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

Dumitru Miron and Alina Dima and Cristian Paun

Academy of Economic Studies Bucharest

15. March 2009

Romania's real convergence toward European Monetary Union

Authors:
Prof. univ. dr. Dumitru Miron
Conf. univ. dr. Alina Dima
Conf. univ. dr. Cristian Păun

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 Treaties. 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. In practice a lot of studies on nominal and real convergence have been developed. In our study we tested the nominal convergence for selected Eastern European Countries including Romania based on distances and clusters methodology.

Keywords: 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 enormous 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 a club of nations, 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 major 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 policies, in particular the EU regional policy channelled mainly through the Cohesion and Structural Funds (Martin and Sanz, 2003).

Catching up between countries or regions imply reduction of the income gaps, is very important to assess whether there is evidence of convergence in per capita income levels between acceding countries and EU-member states during past years. The notion of (real) convergence and its theoretical foundation is well debated in the economic literature. 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 independently of 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).

Structural convergence in the literature is a new 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 (Gacs, 2003 Warcziarg, 2001 and Raiser et al. 2003).

Various studies have come up with different and sometimes conflicting results and conclusions. Thus, Barro (1991) and Barro and Sala-i-Martin (1995) who were among the pioneers of empirical research in this area 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, the UNCTAD (1997) which analyzes longer trends of world income distribution argues 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 intervals 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) or that of conditional convergence (the former studies).

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] data base, or Maddison's [1987] 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). The process of convergence is viewed as long-run one and for relevant results it is needed relevant time-horizon. For very short time series (for instance just one decade of available data), it is practically impossible to analyse adequately any of the convergence hypotheses.

There are also a number of problems – and policy dilemmas – that arise from the asymmetric treatment of the dimensions of convergence. A catching up process involves structural economic relationships between real and nominal variables that are difficult to be observed but that remain important for acceding transition economies. The fact is that real convergence cannot be de-coupled 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.

Real convergence in a theoretical concept understood in terms of GDP per capita. 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 – arrive at 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. More and more capital accumulation and faster growth economic rate for less developed countries or regions are involved. If the catching up countries will decide to increase their openness to integration process, the convergences will be accelerated and the capital flows will generate higher returns. This argument was introduced in the conventional theory of economic integrations since the first steps made by 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) demonstrated that human capital in association with increasing returns will improve the economic growth, the brain drain being suggested to be the vehicle of cross-country divergence 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 models, however, income convergence is not a necessary element. Government policy plays an important role influencing the long-term growth process through economic incentives for the accumulation of various forms of capital and through the promotion of technological innovations. Thus, pro-active regional policy may play a significant role in achieving convergence. More specifically, member countries should try to stimulate those efficient investments in order to extend and improve their allocations in those types of capital assets with direct impact on economic growth, such as: 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 spill over 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. Consequently, the most elaborated and realistic formulations of innovation-driven growth models also stress the complementarity between both domestic R&D and foreign R&D spill over and human capital investments. (C. Martin & Sanz, 2003) 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 (C. Martin & Sanz, 2003). In this sense, human capital started to be 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. David and Kraay (2003) find 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) finds 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) shows that economic integration enhances FDI, fuels expansion of R&D activity, and increases global growth. Finally, Bonfiglioli (2007) finds that financial integration has a positive direct effect on productivity.

As acknowledged by a vast body of literature on the topic, FDIs have represented an important vehicle for technology, innovation and knowledge transfers, stimulating competition, providing financial sources to local enterprises, and boosting domestic investments as a result. A study made 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 this part is that the phenomenon of economic growth convergence of various countries- real convergence - has two aspects (Matkowski and Próchniak, 2004). 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 mainly independent and should be analysed separately, using different methods. However, both types of convergence are closely linked with international co–operation, and especially with the transfer of goods and production factors, with the transfer of technology, international competition and economies of scale, and sometimes also with the co–ordination of economic policy (Matkowski and Próchniak, 2004). Hence a certain interrelation, and at least correlation, can appear between them, especially in countries undergoing the processes of advanced economic integration (Matkowski and Próchniak, 2004).

The most up–to–date 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 equalisation 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 tendency (Matkowski and Próchniak, 2004).

Research Methodology

In our study we proposed 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 used 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 used 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:

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

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][1] or Sneath and Sokal [1973][2]). The models based on clustering alghoritms were divided into two main categories: ierarchical and partitional clustering methods (Anderberg [1973][3], Hartigan [1975][4], Jain and Dubes [1988][5] or Jardine and Sibson [1971][6]). For each category, different other clustering algorithms have been discovered (Tryon and Bailey [1973][7], Kolliopoulos and Rao [1999], Kumar and Sen [2004], Bădoiu, Har-Peled and Indyk [2002]).
Clustering based on k-means has its roots in a model proposed by McQueen (1967)[8] 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 could be applied on an importand volume of data.

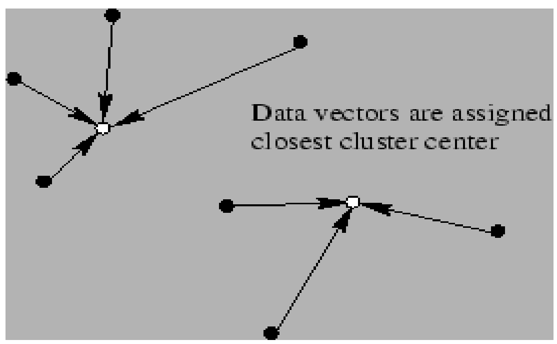

Figure 1: K – means clustering algorithm

[1] See: Jardine, N. and Sibson, R. (1971) Mathematical Taxonomy. Wiley, London.
[2] See: Sneath, P. H. A. and Sokal, R. R. (1973) Numerical Taxonomy. Freeman, San Francisco, CA.
[3] See: Anderberg, M. R. (1973) Cluster Analysis for Applications. Academic Press, New York, NY.
[4] See: Hartigan, J. (1975) Clustering Algorithms. Wiley, New York, NY.
[5] See: Anil K Jain, R.C. Dubes (1988), "Algorithms For Clustering Data", Prentice Hall, New Jersey.
[6] Idem 3
[7] See: Tryon, R. C. and Bailey, D. E. (1973) Cluster Analysis. McGraw-Hill, New York, NY.
[8] See: J. B. MacQueen (1967): "Some Methods for classification and Analysis of Multivariate Observations, Proceedings of 5-th Berkeley Symposium on Mathematical Statistics and Probability", Berkeley, University of California Press, 1:281-297

The alghoritm of k-means starts with the initialize 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 chief 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[9]. Another problem is related to the difficulty in giving an appropriate interpretation to the results (a higher relevancy has the using of this method on an inter-temporal basis. This clustering method minimize the standard deviation inside of each cluster but does'n provide a minimum variance at the level of considered sample of data. The computed centroids will consequently change their position, step by step, 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 establish which two cases are the closest together, then combining these into a single cluster and repeating until the tree is complete. This method is considered to be a commonly 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[10] (1973), shaded density plot[11]. 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

[9] Har-Peled, S. and Mazumdar, S. (2004), "Coresets for k-means and k-median clustering and their applications", Proceedings 36th Annual ACM Symposium Theory Computation, pages 291–300.
[10] Ling, R. F. (1973), "A Computer Generated Aid for Cluster Analysis", Communications of the ACM, 16, 55 – 61.
[11] Freeman, L. (1994), "Displaying Hierarchical Clusters", INSNA Connections, 17(2), 46 – 52.

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)[12]: 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 it was defined by Ward 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 we tested real convergence by taking into consideration a number of Eastern European Countries that didn't acceded the Euro Zone 16 yet: Bulgaria, Czech Republic, Hungary, Estonia, Latvia, Lithuania, Poland and Romania. The real convergence was calculated by using the following indicators:

[12] Described for the first time by B. S. Everitt (1993) in "Cluster Analysis" published in London by Edward Arnold.

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

We observed data for countries included in our study for a period of 9 years (1999 – 2007) obtaining important conclusions on the real convergence evolution. We used yearly data from Eurostat[13] service. The real convergence was tested by taking into consideration an average calculated by Eurostat for Eurozone.

Results based on Euclidian distances

A 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 and gives us the possibility to measure effectively how evolved the distance between Romania and Eurozone (16 countries) or between Romania and other countries included in the model.

Proximity Matrix

	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

This is a dissimilarity matrix

Figure 2: Proximity matrix for Eastern European Countries (1999)

We can observe that in 1999 Romania is the most distanced countries toward Eurozone (a rescaled distance of 1,0 comparing with the distance of 0,886 of Bulgaria or 0,707 of

[13] http://ec.europa.eu/eurostat

Poland). The closest country (taking into consideration indicators used in the real convergence model proposed by this study) toward Eurozone in 1999 was Hungary followed by Estonia and Lithuania.

During 2000 and 2004 we assisted to 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.

Proximity Matrix

	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

This is a dissimilarity matrix

Figure 3: Proximity matrix for Eastern European Countries (2004)

The moment 2004 is relevant for a lot of countries from Eastern Europe (less Bulgaria and Romania) that were accepted to be part of European Union. For few of them this moment was translated into a higher real convergence (Czech Republic, Poland).

For Baltic countries (Latvia, Lithuania and Estonia) after the moment of accession in European Union we observed a reduction in the level of convergence toward Euro Area (16 countries). The same situation is registered in case of Hungary (in 1999 this country 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 seems to be on the right way with their reforming program.

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

Convergence with Euro area	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1:Bulgaria	0,88	0,88	0,86	1,00	1,00	1,00	1,00	1,00	0,89
2:Czech Rep.	0,65	0,67	0,71	0,73	0,73	0,57	0,46	0,48	0,25
3:Estonia	0,54	0,55	0,56	0,36	0,36	0,18	0,60	0,66	0,64
4:Latvia	0,81	0,82	0,76	0,87	0,87	0,87	0,79	0,96	1,00
5:Lithuania	0,57	0,61	0,57	0,51	0,51	0,39	0,45	0,54	0,51
6:Hungary	0,51	0,63	0,62	0,68	0,68	0,56	0,47	0,50	0,76
7:Poland	0,70	0,72	0,72	0,73	0,73	0,56	0,43	0,21	0,09
8:Romania	***1,00***	***1,00***	***1,00***	***0,97***	***0,97***	***0,82***	***0,74***	***0,79***	***0,82***

Table 1: Synthesis of Euclidian Distances toward Euro Area 16 (1999 – 2007)

The analysis at the level of the entire period showed that initially all countries accepted in the first moment (2004) started with a similar situation but applying different reforms before and after accession few countries succeeded to come closer toward countries from Euro Area (especially Poland and Czech Republic that seems to be the most serious ones) and for them the fulfilment of nominal convergence criteria is a matter of time and should be achieved as soon as possible. Other countries like Estonia or Latvia significantly diverged and some of them (Lithuania) remained at the same distance from Euro Area.

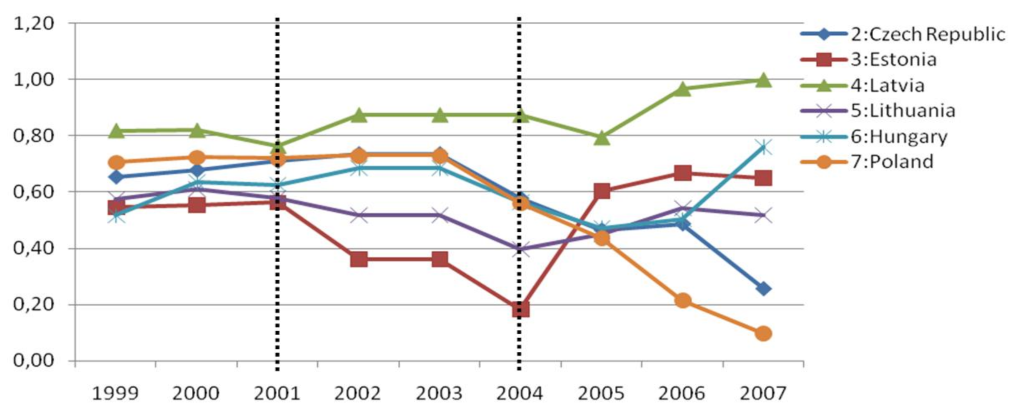

Figure 4: Real convergence for the countries included in EU in 2004

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: after this moment Eastern Countries registered a different evolution toward Euro Area (16). A lot of Easter European Countries decided in that moment to apply economic reforms, being more and more conscious 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 programs for privatization of strategic sectors like telecommunications (TPSA), insurance (PZU), transports (LOT) and created a free market for energy. Estonia closed 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 accession of these countries into European Union. This integration induced different effects in the field of real convergence, Baltic Countries facing with a negative impact (these countries seemed to be insufficient prepared to be part of EU taking into consideration later evolutions, especially for Latvia and Estonia).

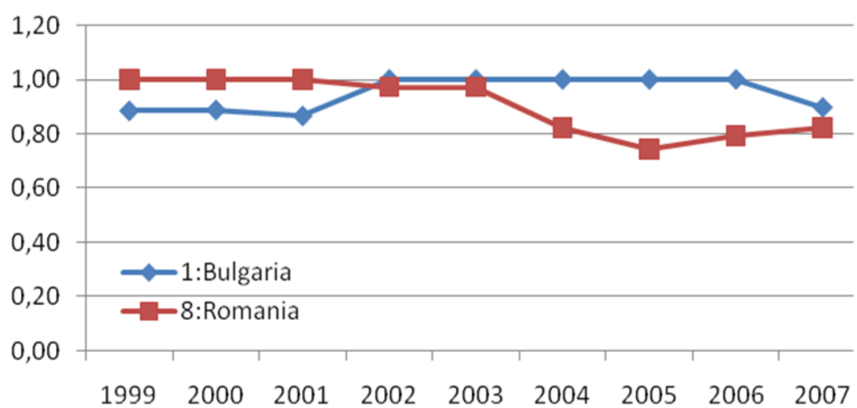

Figure 5: Real convergence for Romania and Bulgaria (1999 – 2007)

Assessing strictly the situation of Romania, we can observe that this country was positioned constantly on places far away from Euro Area (16) in the entire period that we 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 was pushed back to the similar situation as was registered in 2004, being more and more distanced from the performance of Euro Area Countries.

Anyway, it is quite obvious that we are talking about a high distance that should be reduced by our country in order to be compared to other Eastern European Countries that already adopted Euro instead of national currency. The time horizon proposed by Central Bank seems to be now quite not sustainable if it is not doubled by clear reforms that should sustain the private sector and free – market mechanisms.

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

We applied also 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).

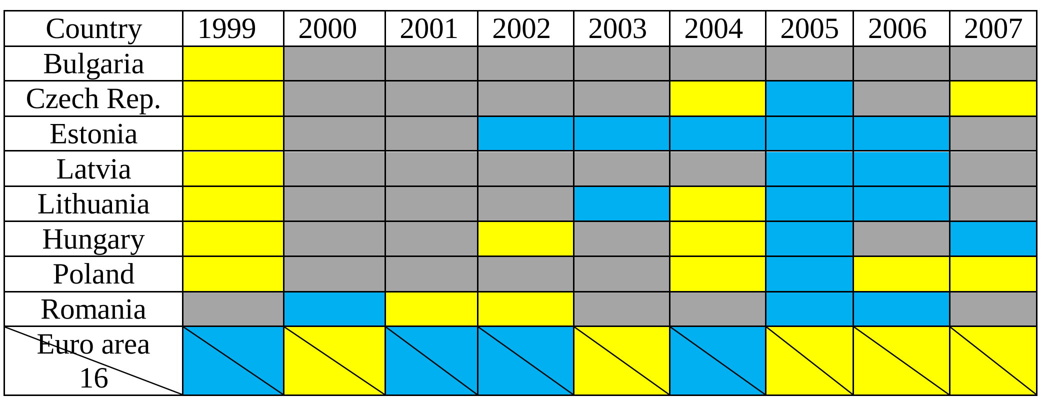

Figure 6: K-means map of clusters for Eastern European Countries (1999 – 2007)

The k-means clusters analysis reflects the following aspects:

- Initially, two from 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) presented common characteristics with few countries from those included in our analysis (with Estonia in 2002 and 2004, Poland in 2006, Poland and Czech Republic in 2007).
- Romania initially started from an individual cluster isolated from the other countries and therefore it was integrated 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 gives us the possibility to study also the level of convergence between different clusters and between cases and the centroids of the clusters (based on distances).

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

Table 2: Distances between Romania's cluster and the cluster containing Euro Area

In the first three years, Romania was completely isolated from the rest of the Eastern Countries (taking into consideration the included indicators). Being single in its cluster, Romania was placed exactly in the centroid during this period. Anyway, 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.

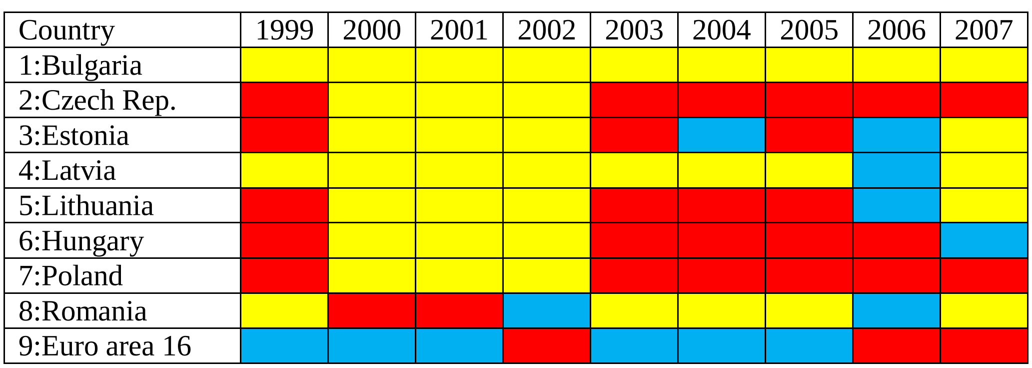

Figure 7: Map of Ward hierarchical clusters (1999 – 2007)

Main conclusion drawn from this clusters analysis is very clear: we do not face with a significant real convergence on the last six years for Romania, all economic reforms and all governance efforts until present remaining, practically, inefficient.

The analysis based on hierarchical Ward clusters shows the similar results (see figure 7): until 2003 Romania evolved isolated from the other countries (less 1999 when Romania was grouped with Bulgaria and Latvia in the same cluster that later 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).

Final conclusions

This paper studied the level and the evolution of real convergence of Romania's economy with Euro Area, in order to conclude on the schedule proposed by Romanian Central Bank to achieve Maastricht nominal convergence criteria before 2014. Our study showed the existence of an important distance between Romania and other developed countries in the area and, also, an important distance toward Euro Area. Taking into consideration this important distance we appreciate that the objective of adopting Euro before 2014 is quite impossible. We should improve a lot of thinks regarding productivity level, external competitiveness or technological and innovative level, even we faced with an important economic growth in the last two years.

References

[1] Abramovitz, M. (1986). "Catching Up, Forging Ahead and Falling Behind". *Journal of Economic History,* 385-406.

[2] Alam, S. (1992). "Convergence in Developed Countries: An Empirical Investigation". *Welwirtschaflliches Archiv,* 191-200.

[3] Anderberg, M. R. (1973). "Cluster Analysis for Applications". *Academic Press,* New York, NY.

[4] Badinger , H. (2007). "Trade policy and productivity". *Eur. Econ. Rev*. (in press)

[5] Baldwin, R. E., Braconier, H. and Forslid, R. (1999). "Multinationals, Endogenous Growth and Technological Spillovers: Theory and Evidence", CEPR Working Paper 2155.

[6] Barro, R. J. (1991) 'Economic Growth in a Cross Section of Nations', *Quarterly Journal of Economics* **106**(2), 407–433.

[7] Barro, R.J. and Sala-i-Martin, X. (1995). *Economic Growth.* New York: McGraw-Hill.

[8] Barro, R.; Mankiw, G.; Sala-i-Martin, X. (1995) "Capital Mobility in Neoclassical Models of Growth". *American Economic Review,* 103-15.

[9] Barro, R and Sala-i-Martin, X. (1991). "Convergence Across States and Regions". *Brookings Papers on Economic Activity,* 107-82.

[10] Baumol, W. (1986) "Productivity Growth, Convergence and Welfare: What the Long-Run Data Show. *American Economic Review,* 1072-85.

[11] Blomström, M. and Wolff, E. N. (1994). ”Multinational Corporations and Productivity
Convergence in Mexico”, in William J. Baumol, Richard R. Nelson, and Edward N. Wolff, eds, op. cit.

[12] Bonfiglioli, A, (2007). Financial integration, productivity and capital accumulation. Institute for Economic Analysis, CSIC

[13] Coe, D. T. and Helpman, E. (1995). ”International R&D Spillovers”. *European Economic Review* 39(5), 859–887.

[14] Costello, D. (1993). "A Cross-Cotmtry Comparison of Productivity Growth" .*Journal of Political Economy,* 207-22.

[15] David D, Kraay, A (2003). ”Institutions, trade and growth”. J Monet Econ 50:33–162

[16] DeLong, B. (1988). "Productivity Growth, Convergence and Welfare: Comment," *American Economic Review,* 1138-59.

[17] Dobrinsky, R. (2003). “Convergence in Per Capita Income Levels, Productivity Dynamics and Real Exchange Rates in the EU Acceding Countries”,_*Empirica* 30. Kluwer Academic Publishers. Netherlands: 305–334,

[18] Dowrick, S.; Nguyen, D. (1989)."OECD Comparative Economic Growth 1950-85: Catch-Up andConvergence". *American Economic Review,* 1010-30.

[19] Everitt B. S. (1993). “Cluster Analysis”. London, Edward Arnold.

[20] Freeman, L. (1994). “Displaying Hierarchical Clusters”. INSNA Connections, 17(2), 46 – 52.

[21] Gacs, J. (2003). “Transition, EU Accession and Structural Convergence”. *Empirica* 30**:** 271–303, 2003. Kluwer Academic Publishers. Printed in the Netherlands.

[22] Galor, O. (1996). ”Convergence? Inference from Theoretical Models”. *The Economic Journal* 106, 1056–1069.

[23] Gao, T. (2005). ”Foreign direct investment and growth under economic integration”. J Int Econ 67:157–174

[24] Grossman, G.; Helpman, E. (1994). "Endogenous Innovation in the Theory of Growth," *Journal of Economic Perspectives,* 23-44.

[25] Har-Peled, S. and Mazumdar, S. (2004) "Coresets for k-means and k-median clustering and their applications". Proceedings 36th Annual ACM Symposium Theory Computation, 291–300.

[26] Hartigan, J. (1975). *Clustering Algorithms*. Wiley, New York, NY.

[27] Heitger, B. (1987). "Corporatism, Technological Gaps and Growth in OECD Countries". *Welwirtschafiliches Archiv,* 463-73.

[28] Iancu, A. (2008). "Real convergence and integration*". Romanian Journal of Economic Forecasting: 1*, 34-37

[29] Jain and Dubes [1988) in Anil K Jain, R.C. Dubes (1988). "Algorithms For Clustering Data". Prentice Hall, New Jersey.

[30] Jardine, N. and Sibson, R. (1971). Mathematical Taxonomy. Wiley, London.

[31] Keller, W. (1999). "How Trade Patterns and Technology Flows Affect Productivity Growth". NBER Working Paper 6990.

[32] Kocenda, E. (2000). "Macroeconomic Convergence in Transition Countries". *Journal of Comparative Economics* 29, 1–23

[33] Levine, R.; Renelt, D. (1992). "A Sensitivity Analysis of Cross- Country Growth Regressions". *American Economic Review,* 942-63.

[34] Ling, R. F. (1973). "A Computer Generated Aid for Cluster Analysis". Communications of the ACM, 16, 55 – 61.

[35] Lucas, R. E. (1988). "On the Mechanics of Economic Development". *Journal of Monetary Economics* 22(1), 3–42.

[36] Maddison, A. (1995). *Monitoring the World Economy, 1820–1992*. OECD

[37] Mallick, R. (1993). "Convergence of State Per Capita Incomes: An Examination of Its Sources," *Growth and Change,* Summer, 321-40.

[38] Mankiw, G. Romer, D. and Well, D. (1992). "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics,* 407-37.

[39] Martin, C. and Sanz, I. (2003). "Real Convergence and European Integration: The Experience of the Less Developed EU Members". *Empirica* 30, Kluwer Academic Publishers. Printed in the Netherland**s:** 205–236

[40] MacQueen, J. B. (1967). "Some Methods for classification and Analysis of Multivariate Observations". Proceedings of 5-th Berkeley Symposium on Mathematical Statistics and Probability. Berkeley, University of California Press 1: 281-297

[41] Nadiri, I. M. (1993). "Innovations and Technological Spillovers". NBER Working Paper 4423.

[42] Nadiri, M. I. And Seongjun, K. (1996). "International R&D Spillovers". Trade and Productivity in Major OECD Countries, NBER Working Paper 5801.

[43] Pack, H. (1994). "Endogenous Growth Theory: Intellectual Appeal and Empirical Shortcomings," *Journal of Economic Perspectives,* 55-72.

[44] Raiser, M., Schaffer,M.E., and Schuchardt, J. (2003). ”Benchmarking Structural Change in Transition”. CEPR Discussion Paper No. 3820, Centre for Economic Policy Research, London.

[45] Romer, P. M. (1986). ”Increasing Returns and Long Run Growth”. *Journal of Political Economy* 94, 1002–1037.

[46] Romer, P. M. (1990). ”Endogenous Technological Change”. *Journal of Political Economy* 98, 5–21.

[47] Romer, P. (1994). "The Origins of Growth Theory". *Journal of Economic Perspectives*, 3-22.

[48] Sala-i-Martin, X. (1996). ”The Classical Approach to Convergence Analysis”. *The Economic Journal* 106, 1019–1036.

[49] Salsecci G. and Pesce, A. (2008). ”Long-term Growth Perspectives and Economic Convergence of CEE and SEE Countries”. *Transit Stud Rev* 15:225–239 Springer-Verlag

[50] Solow, R.M. (1956). ”A Contribution to the Theory of Economic Growth”. *Quarterly Journal of Economics* 70(1), 65–94.

[51] Solow, R. (1994). "Perspectives on Growth Theory". *Journal of Economic Perspectives*, 45-54.

[52] Sneath, P. H. A. and Sokal, R. R. (1973). Numerical Taxonomy. Freeman, San Francisco, CA.

[53] Summers, Robert and Heston, Alan (1991). ”The Penn World Tables (Mark 5): An Extended Set of International Comparisons, 1950–1985”. *The Quarterly Journal of Economics* **106**(2), 327–368.

[54] Tryon, R. C. and Bailey, D. E. (1973). Cluster Analysis. McGraw-Hill, New York, NY.

Viner, J. (1950). *The Customs Union Issue.* New York: Carnegie Endowment for International
Peace.

[55] Vohra, R. (1997). “An Empirical Investigation of Forces Influencing Productivity and the Rate of Convergence Among States”. *Atlantic Economic Journal*, Springer Netherlands, 25, no 41, 412-419

[56] Warcziarg, R. (2001). *Structural Convergence*. Standford University (mimeo).

[57] *** Statistical Office of the European Communities, http://ec.europa.eu/eurostat