A model for assessing Romania's real convergence based on distances and clusters methods

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***Abstract**. Accession into Euro Area for Eastern European Countries became a compulsory and a very demanding step. These new members should achieve specific condition that are called "nominal convergence" criteria and that are defined by Maastricht Treaty. The convergence level reflects how much these countries are prepared to face the challenges and threats of being included into a high competitive economic area. Many studies on nominal and real convergence have been developed lately. The present paper is aimed at testing the real convergence for selected Eastern European Countries, including Romania, based upon distances and clusters methodology.*
Keywords: real convergence, distances, clusters, EMU.

JEL Classification: F15, F41, F36.

Introduction

The hypothesis that poor countries or regions tend to grow faster than rich countries over time and thereby tend to converge to the productivity levels of the leading nations has received high attention in the literature on economic growth and development (Vohra, 1997). Several explanations and theoretical models on economic growth have been suggested to account for this [Abramovitz, 1986; Baumol, 1986; DeLong, 1988; Dowrick and Nguyen, 1989; Barro and Sala-i-Martin, 1991, 1992; Levine and Renelt, 1992; Mankiw et al., 1992; Costello, 1993; Mallick, 1993; Solow, 1994; Grossman and Helpman, 1994; Pack, 1994; Romer, 1994; Barro et al., 1995; Kocenda, 2000; Dobrinsky, 2003; Iancu, 2008, Salsecci and Pesce in 2008].

A cohesive co-habitation in an organization, such as the EU, requires a high degree of convergence among the member states in terms of their economic performance (Dobrinsky, 2003). Although the development level of the country's *real economy* is not a condition for the accession to the EU or a negotiation issue for the accession, the question of catching-up or bridging the gaps between the EU member countries and regions is an important and urgent topic for the economic, scientific and technological strategy of the EU. The issue is even more important because there are significant disparities in the economic development levels of the EU countries and regions. The disparities widened after the accession of the two waves of CEE countries (Iancu, 2008). Thus, testing the existence of real convergence is a key task of economic research that has implications for national and EU macroeconomic and sectoral policies, in particular the EU regional policy channeled mainly through the Cohesion and Structural Funds (Martin and Sanz, 2003).

Since catching up implies reduction of the income gaps, one of the questions that would need to be addressed is whether there is evidence in recent years of convergence in per capita income levels between acceding countries and EU-member states. There has been a long debate in the economic literature of various aspects – theoretical as well as empirical – of the notion of (real) convergence and its theoretical foundation. Three main convergence hypotheses have been formulated (Galor, 1996):
– *the absolute (unconditional) convergence* hypothesis – per capita incomes of countries converge to one another in the long run, regardless their initial conditions [Baumol, 1986; DeLong, 1988]. If countries in general failed to converge, this absence is then explained through institutions [Abramovitz, 1986; Heitger, 1987; Alam, 1992];
– *the conditional convergence* hypothesis – per capita incomes of countries that are identical in their fundamental structural characteristics converge to one another in the long run independently of their initial conditions [Dowrick and Nguyen, 1989; Barro and Sala-i-Martin, 1991, 1992; Mankiw et al., 1992; Levine and Renett, 1992; Barro et al., 1995];
– *the "club convergence*" hypothesis (polarization or clustering) – per capita incomes of countries that are identical in their fundamental structural characteristics converge to one another in the long run, provided their initial conditions are similar as well.
Empirical work on testing these hypotheses largely relies on the actual measurement of the process of convergence between countries and nations. Two main quantitative definitions of convergence have been used mostly in the literature [Barro and Sala-i-Martin (1995), Sala-i-Martin (1996) Vohra (1997), Martin and Sanz (2003), Iancu, (2008)]:

– β ("beta") implies that the poor countries (regions) grow faster than the richer ones and it is generally tested by regressing the growth in per capita GDP on its initial level for a given cross-section of countries (regions)

– σ ("sigma") covers two types of convergence: absolute and conditional (on a factor or a set of factors in addition to the initial level of per capita GDP), meaning the reduction of per capita GDP dispersion within a sample of countries (regions).

Gacs (2003), Warcziarg (2001) and Raiser et al. (2003) introduced the "structural convergence", a concept usually describing the historic evolution of the – most aggregate – composition of output, most often the GDP, as a function of development in per capita income

Various studies have come up with different and sometimes conflicting results and conclusions. Thus, Barro (1991) and Barro and Sala-i-Martin (1995) have persistently argued that the cross-country income data provide empirical support of the convergence hypothesis (they use however relatively more recent, post-war data). On the other hand, a study developed within UNCTAD (1997), analyzing longer trends of world income distribution concluded that during the past 120 years divergence in per capita income levels has been the dominant trend in the world economy while convergence has been taking place mostly within a small group of industrialized countries, during certain periods of time. The controversy arises not only from the different time horizons but also from the type of hypothesis that is being tested: that of absolute convergence (latter study cited) or that of conditional convergence (the former studies cited).

Most of the studies are conducted on a country basis, primarily employing historical data from Organization for Economic Cooperation and Development data sources, the Summers and Heston [1991] database, or Maddison's [1995] historical data. One possible shortcoming of the cross-country study is the inconsistencies in data due mainly to non-standardized measurement methods among countries (Dobrinsky, 2003). In any case, convergence is a long-run phenomenon and its testing requires a sufficiently long time horizon. As the time period for which relevant data for the acceding countries are available is quite short (just one decade), it is practically impossible to test properly any of the convergence hypotheses.

However, researchers agree on the fact that there are also a number of contradictions that arise from the asymmetric treatment of the dimensions of convergence. In particular, during a catch-up process, there is an essential and fundamental economic link between nominal and real convergence that often tends to be neglected, but which is likely to have profound economic implications for the then accessing transition economies. The conclusion is that real convergence cannot be separated from nominal convergence as these are essentially the two sides of one and the same coin; the link between them is given by the dynamics of the real exchange rate.

Generally speaking, real convergence in an area formed by different countries (regions) is understood to mean the approximation of the levels of economic welfare – generally proxied by per capita GDP – across those countries (regions). So, the question of real convergence has to do with the study of economic growth, which, in turn, has traditionally been approached through an aggregate production function.

Using this approach, two main groups of models – the neo-classical and the new endogenous growth models – led to very different predictions of real convergence (Martin and Sanz (2003).

The neo-classical growth models [Solow (1956), Mankiw et al. (1992)] that imply convergence between poor and rich countries (regions), output per worker can rise only if the ratio of capital per worker increases or if technology (i.e. total factor productivity) improves. This should therefore lead to more capital accumulation and faster growth in poor countries (regions) than in rich ones. Consequently, opening up the country (region) – as happens in the framework of an integration process – would only accelerate the convergence process, as capital should flow to capital-scarce countries (regions) to benefit from higher returns. This is, in fact, the line of reasoning adopted in the conventional theory of economic integration, developed since the pioneering work of Viner (1950).

However, the new, more sophisticated growth models developed in the 1980s do not predict that income convergence between rich and poor countries (regions) is the only possible outcome. Thus, one of the first contributions, Romer (1986) considers that returns to capital do not have to be diminishing and Lucas (1988) proves that human capital with increasing returns is the main driving force of economic growth, suggesting the possibility of the brain drain acting as a vehicle of cross-country growth divergence is considered. However, the importance of commercially oriented R&D efforts has been emphasized as the main engine of growth (Romer, 1990), thus also explaining the existence of permanent, and under some circumstances, even widening, technological and income gaps between countries.

In the endogenous growth models, however, income convergence is not a necessary element. Thus, pro-active regional policy may play a significant role in achieving convergence. More specifically, laggard member countries need to boost efficient investments to enlarge and improve their endowments in all those kinds of capital assets with special influence on growth, namely: technology, human capital and infrastructure. Studies developed by Nadiri (1993), Nadiri and Kim (1996), Coe and Helpman (1995), and Keller (1999) – are focused on technology spillovers spread by trade, while studies developed by Blomström and Wolff (1994), Baldwin et al. (1999) – are concerned for the technology spillover effects through foreign direct investments. In this respect, the most elaborated and realistic formulations of innovation-driven growth models also stress the complementarity between both domestic R&D and foreign R&D spillovers and human capital investments. Thus, both the level (stock) and rate of investment in human capital prove crucial for growth not only as a separate factor, but also as a complement to exploiting the effects of new technologies created by either domestic or foreign innovation efforts. Thus, human capital is usually considered as an essential condition for convergence.

A number of recent theoretical and empirical contributions highlight the important role played by institutions, trade, and financial integration in fostering productivity and growth in achieving real convergence and FDIs, as representing an important driver for technology, innovation and knowledge transfers. David and Kraay (2003) found that, in a large cross-section of countries, rapid growth in the very long run is related to high levels of international trade and sound institutions. Badinger (2007) suggested that in addition to trade and institutions, free trade agreements (FTAs) are a further determinant of productivity and per capita income across countries. Gao (2005) show that economic integration enhances FDI, fuels expansion of R&D activity, and increases global growth. Bonfiglioli (2007) argued that financial integration has a positive direct effect on productivity. More recently, a study completed by Salsecci and Pesce in 2008 show a positive relationship between the average change in TFP (Total Factor Productivity) in CEE and SEE countries in 2002–2006 and the average FDI/GDP ratio experienced by the same countries in the same period with relatively stronger TFP performance in countries benefiting from relatively higher FDI/GDP ratios.

One important conclusion of the literature review is that the phenomenon of economic growth convergence of various countries- real convergence - has two main aspects. The first is the tendency to compensate for growth levels; to be more precise, the average income level. The second is the convergence of cyclical growth, that is the tendency for economic fluctuations to become synchronised (in the ideal case, the fluctuations amplitude would also be equal). These two aspects of growth convergence are independent from one another and should therefore be analysed separately, using different methods.

The most recent literature includes many comparative analyses related to the economic growth in the countries of Central and Eastern Europe. There are also many analyses related to equalization of growth levels and a few analyses related to synchronization of economic fluctuations. Results of empirical research encompassing different countries depend to a great extent on the level of homogeneity of the analysed group. Research related to countries with a similar economic growth level (e.g. highly developed) confirms the occurrence of the phenomenon of equalization of income levels, but research encompassing all countries of the world rather denies existence of such a tendency (Matkowski and Próchniak, 2004).

Research Methodology

The present study proposes a specific measure of convergence based on distances between cases (individual countries or group of countries). There are a lot of methods used to calculate the distance between two points from a multi-dimensional space, in order to assess the convergence between two or more individuals (countries in our case). The most usual distances used in convergence analysis are: Euclidian distance, „City Block" (Manhattan) distance, Cebyshev distance, Minkowski of order „m" distance, Quadratic distance, Canberra distance, Pearson correlation coefficient and

Squared Pearson correlation coefficient. In our analysis we use Euclidian distances rescaled to 0-1 range (normalized vectors of data). Euclidian distance measures the distance between a case (country) and another case based on the following formula:

$$d_{ij} = \sqrt{\sum_{k=1}^{n} \left(x_{ik} - x_{jk}\right)^2}$$

This formula is derived from Pitagora distance and is equal with the distance between two points $A(x_i, y_i)$ and $B(x_j, y_j)$ in a space with n dimensions. Each variable was rescaled with values between 0 and 1 by using the following formula:

$$z_i(y_i) = \frac{y_i - \text{lower bound of } y}{\text{upper bound of } y - \text{lower bound of } y}$$

A different perspective on the nominal convergence was obtained by using clustering methods (we tested two different clustering methods: k-means and hierarchical clusters). The main purpose of clusters based models is to reduce the quantity of required data by grouping them by similarities. This method of data grouping by using clustering alghorithms was initially created as an automatic instrument that could permit the organization of information by taking into consideration different categories or taxonomies (Jardine and Sibson [1971] or Sneath and Sokal [1973]). The models based on clustering alghoritms were divided into two main categories: hierarchical and partitional clustering methods (Anderberg [1973], Hartigan [1975], Jain and Dubes [1988] or Jardine and Sibson [1971]). For each category, different other clustering algorithms have been discovered (Tryon and Bailey [1973], Kolliopoulos and Rao [1999], Bădoiu, Har-Peled and Indyk [2002]).
Clustering based on k-means has its origin in a model proposed by McQueen (1967) and is considered the simplest clustering algorithm. The procedure is relatively simple to put into practice on a set of data applied to a definite number of clusters (equal to k) fixed a priori. The starting point is to establish, given a previous analysis, a number of k centroids corresponding to the number of initially established clusters. The most important advantage of this clustering method consists in its simplicity and rapidity and in the fact that it could be applied on large data sets.

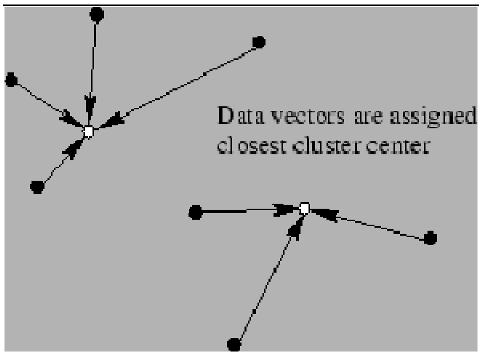

Figure 1. K – means clustering algorithm

The alghoritm of k-means starts with the initialization of K cluster centers, based on same dimensionality as the time series, iteration i=0. The next step is to assign each data vector x_i to the cluster with the nearest center $C_k^{(i)}$. The most used measurement method in k-means clustering algoritms is Euclidian distance metric $C_k^{(i)} - x_j$. Next step in the algoritm is to set new cluster centers $C_k^{(i+1)}$ to the center of gravity of each cluster based on the formula:

$$\mathbf{C}_k^{(i+1)} - E\{\mathbf{x}_j\}_{\mathbf{x}_j \in \mathbf{C}_k^{(i)}}$$

This formula can also be modified to use the median and/or to include an inertia term. The algorithm is restarted again until convergence of cases to each cluster centers. The main disadvantage of the method consists in the fact that initial clusters' number is randomly established without a specific method that could indicat the optimal number of clusters (Har-Peled and Mazumdar, 2004). Another problem is related to the difficulty in giving an appropriate interpretation to the results (a higher relevance has the use of this method on an inter-temporal basis. This clustering method minimizes the standard deviation inside of each cluster but does not provide a minimum variance at the level of considered sample of data. The computed centroids will consequently change their position, gradually, until there is no move left to be made and their position is fixed on the graph.

The hierarchical clusters is a different clustering method used to build a hierarchy between cases (countries) by establishing which two cases are the closest together, then combining these into a single cluster and repeating until the tree is complete. This method is very often used but computationally expensive process based on different distance measures. In practice, there are different methods to represent a hierarchical cluster: vertical or horizontal dendogram, shaded matrix proposed by Ling (1973), shaded density plot (Freeman, 1994). In practice the most used hierarchical clustering methods are: *single linkage clustering* (also known as the nearest neighbour technique, is based on the distance between the closest pair of objects, where only pairs consisting of one object from each group are considered); *complete linkage clustering* (also called farthest neighbour, clustering method is the opposite of single linkage is based on the distance between the most distant pair of objects, one from each group); *average linkage clustering* (based on the distance between two clusters is defined as the average of distances between all pairs of objects) and *average group linkage* (groups once formed are represented by their mean values for each variable - their mean vector, and inter-group distance is now defined in terms of distance between two such mean vectors). In our study we used Ward's clustering algorithm (1963) described for the first time by Everitt (1993): this method is based on the formation of different partitions Pn, P n-1, P1 by minimizing the loss associated with each grouping. This loss is quantified in a form that could be interpretable and Ward defined it in terms of an error sum-of-squares criterion ESS as follows:

$$ESS(X) = \sum_{i=1}^{N_x} \left| x_i - \frac{1}{N_x} \times \sum_{j=1}^{N_x} x_j \right|^2$$

Where: $|.|$ is the absolute value of a scalar value or the norm (the "length") of a vector, N_x – number of observations, x_i – individual values for each object in the case and $\frac{1}{N_x} \times \sum_{j=1}^{N_x} x_j$ is the average for these values.

Mathematically the linkage function - the distance between clusters and - is described by the following expression:

$$D(X, Y) = ESS(XY) - [ESS(X) + ESS(Y)]$$

where ESS (XY) is the error sum of combined cluster resulting from fusion clusters X and Y.

At each step in the analysis it is tested any combination of every possible cluster pair and the two clusters whose merger results in minimum increase in 'information loss' are combined.

Data used in the model

In our model, the real convergence is tested by taking into consideration a number of Eastern European Countries that have not joined the 16-member Euro Zone yet:

Bulgaria, Czech Republic, Hungary, Estonia, Latvia, Lithuania, Poland and Romania. We calculate the real convergence using the following indicators:

- GDP growth rate (defining economic growth);
- GDP per capita in volume (defining productivity);
- Exports to GDP (measuring the international openness and competitiveness);
- FDI intensity (reflecting the openness to international capital);
- Stock market capitalization (showing the dimension of economy and its development level);
- Unemployment rate (representing labour market disequilibrium);
- Labour cost (representing the human capital element);
- R&D expenditures made by private sector (representing private sector innovation capacity).

We analyse the data for the countries included in our study for a period of 9 years (1999 – 2007), thus resulting important conclusions on the real convergence evolution. We used yearly data from Eurostat service. The real convergence is tested by taking into consideration an average calculated by Eurostat for the Euro area countries.

Results based on Euclidian distances

The first method of measuring the real convergence is based on Euclidian distances (rescaled with values in 0-1 range). A higher Euclidian distance between different countries (or group of countries) means a lower convergence. This method is an intermediate step of the analysis method based on clusters allowing estimating the distance between Romania and Eurozone (16 countries) or between Romania and other countries included in the model.

Table 1. Proximity matrix for Eastern European Countries (1999)

	Rescaled Euclidean Distance								
Case	1:Bulgaria	2:Czech Republic	3:Estonia	4:Latvia	5:Lithuania	6:Hungary	7:Poland	8:Romania	9:Euro area 16
1:Bulgaria	,000	,208	,311	,062	,283	,338	,154	,358	,886
2:Czech Republic	,208	,000	,087	,137	,076	,117	,072	,478	,654
3:Estonia	,311	,087	,000	,248	,008	,000	,136	,512	,544
4:Latvia	,062	,137	,248	,000	,226	,276	,119	,430	,818
5:Lithuania	,283	,076	,008	,226	,000	,027	,103	,475	,574
6:Hungary	,338	,117	,000	,276	,027	,000	,160	,524	,517
7:Poland	,154	,072	,136	,119	,103	,160	,000	,379	,707
8:Romania	,358	,478	,512	,430	,475	,524	,379	,000	1,000
9:Euro area 16	,886	,654	,544	,818	,574	,517	,707	1,000	,000

We could notice that in the year 1999 Romania is farthermost country towards Eurozone (a rescaled distance of 1.0 comparing with the distance of 0.886 of Bulgaria or 0.707 of Poland). The closest country (taking into consideration indicators used in the real convergence model proposed by this study) towards Euro area in 1999 was Hungary followed by Estonia and Lithuania.

During 2000 and 2004 we witnessed a light real convergence for Romania (a decrease from 1.0 to 0.823, Romania changing the last place in the "favour" of Latvia and Bulgaria). This period had different impact on Eastern European Countries involved in the integration process: for few countries like Estonia, Lithuania, Poland and Romania this period induced an increase in the level of real convergence meanwhile for other countries (Hungary, Bulgaria or Latvia) this period induced a decrease in the level of real convergence.

Tabel 2. Proximity matrix for Eastern European Countries (2004)

	Rescaled Euclidean Distance								
Case	1:Bulgaria	2:Czech Republic	3:Estonia	4:Latvia	5:Lithuania	6:Hungary	7:Poland	8:Romania	9:Euro area 16
1:Bulgaria	,000	,373	,786	,131	,551	,397	,388	,263	1,000
2:Czech Republic	,373	,000	,368	,246	,128	,000	,002	,235	,578
3:Estonia	,786	,368	,000	,658	,195	,350	,358	,607	,183
4:Latvia	,131	,246	,658	,000	,427	,255	,279	,082	,874
5:Lithuania	,551	,128	,195	,427	,000	,124	,112	,397	,397
6:Hungary	,397	,000	,350	,255	,124	,000	,050	,221	,565
7:Poland	,388	,002	,358	,279	,112	,050	,000	,283	,560
8:Romania	,263	,235	,607	,082	,397	,221	,283	,000	,823
9:Euro area 16	1,000	,578	,183	,874	,397	,565	,560	,823	,000

The year 2004 is relevant for the Eastern Europe countries (except Bulgaria and Romania) that joined the European Union. For few of them this moment was translated into a higher level of real convergence (Czech Republic, Poland). For Baltic countries (Latvia, Lithuania and Estonia) after the moment of accession in European Union, we have noticed a reduction in the level of convergence towards Euro Area (16 countries). The same situation is encountered in the case of Hungary, (positioned, in 1999 the closest to Euro Area conditions), especially in the last year (2007). The closest countries toward Euro Area in 2007 were Poland and Czech Republic that seem to be on the right way with their reforming program.

Countries that seem to diverge remaining far away from Euro Area are Latvia, Bulgaria and Romania. These countries have been accepted as members of European Union but there are still many economic reforms that should be applied in order to increase their performance (even Romania had the highest economic growth rate within the EU in the last two years).

Table 3. Synthesis of Euclidian Distances toward Euro Area 16 (1999 – 2007)

Convergence with Euro area	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Bulgaria	0.88	0.88	0.86	1.00	1.00	1.00	1.00	1.00	0.89
Czech Rep.	0.65	0.67	0.71	0.73	0.73	0.57	0.46	0.48	0.25
Estonia	0.54	0.55	0.56	0.36	0.36	0.18	0.60	0.66	0.64
Latvia	0.81	0.82	0.76	0.87	0.87	0.87	0.79	0.96	1.00
Lithuania	0.57	0.61	0.57	0.51	0.51	0.39	0.45	0.54	0.51
Hungary	0.51	0.63	0.62	0.68	0.68	0.56	0.47	0.50	0.76
Poland	0.70	0.72	0.72	0.73	0.73	0.56	0.43	0.21	0.09
Romania	***1.00***	***1.00***	***1.00***	***.,97***	***0.97***	***0.82***	***0.74***	***0.79***	***0.82***

The analysis shows that all new member countries that joined EU in 2004 started with a similar economic conditions but due to different pre- and post- accession reforms, few countries succeeded to get closer to Euro Area level (especially Poland and Czech Republic that seems to be the most performant), the fulfilment of nominal convergence criteria being a matter of time. Other countries as Estonia or Latvia significantly diverged and some of them (Lithuania) remained at the same distance from Euro Area.

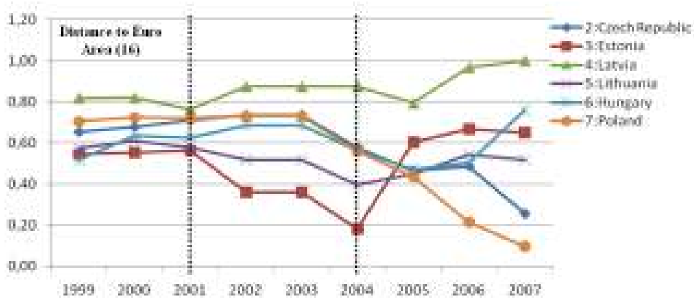

Figure 2. Real convergence for the countries included in EU in 2004

This observation is derived from the volatility associated to this evolution. On the chart representing the evolution of distances toward Euro Area (16) we can identify two distinct areas:

- Year 2001: since then, Eastern European countries took a different evolution path toward the Euro Area (16). Several Eastern European Countries decided at that time, to undertake economic reform programs, being more and more aware that this is their only chance for development and closing the most sensitive negotiation chapters with EU. Poland, for instance, started in 2001 the most important program for privatization of strategic sectors like telecommunications (TPSA), insurance (PZU), transports (LOT) and created a free market for energy. Estonia completed its privatization programme in 2001 by selling the biggest public companies and received a A+ rating from rating agencies (at the beginning of 2002 Estonia closed all 20 chapters of negotiation with EU).

- Year 2004: is the year of EU accession of these countries. This integration induced different effects in the field of real convergence, Baltic Countries facing a negative impact (these countries seemed to be insufficiently prepared to be part of the EU, taking into consideration their later evolutions, especially for Latvia and Estonia).

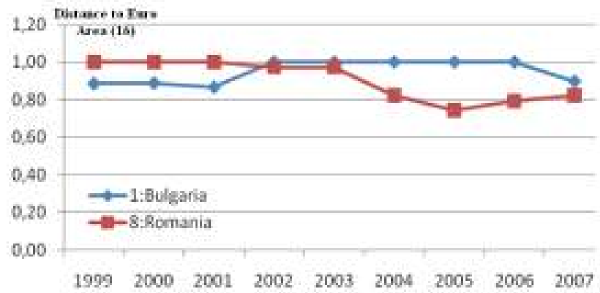

Figure 3. Real convergence for Romania and Bulgaria (1999 – 2007)

In particular, as far as the specific situation of Romania is concern, we could notice that it was placed constantly far away from Euro Area (16) in the entire period analysed (with a light improvement in the last years). Even if Romania in 2005 and 2006 registered a higher real convergence that reduced the distance toward Euro Area (16) from 0.823 in 2004 to 0.795 in 2006, in 2007 Romania came back to the similar situation as that one registered in 2004, being even farther from the performance of Euro Area Countries.

However, it is obvious that a wide gap should be reduced for our country to compare to other Eastern European countries that already adopted Euro to replace their original national currencies. The time horizon proposed by National Bank of Romania seems to be quite not sustainable if it is not accompanied by reforms devoted to support the private sector and stimulate the functional market mechanisms.

Results based on clusters (k-means and hierarchical clusters)

We also undertook an analysis based on clusters in order to have a different image about common characteristics among different Eastern European Countries that want to access European Monetary Union (EMU) as soon as possible:

- An analysis based on k-means clusters;
- An analysis based on hierarchical Ward clusters (based on rescaled Euclidian distance in a 0-1 range).

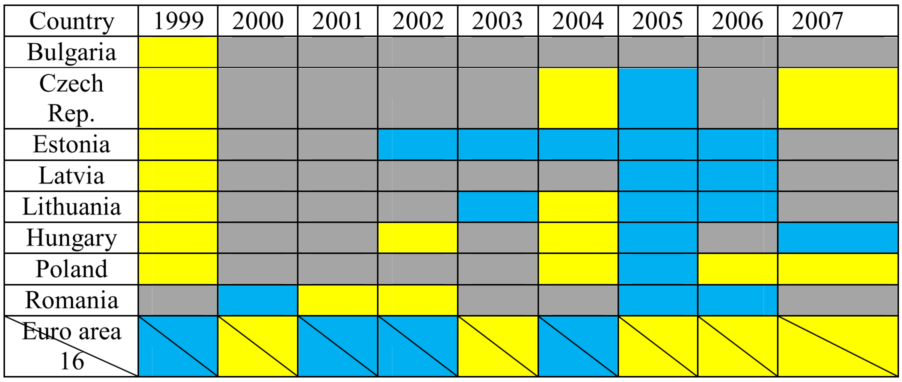

Figure 4. K-means map of clusters for Eastern European Countries (1999 – 2007)

The k-means clusters analysis reflects the following aspects:

- Initially, two out of three clusters were composed by a single case (Romania and Euro Area-16), all the other countries being grouped in a common cluster. The only country with different characteristics than Eastern European Countries and countries that adopted Euro was Romania, being placed far away from them.
- Euro Area (16) exhibited common characteristics with only few countries from those included in our analysis (with Estonia in 2002 and 2004, Poland in 2006, Poland and Czech Republic in 2007).
- Initially, Romania formed an individual cluster isolated from the other countries and then we found that can be included in a cluster composed by Bulgaria, Estonia, Lithuania and Latvia. According to the last evolutions, Romania seems to have similar characteristics with Baltic Countries.

This k-means cluster analysis allows studying also the level of convergence between different clusters and between cases and the centroids of the clusters (based on distances).

Table 4. Distances between Romania's cluster and the cluster containing Euro Area

Indicator	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Romania's cluster	98.6	95.3	78.9	31.3	41.9	42.0	29.8	28.4	28.8
DIST Centroid	0.00	0.00	0.00	7.45	9.70	7.55	9.73	2.79	4.73

Note: DIST Centroid is the distance of Romania toward the centroid of its cluster

In the first three years (2004-2007), Romania was completely isolated from the rest of the Eastern Countries (taking into consideration the above indicators). Being single in its cluster, Romania was placed exactly in the centroid during this period. However, we can observe a light real convergence with the cluster containing Euro Area (16), the distance being reduced from 98.6 in 1999 to 78.9 in 2001. Starting with 2002, Romania was placed into clusters containing more than one country that kept a relative constant distance (even divergence in the last year) with Euro Area (16)'s cluster.

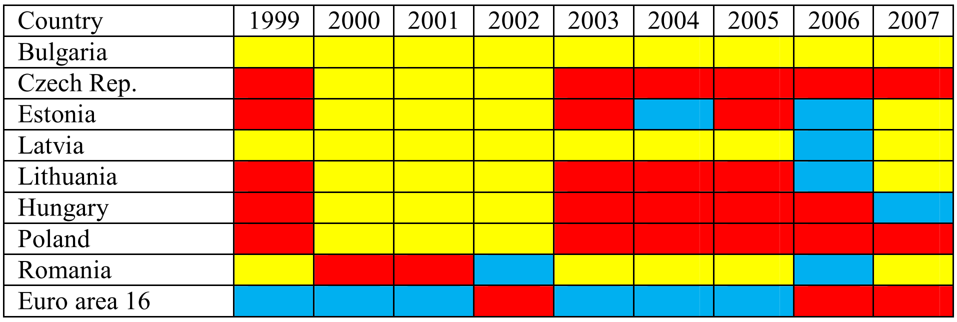

Figure 5. Map of Ward hierarchical clusters (1999 – 2007)

The main conclusion drawn from this clusters analysis is that Romania did not progress towards a significant real convergence in the last six years, economic reforms and governmental efforts being, practically, unsuccessful.

The analysis based on hierarchical Ward clusters shows the similar results (see figure 7): until 2003 Romania evolved isolated from the other countries (the only exception is the year 1999 when Romania was grouped with Bulgaria and Latvia in the same cluster. Later on, in 2006, this cluster will include Estonia and Lithuania without Bulgaria in 2006 that formed a different isolated cluster). It is quite clear that Romania tends to be closer to Baltic countries being more and more distanced from the most developed countries in the region (Hungary, Czech Republic and Hungary) and, of course, more distanced from Euro Area (16).

In conclusion, the analysis of real convergence of Romania's economy on the road to Euro Area is a very important tool to assess the real opportunity of our country to join Euro area in 2014 as proposed by the Romanian Central Bank. Our study shows the existence of an important distance between Romania and other neighbouring countries in the area and an important distance towards Euro Area. Taking into consideration the above-mentioned reasons we consider that the objective of adopting Euro before 2014 is quite impossible. A lot of things should be improved, such as productivity level, external competitiveness or technological and innovative level, even if in the last two years an important economic growth.was registered.

The computed distance between Romania and Euro area is subject to changes if the real economic conditions modify in the future. Further research will include significant changes for Romania's perspectives on the Euro path and the assessment of a realistic timing of Euro adoption.

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