Testing the Convergence Hypothesis in the European Union

MIHAELA SIMIONESCU
Institute for Economic Forecasting
Romanian Academy
Casa Academiei, Calea 13 Septembrie nr. 13, sector 5, 050711, Bucharest
ROMANIA
mihaela_mb1@yahoo.com

Abstract

The main objective of this study is to measure the degree of convergence in European Union-28 (EU-28) in the period from 1995 to 2012. The catch-up rates diminished for many countries in the period from 2008 to 2012, because of the negative effect of economic crisis, when the disparities among countries were larger. Three statistical tests were applied for the entire period and for the two sub-periods (1995-2007 and 2008-2012). All the statistics (T1, T2, and T3) values have indicated the existence of divergence in the EU-28 between the levels of GDP/capita in PPS. However, during the each analysed period there is an obvious decrease of the variance in the last period compared to the first period.

Keywords: *convergence, catch-up rate, GDP per capita, European Union.*

1. Introduction

There are many statistical indicators used to assess the degree of economic convergence for more regions or countries. In this article, we are not interested in the classical measures used to evaluate the convergence. We will use the catch-up rate, which is not actually a convergence indicator, but it provides us indirectly important information regarding the degree of convergence. Moreover, the classical statistical indicators coefficient of variation, variance or inequality indicators are not enough to catch the evolution of the convergence process. Therefore, we propose in this article the study of convergence process in European Union in different periods by using the statistical tests.

This paper has several parts. After a brief introduction, a short literature review is made, underlying the latest results regarding the convergence assessment.

The empirical application supposes the computation of catch-up rates for each state of the EU-28 in different periods and the statistical evaluation of convergence process using the tests recognised by literature. A section dedicated to main conclusions was presented in the end.

2. The economic convergence in literature

Sala-i-Martin (1996) presented two classical measures of convergence represented by beta and sigma indicators that can also be used in order to compute the speed for getting convergence. Sigma measure reflects the convergence or divergence tendency and it depends on the value of sample variance. Beta indicator computes the speed for getting the convergence when it has a negative value. Authors like Mankiw, Romer and Weil (1992) and Islam (1995) showed that the economies with a low

initial income will grow faster than the economies with higher initial incomes, using control variables like population growth and saving rate. Quah (1996) and Durlauf (1996) concluded that the transversal growth model is incompatible with the convergence, but consistent with the multiple mechanisms of endogenous growth. Friendman (1992) and Quah (1996) claimed that the real convergence should not be measured using beta indicator. The beta and sigma measures are linked and reciprocal checked. The poor economies tend to have a high speed of increase compared to the rich countries. This observation implies the following facts: the coefficient of variation for GDP/capita decreases in a slow way and there is a negative relation between the rate of GDP/capita and the initial level of this variable.

Azomahou, El ouardighi, Nguyen-Van, and Cuong Pham (2011) proposed a semi-parametric partially linear model to assess the convergence between EU countries, showing that there is no convergence for members with high income. Beyaert and García-Solanes (2014) measured the impact of economic conditions on long-term economic convergence. The convergence in terms of GDP/capita is different from that of the business cycle during 1953-2010. Cuaresma, Havettová and Lábaj (2013) evaluated the income convergence dynamics and they proposed some forecast models for European countries. The authors predicted that the human capital investment will determine income convergence.

Palan and Schmiedeberg (2010) tested the structural convergence in terms of unemployment rate for Western European countries, observing divergence for technology-intensive manufacturing industries. Le Pen (2011) utilized the pair-wise convergence of Pesaran (2007) for the GDP per capita of some European regions.

Crespo-Cuaresma and Fernández-Amador (2013) determined the convergence patterns for European area business cycles. In the middle of 80's there was an obvious business cycle divergence while in '90 the convergence was persistent.

Kutan and Yigit (2009) used a panel data approach for 8 new countries in the EU and they stated that the productivity growth was determined by human capital in the period from 1995 to 2006. Monfort, Cuestas, and Ordóñez (2013) observed two convergence clubs in EU-14 by applying a cluster analysis. Iancu (2009) assessed the real convergence using the sigma approach in EU members considering three groups: EU-10, EU-15 and EU-25, the results showing an increase of the divergence in the period from 1995 to 2006. Mihuţ and Luţaş (2013) assessed the sigma convergences across the new countries that become member of the EU.

3. Assessing the economic convergence in EU-28

The catch-up rate is used to measure the pace of catching-up more developed regions. Some authors, like Halmai and Vasary (2010), have shown that convergence and catch-up do not express the same concept. The dynamics of the two variables are different, because the convergence shows the degree of progress, while the catch-up indicates the distance to be achieved towards convergence. For GDP growth it is useful to extend the catch-up for narrower residual difference and the convergence will be lower. The catch-up rate is defined as:

$$CR = 100 \cdot \frac{\Delta(y_{i,t} - y_t^*)}{(y_{i,t-1} - y_{t-1}^*)} \quad (1)$$

$y_{i,t}$ −GDP per capita in purchasing power standard (PPS) at time t for country i

y_t^* – average GDP for EU-28 countries

Δ – difference between GDP at time t and GDP at time t-1

The indicator is usually computed for historical actual rates, being used for ex-post analysis of dynamics of catch-up rates.

If we have negative value for catch-up rates, then we can state that the disparities between countries have decreased.

Table 1: Average catch-up rates in EU-28 countries in 1996-2004 and 2005-2013

Country	1996-2004	2005-2013
Belgium	1.87	2.13
Bulgaria	3.24	-0.47
Czech Republic	1.03	0.06
Denmark	1.27	2.10
Germany (until 1990 former territory of the FRG)	7.21	8.61
Estonia	1.36	-2.39
Ireland	18.06	-1.13
Greece	23.76	36.46
Spain	6.15	30.74
France	-0.32	0.49
Croatia	0.94	0.47
Italy	-20.02	-16.69
Cyprus	65.89	42.17
Latvia	-0.65	-2.70
Lithuania	-0.20	-4.22
Luxembourg	2.11	3.60
Hungary	1.87	1.03
Malta	0.45	-1.21
Netherlands	0.59	1.99
Austria	2.24	3.20
Poland	-0.96	-2.67
Portugal	4.09	3.28
Romania	-3.18	-1.24
Slovenia	4.18	5.78
Slovakia	-3.42	-4.74
Finland	1.08	2.40
Sweden	1.17	2.61
United Kingdom	20.22	-11.29

Source: author's calculations

It was observed a decrease of the catch-up rate in the second period compared to the first period for the following countries: Portugal, Bulgaria, Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Croatia. There are also negative catch-up rates for some countries that become more obvious in the second period where the economic crisis have produced many disturbances. The catch-up rate measures the absolute disparity and it is not the best indicator in this context. In the formula of CR there is an absolute amount. Therefore, a positive sign

of the indicator shows an increase in disparity while the GDP per capita may decrease. The solution for this disadvantage is to compute the difference of GDP per capita in two subsequent years:

$$\Delta GDP_{i,t}^{pc} = \frac{y_{i,t}}{y_t^*}\frac{y_{i,t-1}}{y_{t-1}^*} \quad (2)$$

$y_{i,t}$ −GDP per capita in purchasing power standard (PPS) at time t for country i

y_t^* − average GDP for EU-28 countries

In this case the disparity between the countries and the average is diminished for positive values of the difference.

Table 3: Average annual changes of catch-up rates in EU-28 countries in 1996-2004 and 2005-2013

Country	1996-2004	2005-2013
Belgium	1.02	1.42
Bulgaria	0.33	0.42
Czech Republic	2.13	2.34
Denmark	1.02	1.84
Germany (until 1990 former territory of the FRG)	1.01	1.13
Estonia	2.03	0.67
Ireland	1.34	2.49
Greece	0.94	0.77
Spain	1.84	1.37
France	0.87	1.28
Croatia	0.78	0.66
Italy	1.94	2.08
Cyprus	0.55	1.09
Latvia	-0.12	0.70
Lithuania	0.98	1.31
Luxembourg	3.45	5.17
Hungary	1.04	0.29
Malta	1.06	1.52
Netherlands	1.03	1.90
Austria	0.89	1.15
Poland	-0.28	0.55
Portugal	2.05	1.64
Romania	-0.05	0.66
Slovenia	0.23	2.44
Slovakia	1.05	0.95
Finland	1.63	2.03
Sweden	0.87	1.28
United Kingdom	0.93	1.11

Source: author's calculations

A decrease in the value of the average of annual chances of the indicator was observed for fewer countries: Portugal, Greece, Spain, Estonia, Hungary, Slovenia and Croatia. The highest decrease was observed for Hungary, with 72.12% in the second period compared to the previous one. Therefore, for this country we can observe a decrease in disparity. The catch-up rates diminished for many countries in the second period because of the negative effect of economic crisis.

Lichtenberg (1994) proposed a test for the convergence assumption that the variance of an indicator like productivity across regions diminishes over time.

N- number of regions (countries)
T- the end of the analyzed period

Y_{it}- productivity at time t in region i

$y_{it} = \ln(Y_{it})$

$\hat{\sigma}_t^2 = \sum_i (y_{it} - \bar{y}_t)^2$/N- variance of y_{it} across regions

$\hat{\sigma}_1^2$ —variance in the first period

$\hat{\sigma}_T^2$ — variance in the last period

According to Lichtenberg (1994), the ratio $T_1 = \frac{\hat{\sigma}_1^2}{\hat{\sigma}_T^2}$ follows a F distribution F(N-2, N-2) when the productivities do not converge over a period of time.

If the productivities follow an autoregressive model, we have the following relationship:

$$y_{it} = \rho y_{i,t-1} + v_{it} \quad (3)$$

t=2,…, T and i=1,2,…,N

y_{it} —identically and independent distributed (i.i.d.) $N(\mu_1, \sigma_1^2)$ and independent of v_{it}- i.i.d. $N(\mu_1, \sigma_v^2)$

The lack of convergence stated in the null hypothesis supposes the following restriction:

$$\rho^2 = 1 - \frac{\sigma_v^2}{\sigma_1^2} \quad (4)$$

If $\rho^2 < 1 - \frac{\sigma_v^2}{\sigma_1^2}$, there is convergence in time for productivities.

$$y_{iT} = \pi y_{i,1} + u_i \quad (5)$$

i=1,2,…,N

$$\pi = \rho^{T-1} \tag{6}$$

$$u_i = \sum_{t-2}^{T} \rho^{T-t} v_{it} \tag{7}$$

If there is no convergence we have:

$$\pi^2 = 1 - \frac{\sigma_u^2}{\sigma_1^2} \tag{8}$$

Carree and Klomp (1997) have shown the deficiencies of T1 , proposing two alternative statistics: T2 and T3.

The hypothesis in this case is: the initial variance (in the first period) and the last variance (in the final period) are equal.

$$T_2 = (N - 2.5)\ln[1 + \frac{1}{4}\frac{(\hat{\sigma}_1^2 - \hat{\sigma}_T^2)^2}{\hat{\sigma}_1^2\hat{\sigma}_T^2 - \hat{\sigma}_{1T}^2}] \tag{9}$$

T2 follows a chi-square distribution ($\chi^2_{(1)}$).

The covariance of productivities in the initial and last period is:

$$\hat{\sigma}_{1T} = \sum_i (y_{i1} - \bar{y}_1)(y_{iT} - \bar{y}_T)/N \tag{10}$$

The productivities in the first and last period follow a bi-variate normal repartition:

$$\begin{bmatrix} y_{i1} \\ y_{iT} \end{bmatrix} \sim N\left(\begin{bmatrix} \mu_1 \\ \mu_T \end{bmatrix}, \begin{bmatrix} \sigma_1^2 & \sigma_{1T} \\ \sigma_{1T} & \sigma_T^2 \end{bmatrix}\right) \tag{11}$$

$$T_3 = \frac{\sqrt{N}(\frac{\hat{\sigma}_1^2}{\hat{\sigma}_T^2} - 1)}{2\sqrt{1 - \hat{\pi}^2}} \tag{12}$$

$\hat{\pi}$- the least squares estimate for π in the equation

We calculated the statistics (T1, T2 and T3) for gross domestic product (GDP) per capita in PPS for European Union (EU-28) countries from 1995 to 2012.

Table 4: T1, T2 and T3 and other intermediate computations

Statistics and other indicators	Values for 1995-2012	Values for 1995-2007	Values for 2008-2012	Critical values at the 5% level of significance
T1	1.1679	1.1433	1.0089	1.9292
T2	0.3567	1.3785	-0.0066	3.841

T3	-7.5898	0.9390	0,045	1.645
$\hat{\sigma}_1^2$	2.5047	2.5047	2.1637	-
$\hat{\sigma}_T^2$	2.1447	2.1908	2.1447	-
$\hat{\sigma}_{1T}$	2.222	2.2458	2.2329	-
ρ	1.002	1.0028	1.0005	-
$\hat{\pi}^2$	1.1139	1.1630	1.2736	-

Source: author's computations

According to the table, the values of the statistics are lower than the critical value, this fact implying that the null hypothesis cannot be rejected. So, the conclusion is that in all analyzed periods there is not convergence across countries regarding the GDP per capita values in EU-28. However, we can observe that in each period the initial variance is greater than the variance in the final year. Therefore, we can conclude that in each horizon there is evidence of divergence reduction. The lowest diminish is seen the period from 2008 to 2012, which is the period corresponding to the economic crisis. It is obvious that during the crisis the process of reducing the divergence has diminished compared to the previous period and to overall period.

4. Conclusion

The convergence in EU-28 was assessed using some statistical tests and a complementary approach based on catch-up rates to see the tendency of disparity. The results showed that there is strong evidence of divergence in EU-28 countries, even if there is a slow decrease of the convergence during 1995-2012. In crisis period the decrease of divergence is lower compared to the pre-crisis times and compared to the entire analyzed period. This research could be continued by computing other recognized indicators (variability measures or inequality indicators), but the conclusions should be the same.

References:

1. Azomahou, T.T., El ouardighi, J., Nguyen-Van, P., Cuong Pham, T.K. (2011), Testing convergence of European regions: A semiparametric approach, *Economic Modelling*, Volume 28, Issue 3, May 2011, Pages 1202-1210.
2. Beyaert C., García-Solanes, M. (2014), Output gap and non-linear economic convergence, *Journal of Policy Modeling*, Volume 36, Issue 1, January–February 2014, Pages 121-135.
3. Carree, M., &Klomp, L. (1997).Testing the convergence hypothesis: A comment.*Review of Economics and Statistics*, *79*(4), 683-686.
4. Crespo-Cuaresma,J., Fernández-Amador, F. (2013), Business cycle convergence in EMU: A first look at the second moment, *Journal of Macroeconomics*, Volume 37, September 2013, Pages 265-284.
5. Cuaresma, J.C., Havettová,M., Lábaj, M. (2013), Income convergence prospects in Europe: Assessing the role of human capital dynamics *Economic Systems*, Volume 37, Issue 4, December 2013, Pages 493-507.

6. Kutan, A.M., Yigit, T.M. (2009), European integration, productivity growth and real convergence: Evidence from the new member states *Economic Systems*, Volume 33, Issue 2, June 2009, Pages 127-137.
7. Iancu, A., (2009), "Real Economic Convergence," *Working Papers of National Institute of Economic Research* 090104, National Institute of Economic Research.
8. Le Pen, Y. (2011), A pair-wise approach to output convergence between European regions, *Economic Modelling*, Volume 28, Issue 3, May 2011, Pages 955-964.
9. Lichtenberg, F. R. (1994). Testing the convergence hypothesis. *The Review of Economics and Statistics*, *76*(3), 576-79.
10. Mihuţ, I. S., Luţaş M., (2013), "Testing Sigma convergence across new EU members", *Revista Economică*, vol. 65, no. 2-6.
11. Monfort,M., Cuestas, J.C., Ordóñez, J. (2013), Real convergence in Europe: A cluster analysis, *Economic Modelling*, Volume 33, July 2013, Pages 689-694.
12. Palan,N., Schmiedeberg, C., (2010), *Structural Change and Economic Dynamics*, Volume 21, Issue 2, May 2010, Pages 85-100.
13. Villaverde Castro, J. (2004), Indicators of real economic convergence, A. Primer, *UNU CRISE, Working papers*, W-2004/2.