TESTING BETA CONVERGENCE ACROSS EU28 AND EU15 COUNTRIES

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Abstract:*In the attempt to answer the question whether the poorer economies will catch up the economies of the richerones over time, more and more studies on the convergence found that measuring any imbalance between countries exhibita great interest. Whereas at present there is a great diversity of research and approaches to convergence and a huge variety of calculation methodologies, in this paper we present one of the concepts that asserted itself in the process of real convergence namely the beta convergence (β). Although this concept has been contested by some economists like Friedman (1992) and Quah (1993) who state that the regression model of economic growth used can give awrong indication of the presence and expansion of beta convergence, the concept of beta convergence was asserted in the economic literature. It has become an indispensable instrumentfor the measurement, the econometric analysis and description of this process, when considered either in its incipient simple form (absolute beta convergence) or in its developed form (beta conditional convergence).Thus, to identify a possible convergence process or rather a trend of divergenceamong European economies, we have investigated the relationship between the average annual growth rate of the GDP per capita for the period of time T and the initial level of the GDP per capita in the year t_0, employing the methodology proposed by Barro and Sala-i-Martin namely estimating an equation for economic growth. To estimate this equation for the UE 28 and UE 15 countries we haveusedannual statistical data for 2000 – 2014 collected from Eurostat.Results revealed a strong correlation between the variables for the EU 28 countries, while for the EU-15 countriesthe estimations revealed a weak one.As a conclusion, the new member states of the European Union have enjoyed a high rate of real convergence compared to older member states. This confirms the theory that the poorer economies have certain advantages in terms of economic growth compared to richer ones, allowing them to grow faster and recover such disparities between them.*

Keywords: *economic growth, real convergence, beta convergence, econometric model.*

JEL classification: O47, Q56, B23.

Introduction

Economic convergence has preoccupied specialists for many years, representing one of the main benchmarks of the strategy of European integration. Its operationalization requires a proper defining of each type of convergence and of each factor that ensures general convergence. The professional literature has paid special attention to the concept of economic convergence, especially in the context of the process of integration in the European Union.

The issue of poorer countries that have growth rates which are higher than those of the rich countries has been regarded with particular interest in the professional literature concerned with economic growth and development, the issue becoming

more and more interesting when we take into account the process of European integration.

1. Real convergence – a review of professional literature

Convergence has been a recurrent theme in the process of European economic integration. One of the main attractions of adhering to the European Union was for the candidates the aligning to the standards of living of the European Union. According to real convergence, a new member state must grow faster in a sustained manner, so that it may catch up with the average of the European Union (Bongardt and Torres, 2013: 72). Thus the professional literature relies on the hypothesis according to which the poorer countries or regions manifest an accelerated and fastergrowth tendency than the more developed ones in order to achieve their income and productivity level. The majority of studies concentrated on the analysis of the disparities of the GDP per capita between the member states and the recently adhered countries, with results that support the above stated premise (Lein-Rupprecht et al., 2007: 7).

A series of great economists who dealt with long term economic development have taken into consideration the issues of real convergence. Many of them addressed the issue implicitly, when analyzing the role of production factors – capital, labor, natural resources, technological process, human capital – within long term economic growth. At the same time, and also implicitly, they addressed the issue of real convergence also when they referred, on the one hand to economic development and on the other hand to the evolution of certain activity categories and/or complex economic branches with huge economic and social impact, as well as to economic institutions and mechanisms (Iancu, 2006: 6).

According to Kulhanek, real convergence is represented by the differences in the decrease of the development levels, such as the similarity in GDP per capita, the salary and price levels, and the crucial factor of sustainable convergence and growth is represented by the human factor. All the same, most of the times, real convergence is defined as being that process of the GDP per capita and comparative price levels of the respective country approaching the levels which match the state of long term balance (Kulhánek, 2012: 162).

Real convergence is not a spontaneous process; in many cases this depends on the capacity of one country to follow the effect of dissemination of technology, especially through direct foreign investment. Consequently, macro-economic stability, efficient competitiveness regarding goods, services and production factors, as well as good quality human capital are necessary.

Veiga believes that the process of real convergence takes place if: (i) the poorer countries grow faster than the rich ones, (ii) the dispersion of the GDP per capita is in time decreasing, (iii) the classification of countries regarding GDP per capita does not persist or (iv) in case the distribution of GDP per capita evolves from the periphery towards the centre (Veiga, 1999: 1).

Mihaljek states that the purpose of the whole process is to achieve a gradual on-coming of the GDP per capita of the countries from a region towards the average of the less developed countries in the European Union. Real convergence can be achieved only through high sustainable growth rates (on the long term, for example, in case they are accompanied by macro-economic stability and institutional efficiency). In other words, the fulfilling of the criteria for the adherence

to the European Union and the Economic and Monetary Union is a sufficient and necessary condition, but not for the successful long term economic development (Mihaljek, 2003:59).
In trying to answer the question whether the poorer economies will be able in time to catch up with the wealthier economies, more and more studies about convergence believed that the measuring of any inequalities between countries is of great interest.
As in the present there is a great diversity of researches and approaches to convergence and also a great diversity of methodologies for calculating, in this chapter we will present the ways of measuring the convergence process.
We can identify three definitions of convergence considered to be relevant and of reference (see Barro, Sala-i-Martin, 1990; Sala-i-Martin, 1996; Iancu, 2006; Boyle, McCarthy, 1997): the sigma convergence *(σ)* that considers the reduction of dispersion between GDP per capita of some countries respectively regions; the beta convergence *(β)* thatimplies the fact that the poorer countries grow more rapidly than the richer ones and thus they will be able to catch up in a determined time frame. The gamma convergence (γ) is a more recent concept introduced by Boyle and McCarthy (1997 and 1999) that implies the use of a Kendall index (Kendal index of rank concordance) in the testing for beta convergence, a measure that is considered to be more appropriate for capturing the potential mobility of countries (or regions within a country) with regard to the distribution of income levels in time (Martin and Velazquez, 2001: 7).

2. Empirical evaluation of beta convergence processes

One concept that has asserted itself in the process of convergence is the beta convergence. In this section we will test the hypothesis of the beta convergence concerning the 28 countries of the European Union (EU 28) as well as the EU 15 group using as index the GDP per capita. The methodology which is widely used in the professional literature is the one of Barro and Sala-i-Martin that implies the estimation of an equation regarding economic growth. In order to determine if there is a convergence process or rather a tendency towards divergence amongst the European countries, we have taken into consideration the relationship between the average annual growth rate of the GDP per capita for the period of time *T*and the initial level of the GDP per capita in the year t_0 starting from the equation suggested by Barro and Sala-i-Martin and which we have modified to the purpose of this paper as follows (Barro and Sala-i-Martin, 1990: 17):

$$\frac{1}{T}\log\left(\frac{y^i_{t_0+T}}{y^i_{t_0}}\right) = \alpha - \beta\log(y^i_{t_0}) + \varepsilon^i_{t_0,t_0+T} \qquad (1)$$

where**:**

$y^i_{t_0}$ - initial level of the PIB/per capitain the basic (main) period;

$y^i_{t_0+T}$ - initial level of the GDP/per capitaafter *T* periods of time;

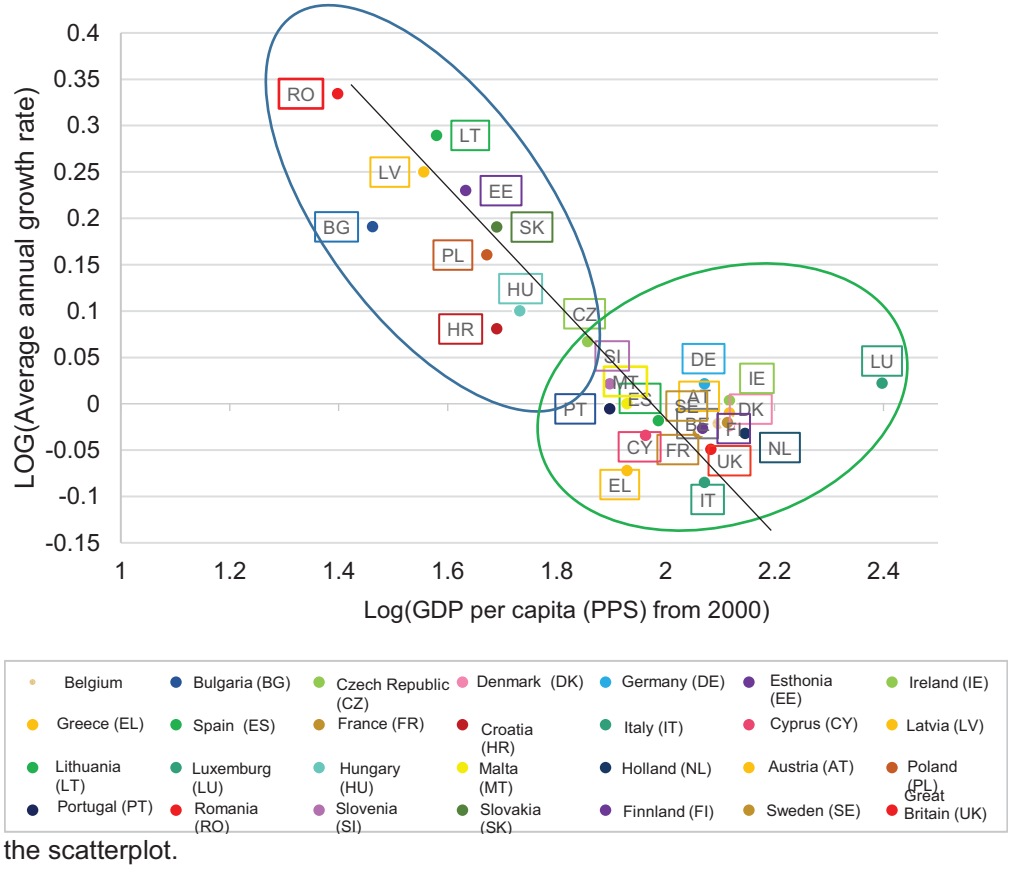
$\varepsilon^i_{t_0,t_0+T}$ - the residual variable;

α – constant (absolute term);

β – the parameter that expresses the inclination of the regression line;

0, T – time period (0 = 2000, T= 2014);
i – country (the 28 member states of the European Union).

The β coefficient expressed, in a comparable form, shows how much the average rate increases, if the level of development drops by a unit. It is preferable that the sign of the parameter be minus. The negative sign of the β parameter is the expression of the inverted relation between the average annual growth rate of the GDP per capita for a period of time of *T* and the initial level of the GDP per capita in the year t_0 (for instance, when the rich countries experience a higher growth than the poor ones).
The statistical data that real convergence is based on in the case of the 28 member states of the European Union is represented by the national data of each member state. The data base is the one offered by Eurostat for the period 2000 – 2014 concerning the GDP per capita to the parity of the power standard (EU 28 = 100). This time frame was chosen, because it includes the pre-crisis period as well as the crisis period, respectively the post-crisis period. In the case of a single-factor model, the most widely used process in the analysis of the relation between variables is the graphical representation of the two strings of values with the help of



the scatterplot.

Figure1 Beta convergence in the EU countries in the period 2000-2014
Source: created by the author

Thus, in order to identify the relation between the mentioned variables, we have created a graphic representation of the pair of points which include the values of the variables, the average annual growth rate and the initial GDP.

According to figure 1 we can state that the slope of the regression line is negative and thus, there is a convergence process among the countries of the European Union in the period 2000-2014. The way in which certain countries are positioned on the graphic confirms the beta convergence theory, according to which the initially poorer countries have the tendency to grow faster than the initially rich ones. In the analyzed time period we can observe that the countries with an initially lower economic level have recorded a higher average annual growth rate - Romania, Bulgaria, Latvia and Lithuania (these countries are in the graphic on the left upper side) while the countries that in 2000 presented a higher economic level, such as Ireland, Holland, Italy, France and Belgium, recorded in the period 2000-2014 a decreased or even negative economic growth (these countries are to be found on the lower right side of the graphic). In the following we propose ourselves to test the above stated with the help of some statistical and econometric tests.
The main problem of any regression model is the estimation of its parameters, for which we will use the generalized least squares method. We will also use several statistical tests in order to investigate the validity of the hypothesis on which the regression model is based on. The regression model parameters, estimated using Eviews software are presented below:

Table 2–The regression model parameter estimates

Dependent Variable: Average anual growth rate
Method: Least Squares
Included observations: 28

	Coefficient	Std. Error	t-Statistic	Prob.
α	0.129008	0.014220	9.072555	0.0000
β	-0.027498	0.003217	-8.548893	0.0000

R-squared	0.737595	Mean dependent var	0.008392
Adjusted R-squared	0.727503	S.D. dependent var	0.017942
S.E. of regression	0.009366	Akaike info criterion	-6.434747
Sum squared resid	0.002281	Schwarz criterion	-6.339590
Log likelihood	92.08646	Hannan-Quinn criter.	-6.405657
F-statistic	73.08357	Durbin-Watson stat	1.539621
Prob(F-statistic)	0.000000		

Source: authors' estimates using Eviews

The values of the estimated coefficients in our sample are α = 0.129008 and β = -0.027498. The latter shows the decrease of the average annual growth rate (the dependent variable) in case the initial GDP per capita increases with a unit while α represents the average annual growth rate in case the GDP per capita was zero.
As the β coefficient is negative, the regression function indicates an inverse correlation between the two variables. In order to investigate the significance if the parameters and to extend the result from our sample on the total population, we have used the Student test. As the T-statistic in absolute value is higher than the critical one (1.96 for a 5% sigificance level), all the parameters are significant. The probability associated to the two parameters are zero, which confirms that the null hypothesis is rejected in both cases.
The results obtained using Eviews software confirm that both parameters are significant both in the sample as well as in the total population, so the model was correctly specified, identified and estimated and we will continue our econometric analysis.
In order to measure the intensity of the correlation between the endogenous variable and its determinants, we will calculate the R-squared value. In our sample, its adjusted value is 0.72, which indicates a strong correlation in the sample. The Fisher tests was used to extend the results on the total population.Given the fact that the statistic of the test is F_{calc}= 73.08 which is higher than the critical one Ft_{ab}= 3.10, the null hypothesis is rejected so the exogenous variable has a significant influence on the endogenous one. The higher the difference between the calculated value of the Fisher test and the critical one, the stronger the correlation. In our case the correlation is quite intense, as the gap between the two values is high.

Testing the model errors' related model hypothesis

Testing the model residuals' independence hypothesis

The first investigated hypothesis is the independence of the residuals. Several statistical tests have been employed for this purpose. In our study we will use the Durbin Watson test, which deals with the first order correlation between the residuals (Stancu, 2011: 48): $\varepsilon_t = \rho\varepsilon_{t-1} + u_t$. The following hypothesis were issued:

H_0: $\rho = 0$, and the alternative:
H_1: $\rho \neq 0$

The ρ is the errors' first order autocorrelation coefficient. We will compute the statistic of the test (Andrei et. al., 2008: 126):

$$DW_{calc} = \frac{\sum_{i=2}^{T}\left(\hat{\varepsilon}_i - \hat{\varepsilon}_{i-1}\right)^2}{\sum_{i=1}^{T}\hat{\varepsilon}_i^2} \quad (2)$$

For a 5% significance level, *k*=1 exogenous variables as well as 28 observations, the critical values of the Durbin Watson test are $d_1 = 1.328$ and $d_2 = 1.476$. Since $d_2 = 1.476 < DW_{calc} = 1.539621 < 4-d_2 = 2.524$, the errors are not correlated, and the null hypothesis H_0 cannot be rejected.

Testing the model residuals' homoskedasticity hypothesis

The homoskedasticity hypothesis was investigated using the White test. The homoskedastic residuals have the following properties: $E(\varepsilon_t) = 0$, $(\forall)$ t=1,28; $V(\varepsilon_t) = \sigma_\varepsilon^2$ - finite, $(\forall)$ t =1,28. White has proven that if the variables involved in the following model are not correlated, the errors are homoskedastic:

$$\hat{\varepsilon}_i^2 = \alpha_0 + \alpha_1 x_i + \alpha_2 x_i^2 + \omega_i \quad (3)$$

Since the statistic of the test is $F_{calc} = 7.89$ and the critical one for a 10% significance level is $F_{tab} = 9.45$ the null hypothesis H_0 cannot be rejected, so the model has homoskedastic errors.

Testing the model residuals' normality hypothesis

Due to the importance of the normal distribution is modelling various statistical procedures, several conformity tests were set up, whose aim was to verify the normality of empirical distributions. The Jarque Berra test is based on the fact that the normal distribution has a null skewness coefficient and a kurtosis coefficient equal to 3.We have computed the empirical distribution's skewness and kurtosis coefficient:

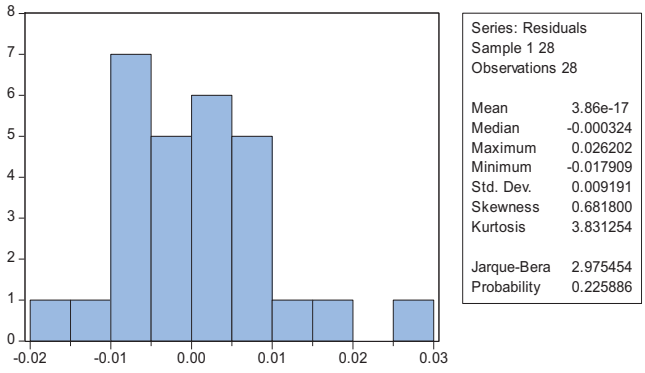


Figure 2 The hystogram and the parameters of the estimated errors
Source: Eurostat data, authors' estimates using Eviews

Since the statistic of the test isJB_{calc} = 2.97, lower than the critical value for a 5% significance level, $\chi^2_{tab(0.05;4)}$ = 5.99 the normality hypothesis of the models' residual cannot be rejected. Since all the 3 hypothesis regarding the estimated errors were verified the model is a valid one.

Figure 1 showed that during 2000 and 2014 the new UE members had a much higher GDP per capita growth rate than the one of the more developped countries. Using econometric and statistical methods we will try to investigate the formerly stated empirical hypothesis. Using the same regression model, we will examine a possible convergence process among the UE 15 countries, during 2000-2014.As stated previously, the main problem of any regression model is the estimation of its parameters, for the second econometric model we will use the same generalized least squares method.The regression model parameters estimated using Eviews software are presented below:

Table3–The regression model parameter estimates for UE15

Dependent Variable: Annual growth rate
Method: Least Squares
Included observations: 15

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.016811	0.009302	-1.807245	0.0939
C(2)	0.007317	0.004455	1.642419	0.1945

R-squared	0.171845	Mean dependent var	-0.001554
Adjusted R-squared	0.108141	S.D. dependent var	0.001979
S.E. of regression	0.001869	Akaike info criterion	-9.603467
Sum squared resid	4.54E-05	Schwarz criterion	-9.509061
Log likelihood	74.02601	Hannan-Quinn criter.	-9.604473
F-statistic	2.697542	Durbin-Watson stat	2.088090
Prob(F-statistic)	0.124459		

Source: authors' estimates using Eviews

The values of the second model's estimated coefficients in our sample are α = -0.016811 și β = 0.007317. This time we notice the presence of an increasing regression function – since the estimated β is positive. As a conclusion, the UE 15 countries are divergent in what regards their GDP per capita.

In order to investigate the significance if the parameters and to extend the result from our sample on the total population, we have used the Student test.

The α parameter is significantly different from zero, for a 10% level of confidence, but the other parameter is not significant - the associated probability for the two statistics is 0.09 for α and 0.19 for β.

So the positive slope of the equation as well as the unsignificant β confirms the lack of a convergence process among these countries.

We have computed the R-squared coefficient in order to measure the intensity of the correlation between the variables among the UE 15 countries, and since its value is $\overline{R^2} = 0.171845$, we concluded that the correlation is a weak one.The Fisher tests was used to extend the results on the total population. Given the fact that the statistic of the test is F_{calc} = 2.6975 which is smaller than the critical one F_{tab} = 3.10, the null hypothesis cannot be rejected so the exogenous variable has an unsignificant influence on the endogenous one.
All in all, we conclude that there is a strong correlation between the selected variables among the UE28 countries, as the R squared is 0.737595 but the correlation is weak among the UE15 countries. The small value of the correlation coefficient for the UE 15 countries indicates a lack on convergence of the GDP per capita.

Conclusions

Even though the issue of real convergence continues to be a focal point in the work of researchers in the field of European integration, this has remained unsolved and controversial. The necessary economic measures that need to be taken in order to eliminate the economic disparity sometimes clash with those that are necessary for achieving nominal convergence for entering the European and Monetary Union. An excessively alert rate of nominal convergence over the real convergence can be accompanied by short term tensions between the two processes. Thus, the speed of the nominal convergence process must be set so that it does not cause delays in the unfolding of real convergence.
In what the beta convergence is concerned, we can conclude that there is a rather strong association between the EU 28 countries between 2000 and 2014, the correlation ratio that studies the intensity of the association between the two variables, the average annual growth rate and that of the initial GDP having the value of 0.73. We cannot say the same thing about the EU 15 states. In this group we have identified a weak association between the two analysed variables, the correlation ratio recording the value of 0.17 for the analysed period. Therefore, the very low value of the correlation ratio within the EU 15 group rejects the existence of the beta convergence, at least from the perspective the GDP per capita.

Acknowledgments
A part of this paper has developed into the postdoctoral thesis, which was part of the project entitled **„SOCERT. Knowledge Society, Dynamism through Research"**, contract number POSDRU/159/1.5/s/132406. This project is co-financed by The European Social Fund through The Sectoral Operational Programme for Human Resources Development 2007-2013. **Investing in people**!

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