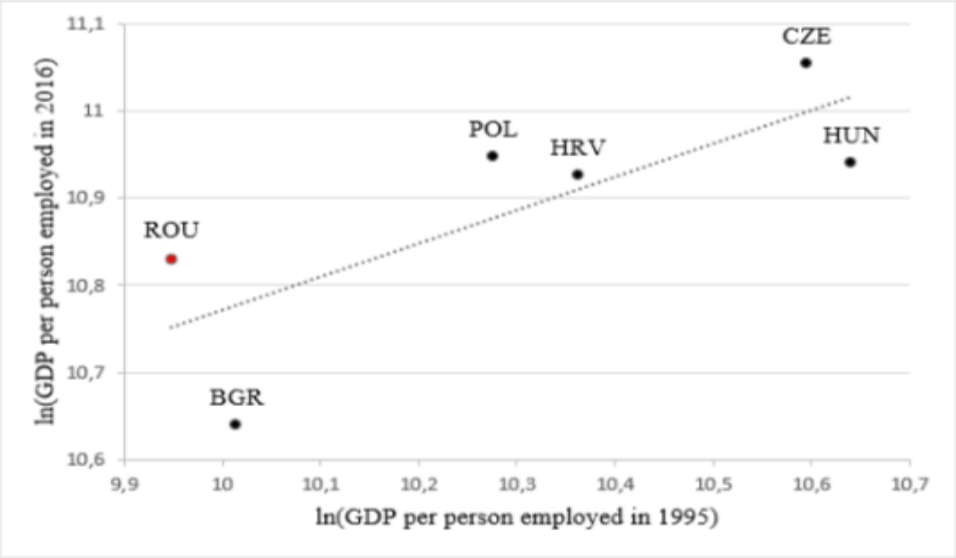

Figure No. 4
GDP per person employed,1995 and GDP per person employed, 2016
Source: authors' estimations based on The World Bank database

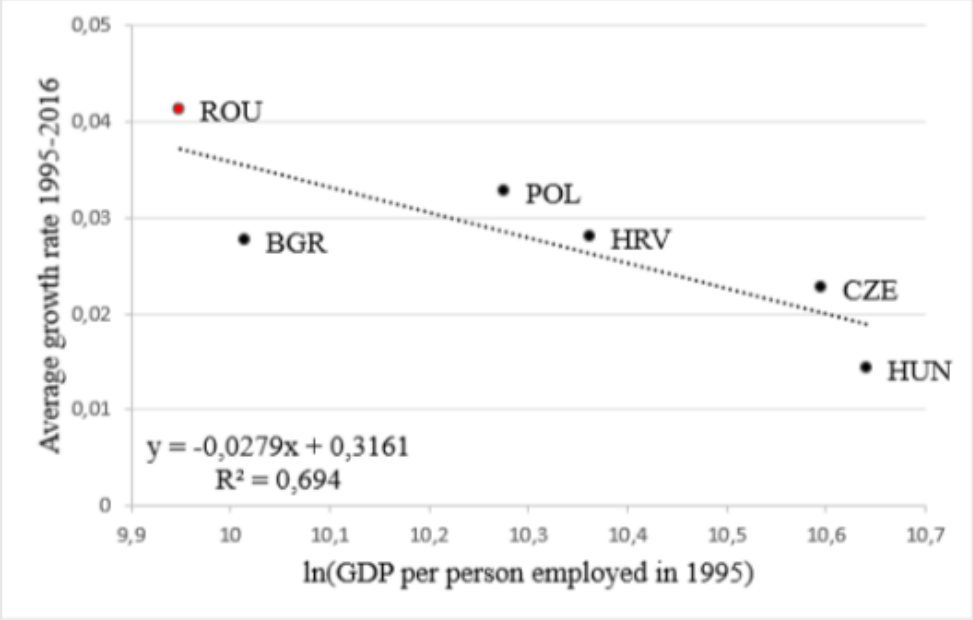

Figure No. 5
Average growth rate, 1995-2016 and GDP per person employed, 1995
Source: authors' estimations based on The World Bank database

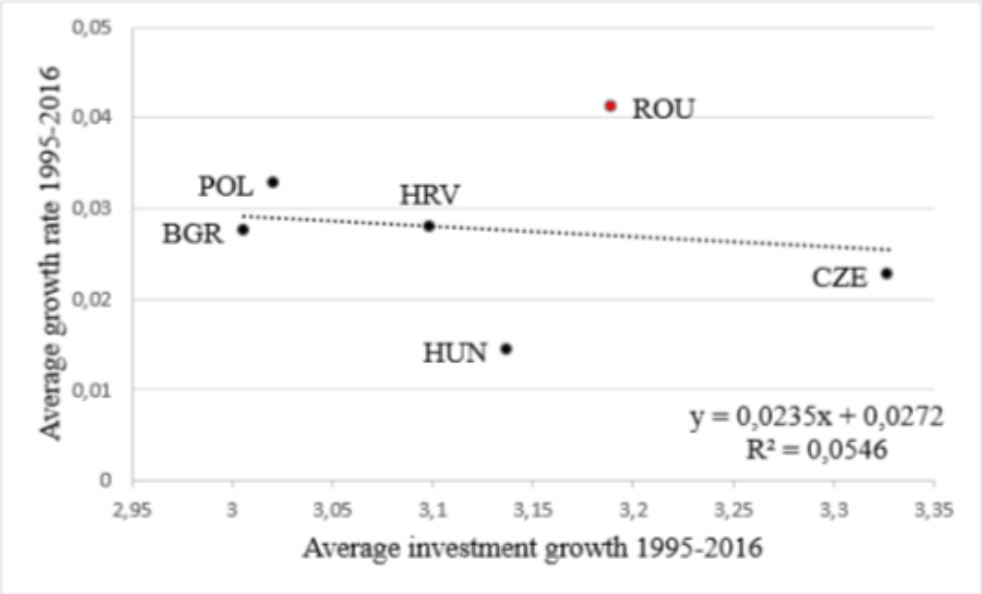

Figure No. 6
Average growth rate and average investment rate, 1995-2016
Source: authors' estimations based on The World Bank database

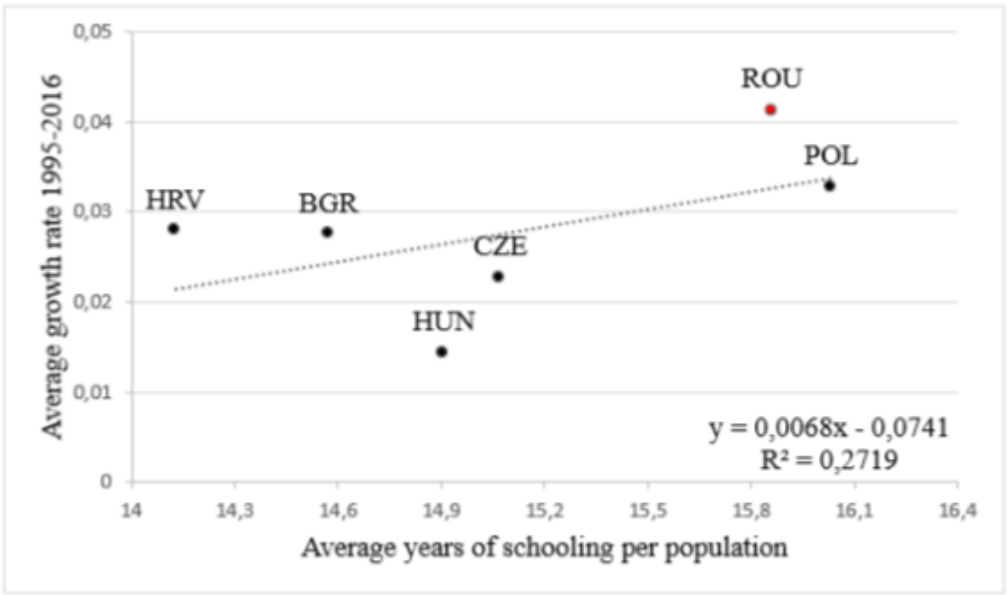

Figure No. 7
Average growth rate and average of schooling years, 1995-2016
Source: authors' estimations based on The World Bank database