I. THE CONVERGENCE PROCESS IN THE EU ESTIMATED BY GINI COEFFICIENTS[1]

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Abstract

At present, there is not an unique indicator to evaluate the converge process. Varying with the assumptions and methodologies considered, with the indicators used and with the periods analysed, the results of the studies on convergence in the European Union are often ambiguous. Some of them support the existence of convergence, others conclude that a convergence process is not yet demonstrated and some authors point out that there is a divergence process. Using the Lorenz curve model and estimating on its basis Gini coefficients for the last decade we demonstrated in this study a significant convergence process in the EU, despite the negative impact of the actual crisis. However, the differences in matter of convergence emerge at the level groups of countries. Thus, while in EU-10 (recently joined countries to the EU) a strong convergence is visible, in EU-15 (old members of EU) a significant trend of divergence was demonstrated.

Keywords: convergence, Gini coefficient, Lorenz curve, divergence, the European Union

JEL Classification: C8, E20, F02, O11, O47

Introduction

The convergence theory has a long tradition in economic literature; the most consistently expressed being in the Solow model (Solow, 1956). Simplifying, on this basis, it can be shown that, as economic development is advancing (usually expressed by the GDP per capita growth), there is a general convergence process

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between countries. Empirical evidence throughout economic history has generally confirmed this process. However, it suggests that convergence is not linear; it is accelerating, sooner or later, depending on a number of specific conditions, after reaching certain critical values (thresholds). Questions concerning their estimation continue to remain a central topic of debate in the economic literature in the field.

Currently, in the specialized literature, including in Romania, there are numerous attempts to quantify in terms of convergence. Based on criteria established by the European Union, the convergence assessment includes indicators of the so-called nominal convergence and that of the so-called real convergence.

On the real side of economic growth, convergence refers explicitly only to the GDP per capita. However, the present analysis used mostly a set of indicators. Also recently, the literature distinguishes between two types of convergence, the so-called β-convergence and σ-convergence, respectively. Typically, they use different indicators which reflect either the long-term reduction in disparities between countries (the index level on the relationship between indicators of different economies, dispersion, Gini coefficient, Theil index, etc..) or the so-called transversal convergence (beta convergence) or, finally, convergence in time series, dynamic distribution, business cycle, etc. (Quah, 1996; Litchfield, 1999; Castro, 2004; Iancu, 2006, 2009, 2010; Monfort, 2008; Pecican, 2009; etc.).

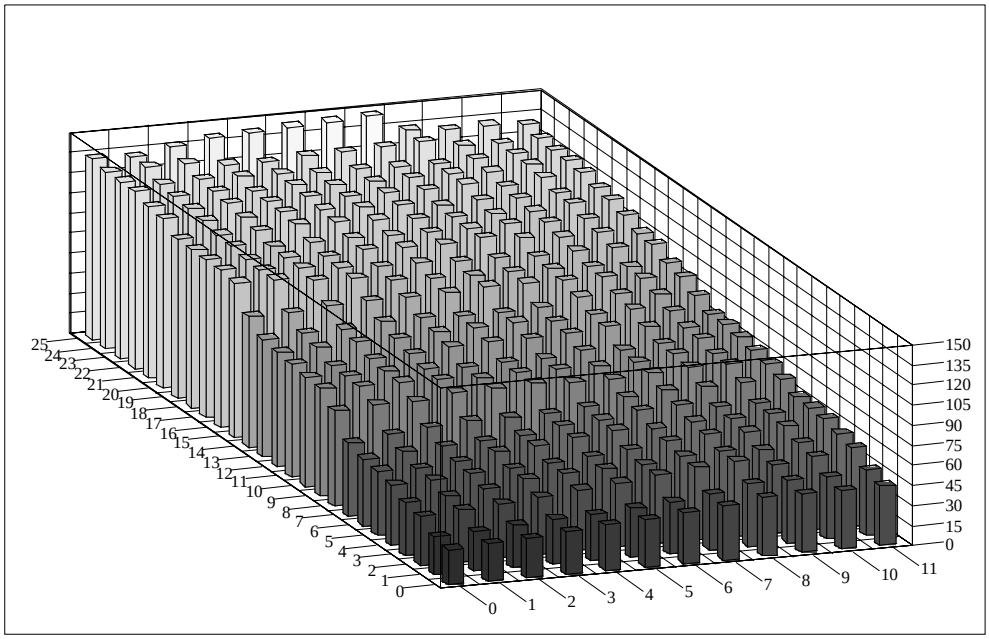
1. Empirical Evidence

Depending on the assumptions and methodologies considered, the indicators used and the periods analysed, the results of the studies on convergence in the European Union are often ambiguous, some strongly supporting the existence of convergence, others concluding that a strong convergence process is not yet demonstrated and some just pointing out that there is a divergence process.

To study convergence in the EU in the period 2000-2011, we first analyze the dynamics of GDP per capita in euro PPS of each member country, compared to the average across the EU. Due to the high level in Luxembourg, we excluded this country from the graphical representation in Figure 1. Years on x axis are ranked from 0 (2000) to 11 (2011), the y axis includes the 26 countries (0 to 25), and the z axis shows the ratio, in percentage of GDP per capita, of each country to the EU average. We should note that in this graph the values of GDP per capita, compared to the EU average, are represented by different 3D bars, lighter and darker grey tones, indicating the highest and lowest, respectively, GDP per capita levels.

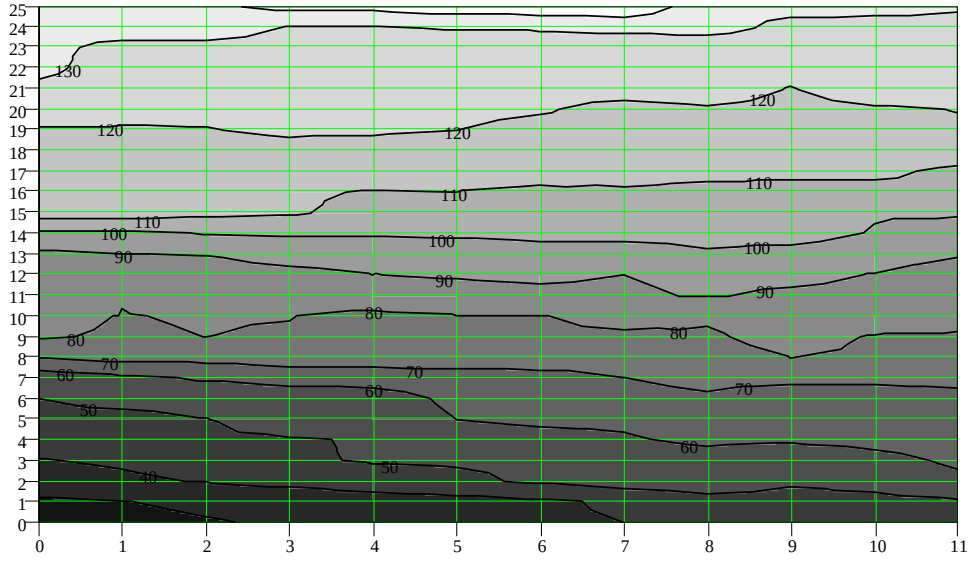
The convergence between 2000 and 2011 is also illustrated by spectral representation of GDP per capita in euro PPS by year and country against the EU average, in Figure 2.

Figure 1



Source: Own calculations based on Eurostat data.

Figure 2



Source: Own calculations based on Eurostat data.

2. The Lorenz Curve Model and Gini Coefficients in the case of GDP Distribution

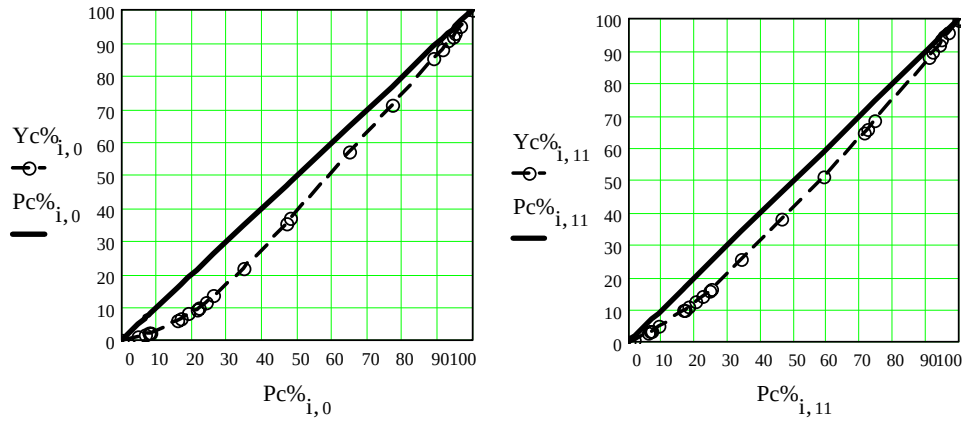
Usually, a useful tool to analyse the inequality of wealth or income distribution is the Lorenz curve (first time developed by Max O. Lorenz in 1905). It can also be used to study the concentration degree related to a certain development indicator in a group of countries, as in the European Union is.

Changes in time in the concentration degree could be a measure of the convergence process. In essence, the Lorenz curve expresses the distribution of a certain indicator of interest, GDP, for instance, within a certain population. Thus, on abscissa the cumulative share of people from lowest to highest GDP per inhabitant is marked and on the ordinate the corresponding cumulative share in GDP. The line passing through all points (x,y) in plane is the resulted Lorenz curve.

The diagonal of the unit square thus formed means the average per capita level of GDP and the area delimited by the Lorenz curve and this diagonal, denoted by A, is considered to represent an aggregate measure of disparities or the degree of population concentration. The diagonal is corresponding to the so-called line of perfect GDP equality (all levels of GDP per capita are equal; by contrast, the line of perfect inequality is represented by the horizontal line, y=0 for all x less than 100%, continuing with the vertical line y=100% when x=100%).

For illustration, we present in Figure 3 the Lorenz curve for the EU in 2000 and in 2011 (where the cumulated weights of GDP, Yc%, on the ordinate and those of the population, Pc%, on the abscissa are expressed as percentage). We can see a diminution of the area bounded by the Lorenz curve and the diagonal in 2011 compared to 2000, which signifies a process of convergence in this period.

Figure 3



Source: Own calculations based on Eurostat data.

For example, the Lorenz curve for the distribution of the EU GDP in 2011 shows that 25% of the EU population (the poorest 14 countries with a GDP per capita less than 23,000 euro) covered only 16.5% of the total EU GDP, and that 20% of the EU

population (the poorest 9 countries with a GDP per capita of less than 19,400 euro) covered only 12.4% of the total EU GDP, etc.

Based on the Lorenz curve a range of indicators can be estimated, including the Gini coefficient, which is defined as the ratio of surface area A (bounded by the Lorenz curve and the diagonal) to the entire area under the diagonal line, denoted by A + B, where B is the area under the Lorenz curve. We may write the relation for calculating the Gini coefficient, G, as follows:

$$G = A / (A + B) \tag{1}$$

Taking into account that the denominator is equivalent to half of the unit, the Gini coefficient is by definition twice A:

$$G = 2\,A \tag{2}$$

where: A is equal to 0.5 - B.

Theoretically, the Gini coefficient can range from 0 (perfect equality) to 1 (perfect inequality). Expressed as a percentage, the Gini coefficient is called the Gini index. For applications, there are different methods to estimate the Gini coefficient, which usually involve large amount of calculus.

One of the methods we are using is based on the econometric approach based on a continuous function, ye (x), that best approximates the Lorenz curve, then by the integration on the interval [0, 1] we can calculate area B, as follows:

$$B := \int_0^1 ye(x)\,dx \tag{3}$$

As a form of the Lorenz curve estimation function we propose the following

$$ye(x) = x / (a\,x + b) \tag{4}$$

which usually produces good estimates.

The results show a clear trend of convergence in the EU in the period 2000-2011, expressed by the fact that the Gini index decreased continuously from 18.0% in 2000 to 13.2% in 2009, and then, in 2010, it increased slightly to 13.6%, followed by a further decrease to 13.0% in 2011.

Another method used for estimating the Lorenz curve Gini coefficient is interpolation, which produces less consistent results, but is less laborious. Thus, if the Lorenz curve is estimated for each interval as a line between two consecutive points, the area B can be approximated by the so-called method of trapezoids. In this case, the relationship for calculating the Gini coefficient is:

$$G := 1 - \sum_{i=1}^{n} \left(\frac{X_i - X_{i-1}}{100}\right) \cdot \left(\frac{Y_i + Y_{i-1}}{100}\right) \tag{5}$$

where: when analysing the distribution of EU GDP, X=Pc% and Y=Yp%.

Based on the calculation result, there is a clear trend of convergence over the analysed period, as the Gini coefficient estimated by this method almost continuously decreased (from 15.8% to 12.2%). The minimum value of the coefficient was reached

in 2009 (11.7%), then in 2010 and 2011 there were somewhat higher values (12.3% and 12.2%, respectively).

Based on the Lorenz curve, another indicator that can be calculated by the Lorenz curve is the maximum vertical distance between the curve and the line of perfect equality (diagonal line). It can be considered that the amount is equal to the proportion of total income that should be transferred from the richer half of the population to the poorest half of the population, given the idea to achieve equality in the distribution of income or GDP between entities (groups of persons, households, countries). Therefore, this indicator is sometimes called the Robin Hood coefficient or the RH index (when it is expressed as a percentage). For example, in the case of the distribution of the EU GDP expressed in PPS, the relationship for the RH index is as follows:

$$RH = \max (Pc\% - Yc\%) \quad (6)$$

where: Pc% is the cumulative share of countries in the EU total population and Yc% is the cumulative share of countries in the EU total GDP.

The results show again a strong convergence in the EU during the analysed period, expressed by an almost continuous decrease in the RH index (from 13.0% in 2000 to 8.7% in 2011).

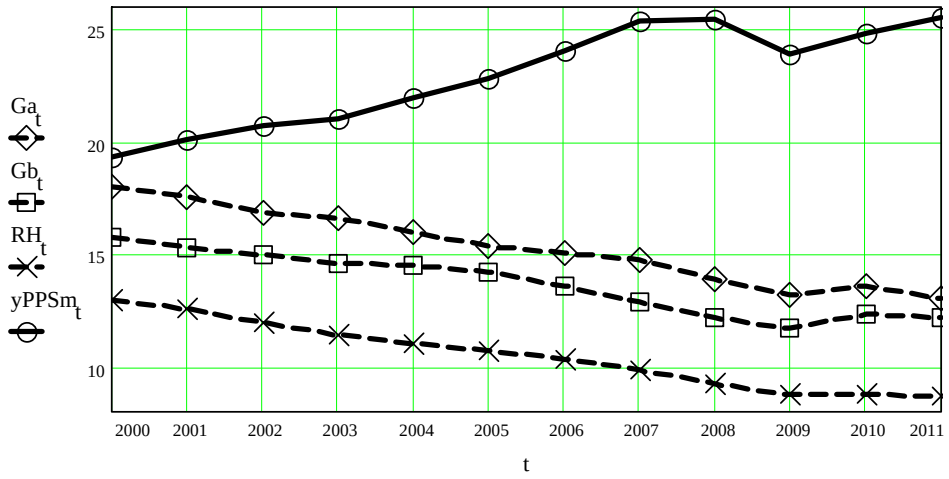
Table 1 presents our estimates for the three indicators of convergence, in the period 2000-2011, and the average level of GDP per capita in euro PPS. Also, Figure 4 shows, on the same graph, the dynamics of indicators used to evaluate the convergence in the EU in the considered period and the levels of GDP per capita. The Gini coefficients corresponding to the two estimation methods used were denoted by Ga (the first method) and Gb (the second method).

Table 1

Year	Ga Coefficient	Gb Coefficient	RH Coefficient	GDP per capita (in euro PPS)
	- in % -			
2000	18.006	15.794	12.960	19,356
2001	17.508	15.314	12.549	20,072
2002	16.820	14.954	11.943	20,736
2003	16.590	14.584	11.439	21,032
2004	15.980	14.482	11.005	22,001
2005	15.399	14.175	10.740	22,855
2006	15.087	13.605	10.343	24,053
2007	14.780	12.891	9.826	25,393
2008	13.874	12.223	9.205	25,426
2009	13.197	11.718	8.794	23,878
2010	13.605	12.322	8.814	24,875
2011	13.045	12.161	8.679	25,544

Source: Own calculations based on Eurostat data.

Figure 4



Source: Own calculations based on Eurostat data.

In the analysed period, a significant reduction in the value of convergence indicators is found, which means an increase in concentration in the EU. Thus, between 2000 and 2011, the Ga coefficient was reduced by 27.6%, the Gb coefficient by 23.0% and RH coefficient by 33.0%. At the same time, GDP per capita increased by 32.0%.

An important conclusion is that as the average level of economic development in the EU increases, the convergence process advances. Moreover, throughout the period 2000-2011, the coefficients of correlation between the convergence indicators, on the one hand, and the GDP per capita, on the other hand, were close to minus 1 (ranging from -0.941 to -0.924).

3. Differences in GDP Per Capita Convergence between EU-15 and EU-10

Often, is useful to separate the EU countries (excluding the two island states, Cyprus and Malta) into two groups: old EU countries, members before the last enlargement in 2004-2007, the so-called EU-15 group (Austria, Belgium, Denmark, Germany, Greece, Finland, France, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the UK) and the former communist countries of Central and Eastern Europe, the so-called EU-10 group (Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia).

Before comparing the indicators of convergence between the two groups of countries, it is important to estimate the concentration degree within the two groups. The absolute value of an estimated convergence indicator for a group of countries expresses in fact the degree of concentration within that group. Just dynamics is a measure of convergence (when the value decreases) or divergence (when the value increases). So the value of an indicator used to assess convergence is reduced, the

concentration within a group of countries is high and conversely, the higher the value of an indicator, the lower the degree of concentration within a group countries.

Applying the same methodology for calculating the convergence indicators, we estimated their value in the two groups of countries for the period 2000-2011. The results of our estimates for the GDP per capita time series, expressed in euro PPS, are summarized in Table 2 for EU-10 and in Table 3 for EU-15, and in the graph in Figure 5 (where ΔyUE10% and □yUE15% are percentage deviations from the EU average in both groups of countries).

Table 2

Year	Ga Coefficient	Gb Coefficient	RH Coefficient	GDP per capita (in euro PPS)
	- in % -			
2000	18.531	17.098	12.693	8,606
2001	18.337	16.969	11.934	9,122
2002	17.272	16.333	11.301	9,696
2003	16.489	15.787	10.598	10,243
2004	15.755	14.675	9.786	11,102
2005	15.196	14.437	9.878	11,784
2006	14.317	13.240	9.359	12,764
2007	13.231	12.446	8.672	14,114
2008	11.497	10.571	7.620	14,787
2009	11.266	10.539	7.307	14,238
2010	10.583	10.007	7.287	14,895
2011	10.262	9.268	7.050	15,772

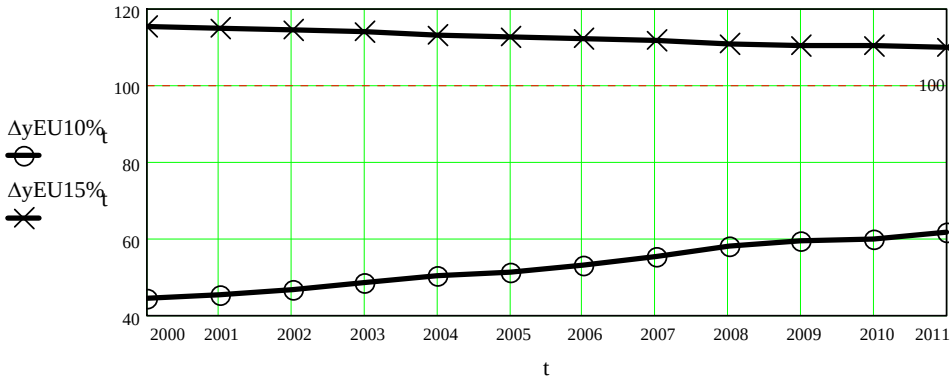
Source: Own calculations based on Eurostat data.

Table 3

Year	Ga Coefficient	Gb Coefficient	RH Coefficient	GDP per capita (in euro PPS)
	- in % -			
2000	4.909	4.876	3.285	22,351
2001	4.638	4.615	3.092	23,103
2002	4.463	4.651	2.924	23,774
2003	4.755	4.827	3.300	23,951
2004	5.333	5.363	3.845	24,931
2005	5.257	5.324	3.832	25,807
2006	5.101	5.096	3.737	27,042
2007	4.977	4.919	3.614	28,355
2008	4.934	4.862	3.492	28,198
2009	4.644	4.613	3.207	26,379
2010	5.714	5.662	4.114	27,457
2011	6.208	6.179	4.436	28,062

Source: Own calculations based on Eurostat data.

Figure 5



Source: Own calculations based on Eurostat data.

First, there are discrepancies between the two groups of countries on the level of per capita GDP. Thus, in 2000 this indicator for the EU-10 represented only 44.5% of the overall EU average, compared with 115.5% for the EU-15. However, in the last decade, there was a significant process of convergence between the two groups of countries, so that in 2011 the GDP per capita in the EU-10 has grown to represent 59 9% of overall EU average, compared to 109.9% for the EU-15, thus confirming the theory derived from the Solow model.

Also, according to the results, there is a huge difference between the two groups of countries, in matter of convergence progress. Thus, while in the group of less developed countries (EU-10) there was a significant decrease in value of the selected indicators (between -44.5% and -45.8%, respectively, for the RH coefficient and the Gb coefficient), which means increasing concentration and, hence, the existence of an intense process of convergence, in the case of the developed countries (EU-15) an accentuated decrease in the degree of concentration was registered, thus a process of divergence, reflected by the increase in value of the selected indicators (between +26.5% for the Ga coefficient and +35.0% for the RH coefficient, respectively).

Although during the period under review the concentration degree within the EU-10 group increased in contrast to a decrease in concentration inside the EU-15, the gap that separates the two groups of countries, although down from 2000, was still significant in 2011: -4.9 percentage points (-13.6 percentage points in 2000) in case of the Ga coefficient, -4.3 percentage points (-12.2 percentage points in 2000) in case of the Gb coefficient and -3.2 percentage points (-9.4 percentage points in 2000) in case of the RH coefficient, respectively.

Another significant difference between the two groups of countries, based on our estimates for the period 2000-2011, is the fact that if for the EU-10 group the convergence was favorably influenced by the increase of the average GDP per capita, for the EU-15 GDP per capita increase was accompanied by a process of divergence.

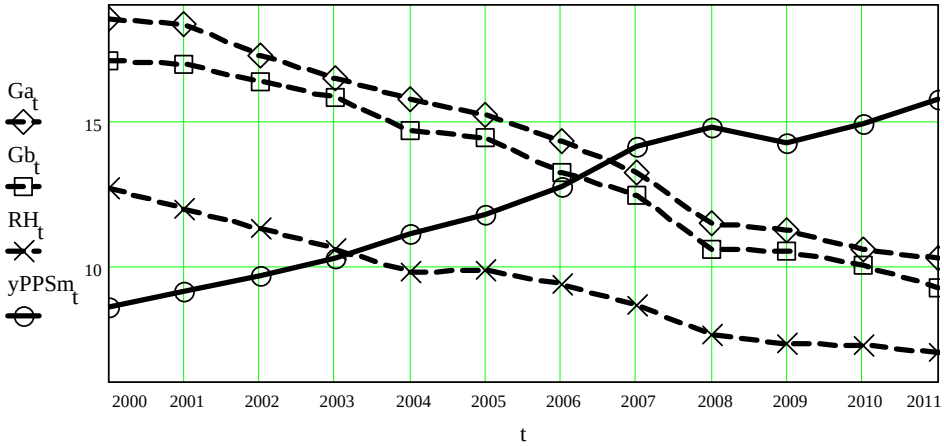
Thus, for the EU-10 there was a strong negative correlation between the average GDP per capita and the convergence indicators (the correlation coefficient ranging

from -0.979 in the case of the RH coefficient, to -0.986 in the case of the Ga and Gb coefficients).

In contrast, for the EU-15, there was a positive correlation between the average GDP per capita and the convergence indicators (the value of the correlation coefficient ranging between +0.480, in the case of the Gb coefficient, and +0.641, in the case of the RH coefficient) over that period.

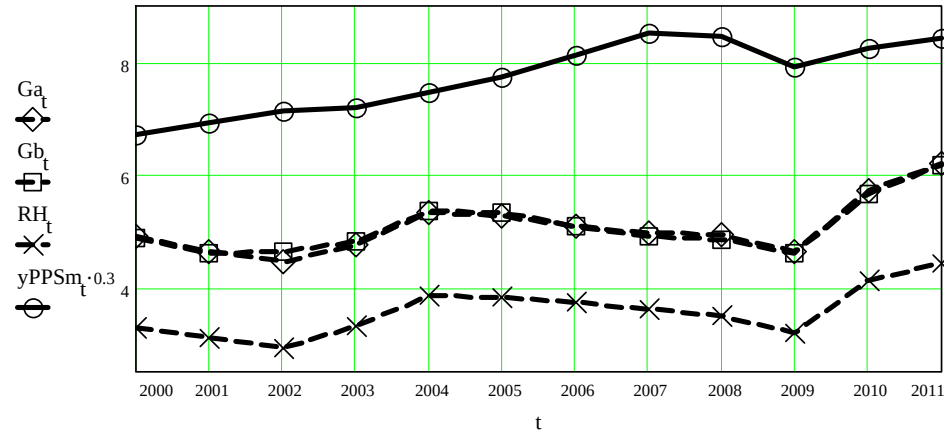
Synthetically, the evolution in the period 2000-2011 for the two groups of countries is shown graphically in Figures 6 (EU-10) and 7 (EU-15). In Figure 7, to fit in the same area of the graph like convergence indicators, the average productivity was multiplied by 0.3.

Figure 6



Source: Own calculations based on Eurostat data.

Figure 7



Source: Own calculations based on Eurostat data.

Conclusions

The Lorenz curve model and the derived Gini coefficients could be useful to evaluate the intensity of the convergence process in the EU. Based on such estimating procedure in case of the GDP per capita time series in the period 2000-2011, it was demonstrated an accentuated convergence proces inside the EU-10 group, but a significat divergence inside EU-15. The crisis seems to have no detectable impact on the convergence process inside of the two groups of EU countries. However, the analysis needs to be extended on a number of significant development indicators and further to estimate an agregate (or composite) index of convergence.

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