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Exploring Trends of Per-Capita GDP among EU-15 Members

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Abstract

The main target of this paper is to study the convergence of per-capita GDP across European Unions' core members over a fairly long period of time. Most of the works in this field are based on either cross-sectional or fixed-effects models by imposing strong restrictions on the model parameters. We propose the estimation of convergence by making use of panel-data analysis. The results partly confirmed the hypothesis of convergence in EU although the rate of convergence is relatively slow.

Keywords: Convergence, European Union
JEL Classification Codes: G1, C22.

1. Introduction

Since the first composition of EU a number of empirical studies have been devoted in order to investigate if European integration has positive or negative impact on long-term growth of member countries. In this context the measurement of any inequalities among countries and regions presents great interest. The target of this study is to detect whether the differences between developed and less developed EU-15 countries stop undergo at least in GDP per capita. According to the economic literature, with reference to the integration theory, there are two distinct aspects relative to the process of growth and the hypothesis of convergence.

The first aspect supports the divergence of regions since a higher integration towards a single currency is expected to increase factor mobility which in turn can be in favor of the prosperous regions. Concentration of economic activity to these attractive centers that dispose a higher level of industrialization can create additional difficulties to the less developed regions and delay their catching up process. The second aspect supports the convergence arguing that the integration process tends to attenuate the differences of regions and as a consequence convergence is attained. The neo-classical approach based on the simple idea of convergence implies that poor regions (or poor countries) grow faster than rich regions (or rich countries) in terms of their GDP per capita. Accordingly, a strong negative relationship between the growth of GDP per capita and its initial level is expected to be found in a cross-section analysis of different economies.

Most empirical papers on economic growth aim at detecting the main determinants of long-run growth without referring explicitly to regional integration. The first papers dealing with the question of a possible growth bonus associated with European integration were all cross-country studies. Basically, they compare EU members with other countries that have not joined the EU, mostly countries at a similar stage of development. Interestingly, the majority of studies do not find any growth bonus for EU member countries. However, panel data regression techniques, in which the same units are observed at different time moments, opened up a new way to deal with the question of possible growth benefits associated with EU membership. Therefore, the main target of this paper is to examine the hypothesis of convergence process (within the integrated European economy) using panel regression analysis. Our prediction, based on projected future GDP values of EU 15 members, is that even if there is a trend towards b-convergence increase it is very unlikely that s-convergence would finally prevail.

The rest of the paper is organized as follows. Section 2 provides an overview of relative theories. In the next two sections (3-4) we test the hypotheses of sigma and beta convergence respectively, by means of panel regression. Section 5 attempts an anticipation of future trends while section 6 concludes the paper.

2. Theoretical Background

Two main approaches are used in order to identify if the growth process is leading to convergence or divergence for countries or regions over time. The first is the traditional approach known as 'sigma' convergence and the second is the neo-classical approach which is referred as 'beta' convergence.

'Sigma' convergence measures the dispersion of real GDP per capita (in constant prices) between regions or countries based on standard deviation of the cross-section series. When the standard deviation is falling (rising) over time, the differences of GDP per capita between regions or countries in absolute terms gradually decrease (increase) and convergence (divergence) is approached. If standard deviation does not show any clear tendency but instead, increases or decreases successively, then a mixed process of convergence and divergence is realized. A different way of measuring the 'sigma' convergence is to use the coefficient of variation which results by dividing the standard deviation with the mean of the sample. The coefficient of variation is a measure of relative variability and is expressed usually, as percentage and not via the units of data in which is referred. If the coefficient of variation decreases over time we have convergence otherwise we have divergence.

The 'beta' convergence of the neo-classical approach is obtained by a regression analysis estimating the growth of GDP per capita over a certain period of time in relation to its initial level. If the regression coefficient 'beta' has negative sign indicates that GDP per capita of countries with lower initial GDP per capita grow more rapidly than this of countries with higher initial GDP per capita. The neo-classical theory presents two types of convergence: unconditional and conditional (Sala-i-Martin 1994). When all regions (or countries) converge to the same terminal point (steady-state point) the convergence is calling unconditional. In such a case, having considered that the economies do not differ significantly in terms of variables like the investment level, coefficient β is estimated without introducing structural variables. On the contrary, when the economies have different structures, it is assumed that they converge to a different steady state point. In this case convergence is calling conditional and both the coefficient β and the structural variables (influencing the level of growth of GDP per capita) are introduced in the model. According to the neo-classical model the query of why poor regions (or countries) grow faster than rich regions (or countries) can be answered by the diminishing returns to capital explanation.

This means that the larger the amount of capital[1] a country holds the smaller would be its rate of increase and vice versa. Hence, poor countries having lower GDP per capita, are predicted to increase it relatively faster. An important contribution on convergence issue was given by Baumol (1986) who shows empirically no absolute-β-convergence in per capita incomes across the world economy. Since then, there has been an outpouring of econometric studies attempting mostly to test the existence of both absolute (*or unconditional*) and *conditional β-convergence* hypothesises both in terms of per capita incomes and productivity to confirm the empirical validity of the neoclassical theoretical paradigm. Only in recent years, given the availability of regional data, the topic of regional convergence– divergence has regained popularity in the European and in the American academic communities. Regarding to the EU studies almost[2] all verify the neo-classical hypothesis indicating a negative relation between the growth of GDP per capita and its initial level (Neven and Gouyette (1994); Fagerber and Verspagen (1996); Tondl (1999)). However, given that the speed of convergence is relatively slow (found not to exceed the 2% per year) it is envisaged that it will take 50 or more years in order the asymmetries to be eliminated.

As for the choice between 'sigma' or 'beta' convergence Sala-i-Martin (1994) shows a preference to 'beta' convergence since it responds to questions, such as, whether poor economies are predicted to grow faster than rich ones, how fast the convergence process is and whether the convergence process is conditional or unconditional. The same author in another paper (Sala-i-Martin 1996) points out that the relation between the two concepts is accurate only to a certain extent which means that 'beta' convergence is a necessary but not a sufficient condition for 'sigma' convergence. On the whole, one could argue that the two concepts are complementary and do not replace each other.

3. Data Description and Sigma Convergence

In this section we will initially give a description of per capita GDP data for the fifteen until lately core EU members which constitute our study-sample. All data used were retrieved from the CD-ROM of World Bank: World Development Indicators 2005. The analysis is performed by measuring the coefficient of variation of GDP per capita in constant prices (of American dollar) using year 1995 as a base-year for the period 1960-2003. The coefficient of variation is selected at this stage as the variable of our interest (instead of standard deviation) due to its relative advantages.

Graph 1: (Coefficient of Variation for EU-15 countries for the period 1960-2003)

[1] In our case the GDP per capita

[2] Hein and Truger (2005) state that real per capita income in the European Union has developed a long-run process of divergence

In above graph the X-axis corresponds to the years and Y-axis to the prices of coefficient of variation[3]. Generally we can argue that in fact, 'sigma' convergence is prevailing for the total period 1960-2003 since the coefficient of variation decreases starting with the price of 0.43 in 1960 but ending up with the price of 0.38 in 2003. However, the trend is not uniform (that is continuously decreasing) at all the period 1960-2003 stimulating us to distinct the sample years in two sub-periods so that we can obtain a better idea of what is really happening. Thus, for the sub-period 1960-1981 we have actually a continuously reduction of the coefficient of variation (see table 1 in appendix) providing evidence of 'sigma' convergence. In contrast, for the sub-period 1982-2003 the trend is increasing (despite some minor fluctuations not presented in previous sub-period) indicating divergence. Our findings are similar to those for the same period reported by Kaitila (2004) who argued that σ-convergence has taken place in the EU15 area in two spells separated by an interim period of stagnation.

4. Testing for 'Beta' Convergence

Firstly, we shall test the hypothesis of unconditional 'beta' convergence for the data which are available about the period 1971-2003[4]. For this reason, we separate the data into four sub-periods 1971-1978 1979-1986 1987-1994 1995-2003[5] estimating the β parameter in the panel regression

$$\left(\ln Y_{Tt,i} - \ln Y_{0t,i}\right)/n_t = a + \beta \ln Y_{ot,i} + \varepsilon_{t,i} \qquad (1)$$

where:

$Y_{Tt,i}$ refers to the real GDP per capita in the last year of period t (t = 1,2,3,4 the corresponding sub-periods) for country i,

$Y_{0t,i}$ is the value of real GDP per capita in the initial year of period t,

n_t is the number of years and T the last year in period t.

For the error term we consider that it is independent of the cross-sectional units (countries) and iid normal. α is the constant term which according to the neo-classics is influenced by the rate of technological progress and the steady-state growth rate of GDP per capita[6].

Before proceeding, we have to point out that Luxembourg is not calculated not only owing to it size but also owing to missing data. By means of model (1) and sensitivity analysis (we extract influential observations and outliers) we get the results shown in table 1:

Table 1:

	Coefficients	P-Value	
Constant	0.046126	0.000	$R^2 = 22.1\%$
Initial GDP	-0.009444	0.000	DW=1.71

Clearly both coefficients are statistically significant while the coefficient of initial GDP per capita has negative sign verifying the hypothesis of unconditional 'beta' convergence. The rate of convergence is equal to 0.91%[7] per year indicating that convergence is quite slow. However it is worth noting that by looking both the graph of coefficient of variation (Graph 1) with respect to time and the

3 Data concerning Germany for the period 1960-1970 were calculated manually.
4 The period of study is now limited in order to avoid personal calculations for Germany in the years 1960-1970.
5 A minimum amount of eight years seems reasonable for studying long-term growth features, because thus business cycle fluctuations are eliminated.
6 Barro and Sala-i-Martin (1992) assume that α is the same for all regions when the steady-state value and the rate of technological progress do not differ significantly across regions.
7 The rate of convergence has been computed as λ=-[1-exp(βT)]/T where β is the coefficient corresponding to initial GDP per capita and T is the sub-period length. The expression for λ results from the log linearization around the steady state in the classical Solow (1956) model.

data presented so far for the period 1971-2003 we observe ‘sigma’ divergence. ‘Sigma’ divergence is not consistent with ‘beta’ convergence indicating that the rate of ‘beta’ convergence was not sufficient to ensure a more close approximation in absolute levels of real GDP per capita (‘sigma’ convergence). Yet it is known that ‘beta’ convergence even at a minimum rate is always sufficient to ensure approximation at levels of real GDP per capita in relative terms.

The autonomous growth which is expressed through constant term is 4.61% while there is no problem of serial correlation (DW=1.71). However, the explanatory power of the model is relatively low ($R^2 = 22.1\%$) highlighting the need for the inclusion of additional structural variables. The obvious candidates are those variables which are explicitly implied by economic theory and have been used in virtually every empirical study on economic growth. These are the Government Consumption (GC) as percentage of GDP, the Openness of the economy (OP) as trade in percentage of GDP, the Foreign Direct Investment (FDI) as percentage of GDP, the percentage of annual inflation and the years in EU at the end of every sub-period. At each one of the aforementioned variables we calculate the mean for every country and sub-period.

Thus, having used sensitivity analysis we have the following results (Table 2 below)

Table 2:

	Coefficients	**P-Value (VIF)**
Constant	0.06729	0.000
Initial GDP	-0.010061	0.049 (4.3)
GC	-0.0009606	0.019 (2.5)
OP	0.00009236	0.048 (1.5)
FDI	0.0014707	0.016 (1.6)
Years in EU	-0.00010391	0.224 (1.4)
Inflation	-0.0010008	0.006 (3.0)

As evident from the table 2 all the coefficients are statistically significant at level 5% except the one referring to the years in EU. In addition, the explanatory power of the model is remarkably increasing ($R^2_{adj} = 47.6\%$) while there are no problems of serial correlation and multicollinearity (DW=1.47 and for all the coefficients VIF<10).

The coefficient of initial GDP per capita is negative verifying the hypothesis of ‘beta’ convergence with rate of convergence 0.97% per year. The negative sign of government consumption’s coefficient implies an inverse relationship between government expenditures and growth. The intuition behind could be that government spending has only a temporary influence on growth, while in the long run the growth-hampering impact of high debt levels as a consequence of excessive government spending predominate. Inflation has negative sign as well indicating the growth-hampering effect of high increases in the price level. On the contrary, the growth is stimulated by the openness of the economy and the foreign direct investments. In fact, an increase in values of these variables can bring about an increase into the production and reduction of unemployment whereas the autonomous growth is 6.73%.

5. Projection of Anticipated Trends

Our final objective in this study is the prediction of long-run evolution of coefficient of variation in an attempt to identify any possible future trends that can be considered as a principal tool for policy making purposes. For this reason we shall use the time series analysis context. Firstly we will proceed by means of Box-Jenkins methodology. We employ the additive model $Y_t = m_t + S_t + X_t$ where m_t = trend component, S_t = seasonal component and X_t = the stationary component.

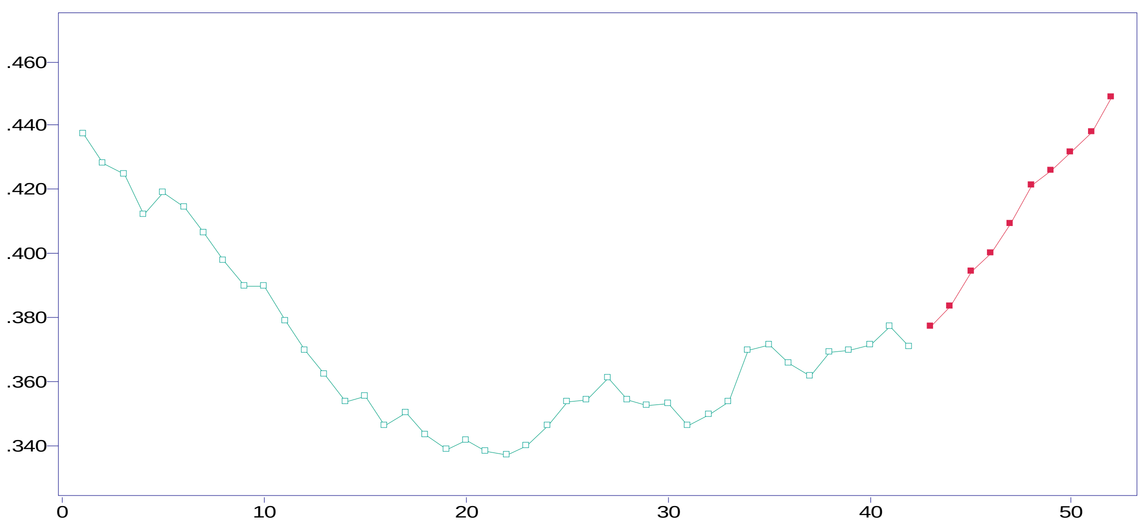
Having used the Box-Cox transformation (because of fluctuations of second period 1982-2003) and by extracting the trend (quadratic) and seasonal component (period: d=7 years) via estimations (see details at the end of appendix) the best ARMA (p,q) model is an AR(1) with minimization of AICC and BIC criteria (see table 3 below):

Table 3:

	AICC	BIC
AR(2)	-366.123	-364.694
AR(1)	**-367.911**	**-368.054**
AR(3)	-366.146	-363.717
ARMA(1,1)	-365.918	-364.494
MA(1)	-350.777	-351.160

The AR (1) model is of the following form: $X_t = 0.821X_{t-1} + Z_t$. The coefficient is statistically significant since the standard error takes the price 0.091541 while Z_t is a kind of noise (e.g.: White noise or Gaussian noise). Accordingly, using the best ARMA model, estimations of trend, seasonal component and by inverting the transformation we can make our predictions displayed in the following graph.

Graph 2: Prediction of Coefficient of Variation until 2013



Unfortunately, given that the predictive observations increase continuously (see both Graph 2 above and table 2 in appendix) without fluctuations like real observations (at least the last time interval) we are forced to use another method of predictions called 'Seasonal Holt-Winters' which gives weight to more recent observations. The h-step predictor of this method is $P_n Y_{n+h} = \hat{a}_n + \hat{b}_n h + \hat{c}_{n+h}, h = 1, 2, ...$[8]

where:

$$\hat{a}_{n+1} = \alpha\left(Y_{n+1} - \hat{c}_{n+1-d}\right) + (1-\alpha)\left(\hat{a}_n + \hat{b}_n\right) \quad \hat{b}_{n+1} = \beta\left(\hat{a}_{n+1} - \hat{a}_n\right) + (1-\beta)\hat{b}_n$$

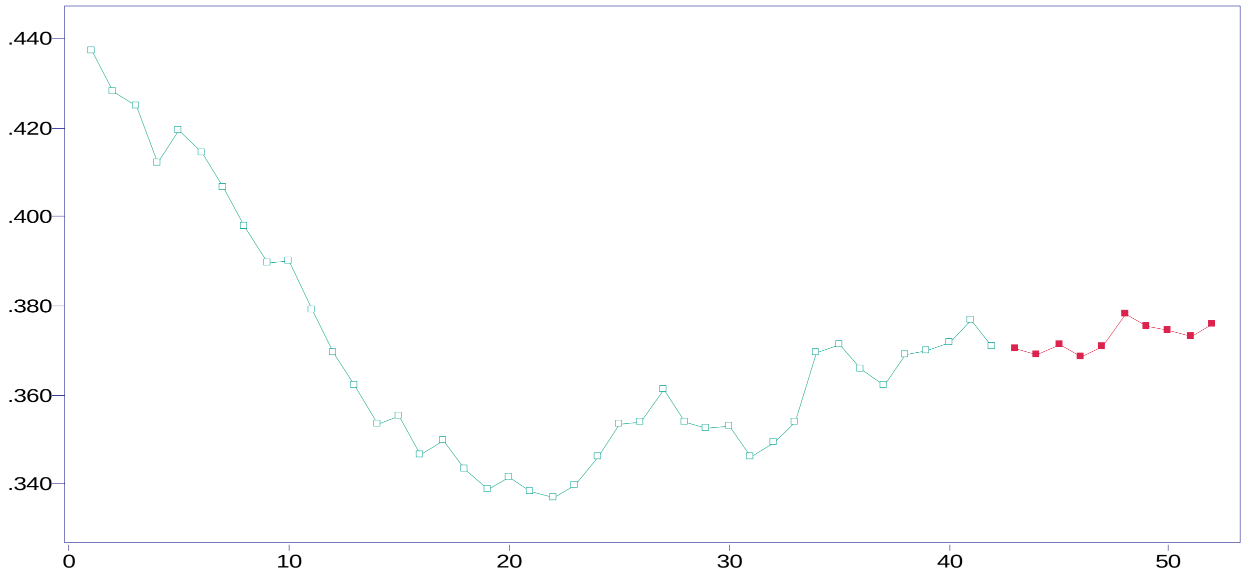
$$\hat{c}_{n+1} = \gamma\left(Y_{n+1} - \hat{a}_{n+1}\right) + \gamma\hat{c}_{n+1-d} \text{ with initial conditions } \hat{a}_{d+1} = Y_{d+1} \quad \hat{b}_{d+1} = \frac{Y_{d+1} - Y_1}{d}$$

$$\hat{c}_i = Y_i - \left(Y_1 + \hat{b}_{d+1}(i-1)\right), i = 1, ..., d.$$

[8] P is the symbol of predictor and not of probability

α,β,γ are chosen in a systematic way to minimize the sum of squares of the one-step errors, $S = \sum_{i=3}^{n} \left(Y_i - P_{i-1} Y_i \right)^2$ obtained when the algorithm is applied to the already observed data. For our data α = 0.84 β = 0.17 and γ = 1.

Graph 3: Prediction of Coefficient of Variation until 2013



As evident, both graph 3 and the table of predictions (see appendix- table 3) present an increasing trend without sharp movements a picture which is more close to the last period's historical data. Therefore our inference, drawn from the fact that both methods predict an upward trend in coefficient of variation, is that the lack of 'sigma' convergence will probably remain over the next years leading the European integration process away from completeness.

6. Conclusions and Suggestions

In this paper we were focused mainly in the study of convergence of GDP per capita in EU-15 based on ideas of 'sigma' and 'beta' convergence. In general, the empirical analysis showed that the period analyzed (1960-2003) was one of an on-going sigma convergence. However, dividing the sample of coefficients of variation in two sub-periods, we ascertained that between 1960-1981 there is 'sigma' convergence while between 1982-2003 exists 'sigma' divergence. This alternation came presumably from the big recession of period 1980-1982 that was the result of continuous increases of oil's prices. This crisis mostly influenced the financially weaker countries.

Then we proceeded into the examination of 'beta' convergence using the method of panel data regression for the period 1971-2003, separating the data in four periods of eight years each. In fact, it was verified not only unconditional but also conditional 'beta' convergence even if for the same period (1971-2003) we had 'sigma' divergence. The disagreement at results of two approaches shows that the rate of 'beta' convergence was not sufficient to ensure a close approximation in the absolute levels of GDP per capita. Finally, assuming that the developments in the EU-15 countries could serve as a good indicator for the future economic development of the accession countries we projected the values of coefficient of variation until year 2013 to find an increasing trend, thus, a clear tendency to 'sigma' divergence.

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Appendix

Table 1: Coefficient of Variation for the Years 1960-2003 in EU

Years	Coefficient of Variation	Years	Coefficient of Variation
1960	0.437500	1982	0.339510
1961	0.428287	1983	0.346030
1962	0.424855	1984	0.353340
1963	0.411929	1985	0.354050
1964	0.419241	1986	0.361249
1965	0.414176	1987	0.354025
1966	0.406328	1988	0.352257
1967	0.398058	1989	0.353073
1968	0.389580	1990	0.346238
1969	0.389868	1991	0.349324
1970	0.378970	1992	0.353859
1971	0.369505	1993	0.369584
1972	0.362024	1994	0.371104
1973	0.353529	1995	0.365613
1974	0.355037	1996	0.361882
1975	0.346369	1997	0.369034
1976	0.349910	1998	0.369704
1977	0.343143	1999	0.371646
1978	0.338886	2000	0.376872
1979	0.341314	2001	0.370996
1980	0.338276	2002	0.384132
1981	0.336639	2003	0.385035

Table 2: Prediction of Coefficient of Variation

Years	Coefficient of Variation
2004	0.37737
2005	0.38337
2006	0.39432
2007	0.40035
2008	0.40948
2009	0.42126
2010	0.42579
2011	0.43176
2012	0.43775
2013	0.44868

Table 3: Prediction of Coefficient of Variation using the "Seasonal Holt-Winters" method

Years	Coefficient of Variation
2004	0.37042
2005	0.36898
2006	0.37142
2007	0.36846
2008	0.37087
2009	0.37824
2010	0.37525
2011	0.37468
2012	0.37324
2013	0.37567

Box-Cox Transformation

$$y^{(\lambda)} = \frac{y^{\lambda} - 1}{\lambda}, \lambda \neq 0$$

$y^{(\lambda)} = \ln y, \lambda = 0$. In our case $\lambda = 1.5$ (the best choice)

Trend component: $\hat{m}_t = -0.46862 - 0.0049844 * t + 0.000097186 * t^2$

Seasonal component: It must $\sum_{k=1}^{d-1} \hat{S}_k = 0$

	$\hat{S}_k$
0	-0.00057725
1	-0.0018322
2	0.00011169
3	-0.00094815
4	-0.000014055
5	0.0026551
6	0.00060491