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# The GDP per Capita Convergence in the European Union

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***Abstract*** *This paper tests the hypothesis of convergence in per capita GDP for the period 2008-2016 using the case study of European Union (EU) Member States. We also included Croatia into the analysis, even though it became an EU member only in 2013. The general framework for testing the convergence hypothesis is based on the panel data approach. Our results show that there was a convergence in per capita GDP (expressed in thousands Euro PPS in the EU-28) during the period 2003-2016, at a significance level of 5%. The outcomes of the Im-Pesaran-Shin test demonstrate that not all the EU-28 countries yielded the same speed of convergence towards the corresponding steady state. The quantitative approach of the convergence in GDP per capita in the European countries based on the fixed effects model is complemented by the presentation of maps, cartograms, and histograms.*

***Key words*** Convergence, steady state, GDP, panel data, Im-Pesaran-Shin test, European Union

**JEL Codes**: C23, C51, F43

## 1. Introduction and literature review

Many scientists and European scholars were interested in assessing the impact of integration on the income inequalities. Some of them argued that the extension of European Union increases the inequality and consequently the divergence process is more obvious. However, other researches brought evidence that integration diminished the inequality tendency.

Petrakos, Rodrígues-Pose and Rovolis (2003) observed from the inequality evolution in European Union short-run divergence but long-run convergence. The regional inequalities follow an obvious cyclical pattern. Similar results were registered inside of each member of EU at the national level. Puga (1999) analyzed the relation between the regional integration and observed differences between countries regarding the income and the production structure. Later, the same author Puga (2002) showed that over the last three decades the inequalities between European countries have not substantially decreased. The income inequalities diminished between states, but inside of each country there are large inequalities between its regions.

Petrakos and Artelaris (2009) analyzed the European regional convergence using a weighted least squares approach, showing that poor countries tend to grow faster than the rich ones.

Iancu (2009) used the sigma convergence to measure the evolution of real convergence process between the EU countries on three groups: EU-25, EU-15 and EU-10, the coefficient of variation indicating a divergence growth of the economies during 1995-2006.

The nominal convergence is a multilateral process that supposes the gradual and relative high harmonization of policies and national institutions of the EU members in financial and monetary domain. The measures for achieving the nominal convergence are strongly correlated with the demarches for economic integration. Maastrich treaty is, actually, the official document that confirms the introduction of this concept of “nominal convergence”. It ensured the introduction of a common monetary policy that uses the same currency and a single central bank- Central European Bank. Moreover, this treaty indicated the nominal convergence criteria for EU members in order to become members of European monetary zone. The objective of exchange rate policy and of common monetary policy is to ensure the prices stability and the supporting of the general economic policies in EU for achieving real convergence.

The convergence criteria are, in fact, minimal conditions required for EU members in order to enter euro area. These countries do not have to give up to their national monetary policy or to national currency, but they have to adopt the common monetary policy of the European Central Bank and to adopt the single European currency.

The nominal convergence means to align prices and income. If it is not accompanied by real convergence, it will generate import surplus and current account deficits in poor countries. The current account deficit generates the crisis adjustment in terms of unsustainable incomes and prices. This process can be observed in the euro area countries facing the economic crisis. The real convergence supposes that goods and services production grows more in poor countries compared to reach ones in order to bring near the levels of consumption and production. This approach is based on productivity growth that induces convergence. The economic prosperity has to be the consequence of innovation and investment. The nominal and the real convergence cannot be separated. The nominal shocks have real effects.

Capital inflows unleash real processes that continue to develop on long run. On the other hand, the increases in real productivity generate prices and incomes growths in sectors without a great increase in productivity or in nominal

convergences. In what concerns the advantages of euro adoption, the most important one is related to the elimination of exchange rate risk and the stimulation of external commerce.
For analyzing the convergence in GDP per capita in EU-28, two approaches are proposed: suggestive maps and graphs and a quantitative approach rarely used in literature because of the method complexity.
Beside the graphical representation with an intuitive character, there are advanced quantitative methods for checking the convergence hypothesis in EU. Even if most of the studies from literature are based on the statistical indicators computation for analyzing the economic convergence, only few approaches use some statistical tests for checking the convergence. For example, the coefficient of variation is calculated for each year, following then its evolution in a certain period. In a certain time period, the indicator might not decrease from a year to another. It might increase then decrease and it does not offer a unitary image on the global process of convergence. The statistical tests on panel data allow the formulation of a unique conclusion (convergence or divergence), even if they permit some interpretations when the convergence is confirmed. It is possible to have countries that have GDP per capita values that do not converge towards the European mean.

## 2. Methodology of research

Aspects regarding the analysis of GDP per capita convergence might be put into evidence using maps and various types of graphs. In literature, the graphs in analyzing the convergence are used more to emphasize the conclusions related to economic convergence analysis based on the calculation of some convergence indicators. However, the graphs allow us to see in a simple and useful way groups of countries with close values for GDP per capita or high differences regarding this indicator values.
One of the most used statistical indicators for appreciating the economic convergence or divergence at a certain moment is given by the coefficient of variation:
The dispersion (variance) is computed as:

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2 \quad (1)$$

Where:

$x_i$- the variable value for country i
i-index for country
$\bar{x}$- the mean (average)

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (2)$$

The dispersion is utilized for computing the standard deviation ($\sigma = \sqrt{\sigma^2}$) and the coefficient of variation defined as:

$$CV = \frac{\sigma}{\bar{x}} \quad (3)$$

The general framework for checking the convergence hypothesis on panel data was described by Evans and Karras (1996). Unlike the previous approaches from literature, these authors' methodology supposes a less degree of restrictiveness of the data generating process. If we consider a number of N countries (i=1,2,...,N, i-index for countries, t-index for time), their economies converge if and only if the differences between countries regarding expected GDP per capita (y) are stationary.

$$\lim_{p\to\infty} E_t\left(y_{it+p} - \overline{y_{t+p}}\right) = \mu_i \quad (4)$$

Where:

$\mu_i$- individual effects
$\bar{y}$- average GDP per capita
p- maximum number of lags

the convergence is achieved if the GDP per capita deviations from the general average $\overline{y_t}$ tend, when time tends to infinity, towards the individual constant values. The convergence might be absolute or conditional depending on the effects $\mu_i$.
The absolute convergence is achieved if the individual effects are null for each country in the panel. If there are some non-null individual effects, the convergence is conditional (the growth rates are the same, but the level is different). Evans şi Karras (1996) started from the following functional data generating process:

$$\Delta(y_{it} - \overline{y_t}) = \alpha_i + \rho_i(y_{it-1} - \overline{y_{t-1}}) + \sum_{j=1}^{p} \gamma_{ij} \Delta\left(y_{it-j} - \overline{y_{t-j}}\right) + \epsilon_{it} \quad (5)$$

Where:

$\rho_i, \gamma_{ij}$- parameters
$\alpha_i$- fixed individual effects
$\epsilon_{it}$- asymptotic non-correlated errors in individual dimension

The p lag selection affects the unit root test power. The best choice is to test the lag length for each country and the selection of optimal lag should be based on an informational criterion, like Hannan-Quin- HQ. The optimal lag based on HQ criterion is 1.
Following there stages, the convergence assumption is checked (differences in GDP per capita along EU economies are stationary) or the divergence assumption.

*Stage 1:* the above model is estimated using ordinary least square method and the standard errors of estimators are kept $\widehat{\sigma_i}$. The normalized data series is obtained using the N standard errors:

$$\widehat{z_{it}} = \frac{y_{it} - \overline{y_t}}{\widehat{\sigma_i}} \quad (6)$$

for i=1,2,...,N

*Stage 2:* The normalized model is built:

$$\Delta\widehat{z_{it}} = \delta_i + \rho\widehat{z_{it-1}} + \sum_{j=1}^{p_i} \gamma_{ij} \Delta\hat{z}_{it-j} + \mu_{it} \quad (7)$$

$\delta_i = \frac{\alpha_i}{\widehat{\sigma_i}}$ and $\mu_{it} = \frac{\epsilon_{it}}{\widehat{\sigma_i}}$

The parameters estimation of this model is based on ordinary least square method with dummy variables or fixed effects estimators: LSDV- Ordinary Least Squares with Dummy Variables.

*Stage 3:* The t statistics corresponding to $\rho$ ($t_{\widehat{\rho}}$) are compared to critical values based on simulation. At a certain level of significance, if the computed value $t_{\widehat{\rho}}$ is higher than the critical value, the null hypothesis ($\rho = \rho_i = 0$) for each *i* country is rejected in favour of alternative hypothesis ($\rho_i < 0$ for each *i* country). In case on null hypothesis rejection, the conclusion is that there is convergence in GDP per capita for the analysed countries. However, if null hypothesis is rejected, we cannot certainly claim that the economies converge. It is possible that some of them to convergence, but other not.
For testing the hypothesis of common speed of convergence ($\rho = \rho_i$, for each *i* country) IPS (Im-Pesaran-Shin) test is used.
The IPS test is based on the fixed effects estimator ($\hat{\rho}_{FE}$) and the group mean estimator ($\hat{\rho}_{GM}$) of $\rho$ parameter. Unlike group mean estimator, that is consistent under both assumptions of the test (homogeneity and heterogeneity), the fixed-effects estimator is efficient only under the homogeneity assumption. The IPS statistics is defined as:

$$H_{\widehat{\rho}} = \frac{(\widehat{\rho}_{MG} - \widehat{\rho}_{EF})^2}{\widehat{\sigma}_{MG}^2 \widehat{V}} \quad (8)$$

Where:

$$\hat{\sigma}_{MG}^2 = \frac{1}{N} \sum_{i=1}^{N} \hat{\sigma}_{\epsilon_i}^2 \quad (9)$$

$$\hat{V} = \frac{1}{N^2} \sum_{i=1}^{N} (X_i' H_T X_i)^{-1} - \left(\sum_{i=1}^{N} X_i' H_T X_i\right)^{-1} \quad (10)$$

$$X_i' = [\left(y_{i,0} - \bar{y}_0\right), \dots, (y_{i,T-1} - \bar{y}_{T-1})] \quad (11)$$

Where:

$H_t$- operator used to vanish individual effects.

Under the null assumption and considering N and T large enough, the IPS statistic follows a chi-square distribution with one degree of freedom ($\chi^2(1)$).

## 3. The panel data approach in the analysis of convergence in GDP per capita in European Union

The objective of this study is to check the convergence hypothesis in GDP per capita in European Union (EU-28) for the period 2003-2016. In case of convergence, we check if all the countries have the same convergence speed towards steady state. The values of GDP per capita in PPS thousand Euro (EU-28=100) are provided by Eurostat. The length of analyzed period is rather short, but the Eurostat values are provided starting with 2002. For achieving the desired objective, panel approach will be employed that eliminate the practical disadvantages of o short period because of data lack. The convergence hypothesis test of GDP per capita for EU-28 was made by Simionescu (2014), observing after crisis start (period from 2008 to 2012) a slowdown of convergence in GDP per capita.
In 2008, the coefficient of variation of GDP per capita in EU-28 countries was 43%, while the value for 2016 was 42.31%, slightly lower than in 2008. The results based on coefficient of variation indicated a divergence of GDP per capita.
For checking the convergence assumption, some improvements were brought recently in literature to stationary tests for panel data. However, the results interpretation using unit root tests for panel data should be cautiously made. In case of strongly rejection of convergence hypothesis for an individual data series, without the rejection of the other series, there is no economic significance. Two solutions were offered to this problem: the combination of some independent tests (Im-Pesaran-Shin (2003) test (IPS)) and the estimation based on iterative Bayesian method of a dynamic and heterogeneous model. The IPS test allows for heterogeneity between countries in panel, fact that eliminates the assumption that all countries converge towards the same convergence rate. Indeed, for EU countries there is a rather high variability regarding GDP per capita values. Countries from Central and Eastern Europe, members of EU (Bulgaria, Romania, Hungary, and Poland) registered low values of GDP per capita in the period 2003-2016. On the other hand, there are countries that have higher values of GDP per capita, among them being Belgium, Luxembourg, Germany, Austria, Switzerland, Netherlands, and Denmark. Moreover, Luxembourg is the country with the highest GDP per capita value, far exceeding the average of EU-28. In literature, for analyzing the convergence in EU, the countries separation in two large groups is recommended (Cyprus and Malta are excluded): the old members of EU, ie EU-15 (England, Austria, Belgium, Denmark, Germany, Greece, Finland, France, Ireland, Italy, Luxembourg, Holland, Portugal, Spain and Sweden) and the post-communist countries from Central and Eastern Europe (Bulgaria, Czech Republic, Croatia, Estonia, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia and Hungary), as it appears in the study of Albu, Iordan and Lupu (2012). The analysis is made in this case for entire European Union (EU-28). The research is made under the assumption of countries heterogeneity regarding GDP per capita values.
Three steps for checking the convergence/ divergence hypothesis were followed (differences in GDP per capita across economies are stationary).

*Step 1*: Calculation of standard errors of estimators

*Table 1*. Values of estimators standard errors

| Current no. | Country | $\widehat{\sigma}_i$ |
|---|---|---|
| 1 | Belgium | 0,11 |
| 2 | Bulgaria | 0,089 |
| 3 | Czech Republic | 0,248 |
| 4 | Denmark | 0,194 |
| 5 | Germany | 0,223 |
| 6 | Estonia | 0,144 |
| 7 | Ireland | 0,178 |
| 8 | Greece | 0,19 |
| 9 | Spain | 0,167 |
| 10 | France | 0,101 |
| 11 | Croatia | 0,243 |
| 12 | Italy | 0,069 |
| 13 | Cyprus | 0,329 |
| 14 | Latvia | 0,126 |
| 15 | Lithuania | 0,139 |
| 16 | Luxembourg | 0,227 |
| 17 | Hungary | 0,275 |
| 18 | Malta | 0,227 |

| Current no. | Country | $\widehat{\sigma_t}$ |
|---|---|---|
| 19 | Holland | 0,183 |
| 20 | Austria | 0,212 |
| 21 | Poland | 0,085 |
| 22 | Portugal | 0,24 |
| 23 | Romania | 0,077 |
| 24 | Slovenia | 0,255 |
| 25 | Slovakia | 0,062 |
| 26 | Finland | 0,351 |
| 27 | Sweden | 0,3 |
| 28 | United Kingdom | 0,086 |

***Source:*** author's calculation

*Step 2:* Normalized model is built.
The results of fixed effects model estimation are presented in table 2.

*Table 2.* Fixed effects model

| | |
|---|---|
| Constant | -0.2200 (0.001) |
| z1 | -0.08524 (0.000) |
| Sigma_u | 81.3795 |
| Sigma_e | 285.7303 |
| Rho | 0.07503 |
| F test that all alfa_i=0 | *12.44 (0.0005)* |
| R-squared within | 0.0489 |
| R-squared between | 0.6191 |
| R-squared overall | 0.0272 |
| Correlation (alfa_i, x beta) | -0.2009 |

*Step 3:*
The computed value of t statistic is -3.53, in absolute value being higher than the critical value, which implies the rejection of null hypothesis (the p- value associated to calculated statistic is 0.001, lower than 0.05). Therefore, for a significance level of 5%, the conclusion is that in the period 2003-2016 there is convergence in GDP per capita in PPS thousand Euro for EU-28. The result should be cautiously taken, because it is possible for some countries not to converge. In order to sustain this last affirmation, that it is a limit of this statistic test, some economic arguments should be brought. Practically, the economic knowledge should be harmoniously combined with the results of statistic tests application. For example, countries like Malta and Cyprus are different for the rest of the EU countries regarding the values and the evolution of GDP per capita. The existence of the two groups of countries for convergence analysis (old members, with developed economies and post-communist countries) suggests that there are low chances that all economy convergence. However, the statistic test indicates that even if there are several economies that do not converge towards average GDP per capita of EU-28, their influence on general convergence process is not statistically significant. The economic crisis period should not be omitted. The negative effect of recent economic crisis on convergence process is analyzed by Albu (2012). The author proved, using the coefficients of variation analysis, that there was a strong convergence process in GDP per capita at EU-28 over the period 2000-2009, but the crisis slowed it in the period from 2010 to 2016.
However, we do not know if all the countries have the same convergence speed. This means that the countries need the same period for convergence towards their steady states. Therefore, IPS test is used for testing the hypothesis of common convergence speed ($\rho = \rho_i$, for any *i* country). The results of IPS test application are presented in table 3.

*Table 3.* IPS test

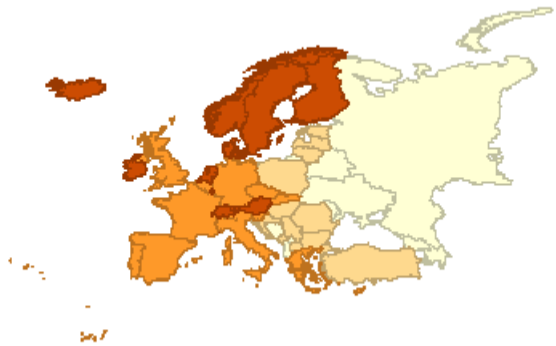
| | Statistic | p-value | Fixed-N exact critical values | | |
|---|---|---|---|---|---|
| t-bar | -3.4177 | | 1% | 5% | 10% |
| t-tilde-bar | -2.2521 | | -1.830 | -1.740 | -1.690 |
| Z-t-tilde-bar | -7.0018 | 0.000 | | | |

The p-value of IPS statistic is 0, lower than 0.05, which suggests the rejection of null hypothesis. Consequently, not all the countries from EU-28 have the same speed convergence towards their steady state.

So, combining the results of methods application, we can conclude that in the period 2003-2016 at EU-28, there is evidence for convergence, but the countries do not have the same convergence sped towards steady state.

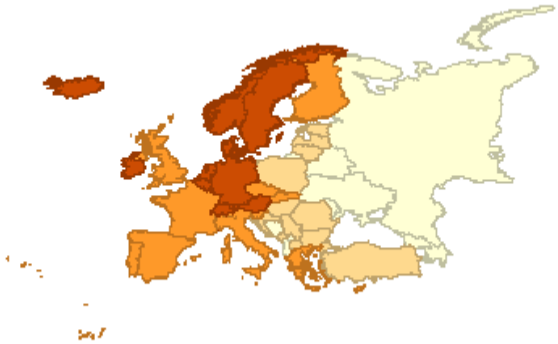
## 4. The graphical approach in the analysis of convergence in GDP per capita in European Union

Difference between groups of countries from Europe from GDP per capita values point of view (in PPS thousand Euro, EU-28=100) can be seen in the graphs and maps for 2008, the year when world economic crisis started and for 2016. The period between the two years correspond to economic crisis period, many European states registering a decrease in GDP per capita in 2016 compared to 2008. For EU-28, GDP per capita in PPS thousand Euro (EU-28=100) decreased in 2016 compared to 2008 in Greece (with 22.58%), Spain (with 9.70%), Croatia (with 9.23%), Italy (cu 6.73%), Cyprus (with 14.14%), Holland (with 2.98%), Slovenia (with 8.79%), Finland (with 7.56%), England (with 5.26%). The highest decrease of GDP per capita was registered by Greece (a decrease with almost 23%). This high decrease registered by Greece during the economic crisis is explained by the huge public debt and high budgetary deficit.
11 countries had GDP per capita in PPS (EU-28=100) in 2008 between 0 and 26 and 11 states had GDP per capita between 119 and 263. Most of the countries (14) had GDP per capita in PPS thousand Euro between 72 and 116. Romania is located in the group of countries with GDP per capita in 2008 between 34 and 69, with countries like Bulgaria, Estonia, Lithuania, Latvia, Croatia, Hungary, Poland, Serbia, Montenegro, San Mariano, Turkey and Macedonia.



***Source:*** author's graph

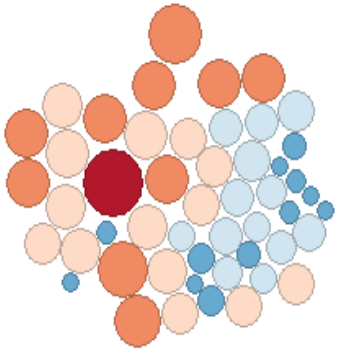
*Figure 1.* Distribution of groups of countries from Europe according to GDP per capita values in PPS thousand Euro in 2008



***Source:*** author's graph

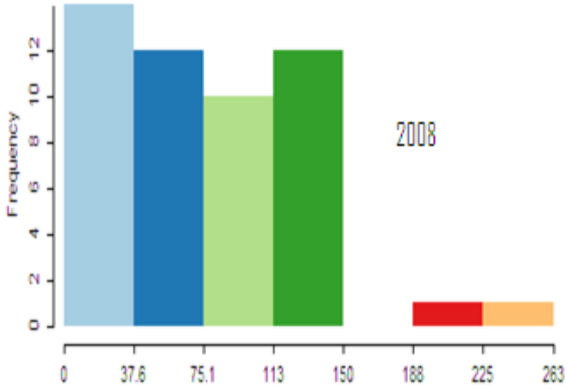
*Figure 2.* Distribution of groups of countries from Europe according to GDP per capita values in PPS thousand Euro in 2016

11 countries had GDP per capita in PPS thousand Euro (EU-28=100) in 2016 between 0 and 30 and 12 states had GDP per capita between 116 and 264. The most countries from Europe (13) had a GDP per capita in PPS thousand Euro between 35 and 74 and 13 countries had GDP per capita between 75 and 112. Romania is located in the group of countries with GDP per capita between 35 and 74 in 2016, with countries like Bulgaria, Estonia, Lithuania, Latvia, Croatia, Hungary, Poland, Serbia, Montenegro, San Mariano, Turkey and Macedonia. The GDP per capita decrease of more states from EU contributed to the slowdown of the GDP per capita convergence. Recent studies from literature, like that of Albu (2012), indicated that the recent world economic crisis slow downed the EU convergence process. The following cartogram for European countries was built after the next scheme: the circles' surface used to represent the countries is proportional to GDP per capita values from 2016, while the main point that connects the circles is the GDP per capita in 2008. Each colour of the cartogram corresponds to a different group of countries.
From the cartogram the existence of an outlier which is Luxembourg (the circle that is red coloured). Indeed, this country has the highest GDP per capita in 2008 and 2016. The cartogram is not enough compact, existing, excepting Luxembourg, 4 different groups of countries like GDP per capita values in 2008. The same colour bubbles represent the countries with the closest GDP per capita values in 2008. There are two neighbor circles with different coloured surfaces and large differences as surface size. This indicates that there are neighbor countries with high differences like GDP per capita size in 2008 and 2016. These large gaps between countries are serious breaks that slowdowned the convergence process over 2008-2016.



***Source:*** author's graph

*Figure 3*. Cartogram for GDP per capita in 2008 and GDP per capita in 2016




***Source:*** author's graph

*Figure 4.* Histogram of GDP per capita distribution in thousand Euro PPS in Europe in 2008

In 2008 and 2016, the most countries had a lower than 37.6 GDP per capita. As the growth of GDP per capita, the number of states that fall into the following groups decreased in 2016. In 2008 there were several States with a per capita GDP in thousand Euro PPS between 113 and 150.

## 4. Conclusions

In the case of EU countries there is a fairly large variability in terms of the GDP values per capita values. Countries in Central and Eastern Europe, (Bulgaria, Romania, Hungary, Poland) registered in the period 2003-2016 small values of GDP per capita. On the other hand, there are countries that have much higher values of GDP per capita, among them being Belgium, Luxembourg, Germany, Austria, Switzerland, Netherlands, Denmark. Furthermore, Luxembourg is the State with the highest GDP per capita, far surpassing the average of EU-27.

In the period 2003-2016, EU-28 there is evidence in favor of the convergence process, but the states do not have the same speed convergence towards the steady state. The decline in per capita GDP of many countries in the European Union slowed down the process of convergence in per capita GDP.

The convergence analysis in the EU is useful in order to determine the extent to which European economies are approaching to steady state and meet the prerequisites for accession to the euro area. The limits of this research are given by the disadvantages of statistical tests that with a certain level of significance.

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