Διπλωματική Εργασία: "Η οικονομική σύγκλιση των χωρών κάτω απο την υπόθεση της μεταξύ τους εξάρτησης" (Testing economic convergence under crosses sectional dependence)

Ζάννας Απόστολος (MXPH/0404)

Επιβλεπουσα: Λέκτορας κ. Χρίστου Χριστίνα

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I. INTRODUCTION & THEORETICAL FRAMEWORK

Over the last decades there has been a revival of interest in the topic of economic growth, which has been marked by new approaches (endogenous growth theory) and a great emphasis on empirical analysis. A major focus of this empirical research has been to quantify the impact of factors such as human capital, economic policies and institutions in explaining intercountry differences in economic growth. Another important focus has been on the issue of convergence, that is, whether there has been a tendency for real per capita income differences between rich and poor countries to narrow significantly over the long run.

As it is well known, the standard neoclassical growth model [Solow (1956), Swan (1956)] assets that per capita output across countries or regions converges when they have similar preferences, technology levels and institutional and legal systems. Thus gaps in national or regional outputs must disappear over time. On the other hand, the endogenous growth model [Romer (1990), Grossman & Helpman (1991), Aghion & Howitt (1992)] asserts that per capita income is mainly influenced by country specific factors which endogenously influence output dynamics. If this is the case, countries will not converge over time given that per capita income only responds to country specific factors.

From an economic policy point of view, the issue of convergence or divergence is very important. In the case of spontaneous convergence, this would point to the existence of market forces, which will eventually lead to similar living standards across countries. In the case of persistently large (or widening) gaps between poor and rich countries, there could be a need for economic policy measures (domestic and international) to stimulate a catch – up process. More generally, this analysis raises questions about the effectiveness and impact of domestic institutions and policies on long – term growth performance. So, convergence is a concept that has gained popularity among economists, not only because of the importance of the issue about poor countries catching up with the rich ones, but also because this analysis can serve as a way to verify the validity of different growth models.

We can say that convergence is a process that may be analysed from various aspects. As Quah (1996, p.1354) points out: "Certainly, understanding economic growth is important. But growth is only one of many different areas in economics where analyzing convergence sheds useful insight". Real convergence describes the convergence of income levels, nominal convergence reflects the convergence of price levels and institutional convergence implies harmonisation of legislation. In addition one can also speak about the convergence of business cycles, consumer behaviour, social stratification and so on. In final analysis, the concept of economic convergence is a prediction about the pattern of economic growth across countries over time.

The reason for this sudden increase in interest was two fold. First, the existence of convergence across economies was proposed as the main test of the validity of modern theories of economic growth. Moreover, estimates of the speeds of convergence across economies were thought to provide information on one of the key parameters of growth theory: the share of capital in the production function. Second, and perhaps more importantly, a data set on internationally comparable GDP levels for a large number of countries became available in the mid 1980s. This new data set allowed empirical economists to compare GDP levels across a large number of countries, and to look at the evolution of these levels over time, a necessary feature for the study of the convergence hypothesis.

In Europe, convergence is a critical issue for both the Eastern and the Western (and more developed regions). One of the ultimate goals of the process of economic and political transformation that started in the former centrally planned economies (CPEs) in the ECE region in the early '90s was to improve the standards of living and the economic welfare of the population in these countries. The failure of the command economies to deliver on their promises to catch up quickly with the living standards and the quality of life prevailing in the developed market economies was one of the key factors that in the end brought about the fall of the communist system in Eastern Europe and the former Soviet Union. The collapse of the political system in these countries mirrored the collapse of their economies, overburdened with shortages, macroeconomic disequilibria and structural rigidities, employing obsolete technologies and supplying final goods of mediocre quality and largely isolated from the main international markets.

The start of transition to a market economy generated high hopes and expectations on the part of the peoples living in the eastern part of the continent. One of the strategic policy goals of the transition economies is to achieve sustained and high rates of economic growth that would enable them to catch up with the living standards of the developed market economies of Western Europe.

The issue of convergence, both nominal and real, is also relevant in the context of west European integration. In fact, Article 2 of the Treaty on European Union stipulates that "The Community shall have the task … to promote … a high degree of convergence of economic performance, … the raising of the standard of living and quality of life, and economic and social cohesion and solidarity among Member States". In a similar vein, Article 130a stipulates that "the Community shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions, including rural areas".

The lack of convergence across countries is an interesting finding on various grounds. It says that, in our world, the degree of cross – country income inequality not only fails to disappear, but rather tends to increase over time (σ-divergence). It also suggests that countries which are predicted to be richer a few decades from now are the same countries that are rich today (β-divergence). These findings may be used by economists or politicians to devise international institutions which may work to overturn this sombre tendency. In addition, the need to reduce disparities in terms of development levels across the various European regions is directly related to some of the basic principles behind the forming of the EU, especially since the introduction of the Single Act and the Maastricht agreements. In particular, one of the specific assumptions of the European integration program is that it will drive the growth of all members, thereby increasing economic and social cohesion.

i. **Definitions of convergence**

"One of the difficulties in determining economic convergence is the absence of a broadly acceptable measure of economic convergence. Many papers have addressed the issue of the convergence of economies and the number of definitions of convergence is almost as great as the number of papers"[1]

This paper is based on the most acceptable and extensively used definitions of Bernard and Durlauf (1995), who proposed two definitions of convergence which captured some of the implications of the neoclassical growth model for the permanence of contemporaneous output differences. These definitions characterized convergence between a pair of economies i and j. Their first definition considered the behavior of the output difference between two economies over a fixed time interval and equated convergence with the tendency of the difference to narrow.

Definition 1: Convergence as catching up. Countries i and j converge between dates t and t + T if the (log) per capita output disparity at t is expected to decrease in value. If $y_{i,t} > y_{j,t}$,

$$E(y_{i,t+T} - y_{j,t+T} / \Im_t) < y_{i,t} - y_{j,t}$$

Their second definition asked whether the long – run forecasts of output differences tend to zero as the forecasting horizon increases.

Definition 2: Convergence as equality of long – term forecasts at a fixed time. Countries i and j converge if the long – term forecasts of (log) per capita output for both countries are equal at a fixed time t,

[1] S.G. Hall, D. Robertson & M.R. Wickens (1997), "Measuring economic convergence" pp.131-132

$$\lim_{k \Rightarrow \infty} E(y_{i,t+k} - y_{j,t+k} / \Im_t) = 0$$

The relationship between these two definitions is straightforward. In fact, it is easy to show that the definitions can be ordered in terms of the range of restrictions placed on the behavior of output differences.

Cross – country output convergence :

We consider the problem of output convergence of N countries and suppose that the logarithm of real per capita output of country i at time, y_{it}, for i= 1,2,…,N, satisfies the decomposition $y_{it} = c_i + g_i t + u_{it} + \eta_{it}$ with u_{it} given by the multi – factor model $u_{it} = \theta'_i f_t + \varepsilon_{it}$, namely

$$y_{it} = c_i + g_i t + \theta'_i f_t + \varepsilon_{it} + \eta_{it}, \text{ for i= 1,2,…,N} \quad (1)$$

According to Bernard and Durlauf' s Definition 2, countries i and j converge if

$$\lim_{k \Rightarrow \infty} E(y_{i,t+k} - y_{j,t+k} / \Im_t) = 0 \quad \text{at any fixed time t,} \quad (2)$$

where $\Im_t$ is the information set at time t, which contains at least the current and past output series $y_{i,t-s}$,for i = 1,2,…,n and s = 0,1,2,…. Based on this definition Bernard and Durlauf (BD) state that for countries i and j to converge it is necessary that their outputs are cointegrated with cointegrating vector (1,-1). However, as it is demonstrated below cointegration is not sufficient for (2) to hold.

Making use of the output processes in (1) we have:

$$E(y_{i,t+k} - y_{j,t+k} / \Im_t) = (c_i + c_j) + (g_i + g_j)(t + k) +$$

$$+(\theta_i + \theta_j)' E(f_{t+k} / \Im_t) \; E(\varepsilon_{i,t+k} - \varepsilon_{j,t+k} / \Im_t) +$$

$$+ E(\eta_{i,t+k} - \eta_{j,t+k} / \Im_t)$$

Under our assumptions $\eta_{i,t+k} - \eta_{j,t+k}$ is a stationary process, irrespective of whether the technology and demand shocks are I(0) or I(1). Hence $\lim_{k \Rightarrow \infty} E(\eta_{i,t+k} - \eta_{j,t+k} / \Im_t) = E(\eta_{it} - \eta_{jt}) = 0$

Also the case where the idiosyncratic component of u_{it} namely ε_{it} is I(1) can be ruled out, since in that case $\lim_{k \Rightarrow \infty} E(y_{i,t+k} - y_{j,t+k} / \Im_t) \neq 0$

Consider now the two remaining cases where $\theta'_i f_t \sim I(0)$ or $\theta'_i f_t \sim I(1)$. Under the former countries i and j converge in the sense of BD, if

$$c_i = c_j$$

and

$$g_i = g_j \qquad (3)$$

Under $\theta'_i f_t \sim I(1)$ in addition to the above conditions it is also required that $\theta_i = \theta_j$ (4)

Out of the above three conditions the first, $c_i = c_j$, is the most unlikely to be satisfied as it requires the two economies to be identical almost in every respect, including their saving rates and initial endowments. A less stringent definition of convergence can be formulated in terms of the (conditional) probability of the output gap, $y_{it} - y_{jt}$, falling outside a pre – defined interval.

Definition 1 (Pair – wise Convergence): Countries I and j converge if for some finite positive constant C, and a tolerance probability measure $\pi \geq 0$,

$$\Pr\{|y_{i,\, t+s} - y_{j,\, t+s}| < C / \Im_T\} > \pi$$

at all horizons, s = 1,2,…,∞.

Applied to (1), this definition clearly rules out deterministic as well as stochastic trends in the output gap process. Unless (3) and (4) are both satisfied, it is easily seen that

$$\lim_{k \Rightarrow \infty} \Pr\{|y_{i,\, t+k} - y_{j,\, t+k}| < C / \Im_t\} = \mathbf{0},$$

for all finite positive constants, C, and the output gap diverges. However it is important to note that the above probabilistic definition does not necessarily require that $c_i = c_j$. Therefore, it allows convergent economies to have different endowments, saving rates or population growth rates.

Two concepts of convergence that also appear in the classical literature are β-convergence and σ-convergence[2]. We say that there is absolute β-convergence if poor economies tend to grow faster than rich ones. If we have data on real per capita GDP for a cross – section of economies, $\gamma_{i,\, t,\, t+T} = \log (y_{i,}$

[2] Xavier X.Sala-i-Martin (1996) , "The classical approach to convergence analysis" pp.1019-1036

$_{t+T}$ / $y_{i,t}$)/T is economy i's annualised growth rate of GDP between t and t+T and log ($y_{i,t}$) is the logarithm of economy i's GDP per capita at time t, then we estimate the regression

$$\gamma_{i,t,t+T} = \alpha - \beta \log (y_{i,t}) + \varepsilon_{i,t}$$

and if we find β>0, then we say that the data set exhibits absolute β – convergence.

The concept of σ – convergence is that a group of economies are converging in the sense of σ if the dispersion of their real per capita GDP levels tends to decrease over time. That is, if $\sigma_{t+T} < \sigma_t$, where σ_t is the time t standard deviation of log ($y_{i,t}$) across i.

The concepts of β-convergence and σ-convergence are related and we can say that β-convergence, although necessary, is not a sufficient condition for σ-convergence. The reason why the two concepts of convergence may not always show up together is that they capture two different aspects of the world. More specifically, σ-convergence relates to whether or not the cross – country distribution of world income shrinks over time and, on the other hand, β-convergence relates to the mobility of different individual economies within the given distribution of world income.

Furthermore, there is the idea of conditional convergence which is estimated on the basis of a multivariate regression analysis, with initial income and a set "conditioning variables" (V) that are supposed to determine the long – run income level as explanatory variables, i.e. $[y(t) - y(0)] = a + by(0) + cV + e$. Conditional convergence exists if the coefficient on initial income is negative. In other words, in case of conditional convergence there is a negative partial correlation between initial income per capita and subsequent growth.

In addition there is the idea of club-convergence which is based on models that yield multiple equilibrium. Which of these different equilibrium an economy will reach, depends on its initial position or some other attribute. A group of countries may approach a particular equilibrium if they share the initial location or attribute corresponding to that equilibrium. This produces club-convergence.

II. REVIEW OF THE PREVIOUS LITERATURE

The question of what will the distribution of world per capita income and productivity look like in the future spawned the empirical convergence literature and was the motive for many debates and disagreements.

In 1986 Maddison examined the evolution of per capita income gap between developed and developing countries and agreed with the aspect that Western countries already had a great lead before their economic growth accelerated[3]. Then, Abramovitz (1986) brought forward the "catch up" hypothesis by using the data base of Maddison's (1982) time series for the productivity levels of 16 countries during the 1870 – 1979 period. The hypothesis asserts that countries that are technologically backward have a potentiality for generating growth more rapid than that of more advanced countries, provided their social capabilities are sufficiently developed to permit successful exploitation of technologies already employed by the technological leaders. Baumol (1986) ended to the same conclusion and his research is the most known referring to the non tied up convergence. In a sample of 16 OECD countries observed an important negative coefficient to the variable of the initiate income in a growth initial level regression. He then tried to expand this relationship to a sample of 72 countries but he didn't find any convergence results. We can say that Baumol was the first to bring up the "club convergence" idea due to this difference of results according to the size of the sample used. He raised the possibility that the world might be divided into "convergence clubs", distinct groups of countries that revert toward different common trends. Another possibility is that some countries revert toward a common trend while others diverge from that common trend and from each

[3] David S. Landes, The Unbound Prometheus (Cambridge, 1969)

other. Since then, Durlauf & Johnson (1992), Quah (1996) and Ben David (1994) have provided some support for these possibilities. Furthermore and by following the seminal work of Baumol many authors [Barro (1991) and Mankiw, Romer & Weil (1992)] have tried to investigate conditional convergence, which means that besides keeping the neoclassical framework of including in the model the initial income variable, capital and labour, they added some other factors explaining the process of convergence. We can also say that the two studies of Abramovitz (1986) and Baumol (1986) developed the essential point that the richest countries in the world appear to exhibit convergence while the world as a whole does not. For example, in samples of rich countries, such as the OECD, per capita incomes have converged in the post – World War II era, but in large samples of countries (the "world"), per capita incomes haven't.

De Long (1988) indicated that the definition of the "developed" countries by Baumol suffered from an "ex post" problem and that if an "ex ante" definition of "developed" is used then the convergence disappears. More specifically, according to De Long, only a regression run on an "ex ante" sample, which is a sample not of nations that had converged but of nations that seemed in 1870 likely to converge, could tell whether growth since 1870 exhibited convergence. Dowrick and Nguyen (1989) examined the Total Factor Productivity (TFP) convergence through the cross section regression. Their contribution was that they unbinded the hypothesis of the common capital – output ratio for all the countries of the sample. In their research combined the initial income coefficient with that of the most developed country of the sample, which was the United States of America. That helped them to define the coefficient of the initial income as declaratory of the TFP convergence and the results from the 15 countries sample supported the existence of convergence.

Quah (1990) presented an analysis for the GDP of 114 countries from 1970 to 1985. With a large N and T he developed the "random field data" theory and denied the null hypothesis of the unit root. Furthermore, he was from the pioneers who allowed specific intercepts for his samples at the divergence analysis. Barro (1991) was one of the few researchers who examined the convergence subject from the aspect of the New Growth Theories (NGT). By studying the simultaneous route of growth, investments and fertility, ran many different regression tests without including the human and labour capital in his research. The results didn't support the existence of non tied up convergence in a sample of 98 countries, so he ended to the conclusion that NGT were right and noted that if he had included the human capital then the β would be important and negative.

Mankiw, Romer and Weil (1992) used the time series data of Summers and Houston and tried to explore the tied up convergence. By testing the neoclassical growth hypothesis for identical technology, saving and inflation they proved the conditional convergence. De Grauwe (1992) elaborated on the subject of convergence of inflation rates prior to the acceptance of a country in the monetary union. He argued that in 1991 the degree of inflation convergence among the countries participating in the EMS achieved its historically highest level and further narrowing of the differences among inflation rates is unrealistic. He concluded that the inflation convergence criterion is too tight to fulfill. In a later research De Grauwe (1995) found that a further drop in inflation differentials occurred after 1991, however he again cautioned against tight nominal convergence criteria. Levin and Lin (1992) used the advantages of the panel data timeseries to raise the power of the statistical test.

Bernard and Durlauf (1995) gave the definition of the convergence and helped the next researchers. Furthermore, they used the new Maddison (1986) data base of yearly PPP adjusted levels of per capita GDP for 15 OECD countries from 1900 - 1987. They showed that there are few signs of convergence in the long term, but enough signs of common trends. In addition they noted the difference between the cross sectional convergence tests and the timeseries tests and therefore indicated that in the second case the differences among the countries can' t include unit root or time trend.

Ben David (1995) applied another test based on the divergence of the GDP per capita of every country from the average of all the countries. He showed the existence of convergence among the richest countries and among the poorest countries as well. Gouyette (1995) assessed convergence in output per capita across 107 European regions for the period 1975 – 1990. His results supported the convergence hypothesis for the northern regions of Europe but not for the southern ones. Deuhurst and Mutis – Gaitan (1995) defined a model of varying convergence rates in GDP per capita among the 63 official regions of the European Union during 1981 – 1991 and concluded that the varying convergence rates for different subgroups in the sample adjust towards a common equilibrium growth rate. Armstrong (1995) constructed three 85 – region data sets drawn from twelve EU member states for different time periods and observed the existence of stronger convergence in the past.

Sala – i – Martin (1996) applied the concepts of β and σ convergence to a variety of data sets that included a large cross – section of 110 countries, the sub – sample of OECD countries, the states within the United States, the prefectures of Japan and regions within several European countries. Except for the large cross – section of countries, all data sets displayed strong evidence of σ – convergence and absolute β – convergence. The cross – section of countries exhibited σ – divergence and β – convergence. The speed of conditional convergence was close to 2% per year. The β – convergence approach has been applied in numerous other papers also, notably in the works of Dowrick &Nguyen (1989), Barro & Sala – i – Martin (1995) and Mnkiw et al. (1992). This approach, however suffers from serious econometric pitfalls, as pointed out by Friedman (1992) and Quah (1993). Moreover, Bernard & Durlauf (1995, 1996), Durlauf & Johnson (1995) and Evans & Karras (1996a, 1996b) have shown that the β – convergence approach would quite likely produce misleading results.

Evans and Karras (1996) with the help of the unit root analysis pooled deviation data from 56 countries. In their paper, convergence is characterized by the reduction in income differentials within specific groups of countries over time. The results showed denial of the null hypothesis and therefore the existence of convergence. Furthermore, they uncovered the conditions that must be present for the β – convergence approach to produce reliable results. These conditions require that the dynamical structures of the economies have identical first – order autoregressive representation, every economy affects every other economy completely symmetrically and the vector of variables control for all permanent cross – economy differences. Evans (1996) had the same results from a sample of 13 countries during 1870 – 1989.

Fagerberg and Verspagen (1996) analysed the regional growth in the post war period from a sample of 70 provinces covering 6 members of the European Union. Their empirical results showed that there has been divergence in many and important indices.

Islam and Chowdhury (1997) tested the history of the Asian – Pacific economic growth and the route to an integration through the commerce, the foreign investments and the labour immigration. They supported that the need for integration is due to the power of the market and not a political decision as it is in Europe. With data from 1960 to 1990 identified huge signs of growth, limitation of the dependence from the American market, improvement in the way of life and many signs of the existence of convergence. Siklos and Wohar (1997) examined the relationship between interest rates and inflation rates for 10 countries during the period 1974 – 1995. They found evidence of a unique cointegrating relationship between nominal interest rates of European Monetary System (EMS) countries, the US and Canada, and the US, Germany and Japan. No similar relationship was obtained between inflation rates with one exception, so they interpreted those results as convergence in inflation but not in interest rates. Greasley and Oxley (1997) extended the Bernard and Durlauf analysis and with the same data they tested bivariate subgroups and found evidence of output convergence in some pairs. Siriopoulos and Asteriou (1997) considered the issue of convergence across Greek regions, following the theoretical basis of the neoclassical model of economic growth. Their analysis found no evidence of convergence and supported the hypothesis of dualism across the southern and the northern parts of the country.

Li and Papell (1998) examined convergence of per capita output for 16 OECD countries. With the use of the concepts of deterministic and stochastic convergence[4] they developed techniques which incorporated endogenously determined break points to test the unit root hypothesis in relative per capita income. The test provided evidence of deterministic convergence for 10, and stochastic convergence for 14 of the 16 OECD countries.

Orlowski (1998) compared the GDP per capita and other basic indexes of Poland with those of the European Union and indicated that there is convergence in some of them but there have to be structural changes in order to empower this convergence. Veiga (1999) splited in two periods the data and tested for σ – convergence among 15 countries. He noted that in the first period (1960 – 1970) the rate of convergence was higher than the second one. Furthermore, the convergence as a whole reached 2,45% and after the Maastricht Convention started to fall.

Giannas, Liargovas and Manolas (1999) searched for convergence among the members of the European Union during the period 1970 – 1990, by testing not only economic indicators but also social and quality of life variables such as pollution, public services, health care, crime rates etc. The main tool of their analysis was the Coefficient of Variation (CV) for 8 economical and relative to the quality of life indicators for each of the three sub - groups of the 15 EU countries. In order to study the relative position of every country in comparison to the others they classified them on the basis of a complex index including their quality of life status for various years. Then, they defined and counted the convergence and indicated that there has been convergence during 1970 – 1975 and 1985 – 1990 and divergence during 1980 – 1985. Yin, Michelis and Zestos (2000) examined several indexes concerning the 15

[4] Stochastic convergence postulates convergence if the log of relative output is trend stationary and has been proposed by Carlino & Mills (1993). This definition, however, is open to criticism because the presence of a time trend allows for permanent per capita output differences. A stronger definition of convergence is deterministic convergence, which appears when the log of relative output is level stationary.

members of the European Union, including Austria, Finland and Sweden, for the period between 1960 and 1995, which they separated to 7 sub - periods. They concluded that convergence exists and that there are different types of convergence according to the size of the examination.

Boldrin and Canova (2000) in their research about the inequality in the European Union indicated the existence of not so strong convergence in the GDP per capita index. Estrin (2001) examined whether the ex communist countries converged to the countries of the Western Europe during the 1970 – 1998 period and came to the result that there are not enough evidence of convergence. Kocenda and Pappel (2001) examined whether there exists convincing evidence of inflation convergence within the European Union and whether the Exchange Rate Mechanism (ERM) helped to accelerate the convergence. They used panel data analysis for the 1959 – 1994 period, with 1979 (inception of the ERM) as a midpoint, and for different groups of countries and the results of their research were supportive of convergence. The countries which continuously participated in the narrow ERM bands showed a dramatically higher convergence rate during the period following establishment of the mechanism. Michelis and Neaime (2001) tested for β and σ convergence to the countries of the Asian – Pacific region and had positive results for the 1960 – 1990 period but non powerful convergence for the whole period (1960 – 1999).

Brada and Kutan (2001) compared the convergence with German monetary policy of the transition – economy candidates for EU membership, of non – transition candidates and of countries that had recently joined the EU. They employed the Phillips – Perron (PP) test for cointegration and concluded that the monetary system of the members of the European Union converged with that of Germany and the same happened with Malta and Cyprus. All the other countries had weak convergence. Rassekh, Panik and Kolluri (2001) introduced a procedure for testing the convergence hypothesis and applied it to 24 OECD countries for the period 1950 – 1990. Their approach was an attempt to capture the economics of the convergence hypothesis, while avoiding the problems associated with β and σ convergence. They applied an ARMA process to their sample data and found only modest support of the convergence hypothesis in the OECD during the postwar era. Beyaert (2003) examined the output convergence with the help of differentials and panel analysis through the use of 3 tests. He found total convergence until 1970 for the 14 members of the European Union (except Luxembourg) and some kind of convergence after 1970. Luginbuhl and Koopman (2003) examined the convergence in GDP for Germany, Italy, France, Spain and Holland and noted σ – convergence and trend cycles of potential power. Brettell (2003) in his research showed that there is no so strong β or σ convergence among the countries of the European Union for the data of the 1980 – 2001 period, but they exist when the regions are analysed separately.

Kutan and Yigit (2003) investigated, for the period after 1993, the issue of real and nominal economic convergence of transition economies within their own groups and to the European Union. They extended Kocenda's study not only by using a more stable period (post '93) but also by employing the panel estimation approach developed by Im, Pesaran and Shin (1997), which offered less restrictive assumptions about convergence by allowing heterogeneity in the convergence rates. They found that the first – round candidates had made significant progress in monetary policy convergence with respect to the EU and there was significant real convergence between the first round candidate economies and EU. On the other hand the second round candidate countries didn' t make the same progress in the convergence issue as the first ones. Giles and Feng (2003) found powerful output convergence for the 14 countries of the OECD but weak convergence in indexes relative to the "well being". Kaitila (2004) examined the existence of β and σ convergence among the European Union and the accession countries of the Baltic and Eastern Europe for the 1960 – 2001 period. He didn' t find any evidence for β – convergence, but he did find signs of σ – convergence during 1960 – 1973 and 1980 – 2001.

III. PURPOSE

The purpose of this paper is to examine the economic convergence of a group of countries with the use of new econometric techniques and compare the results with the results of former papers which's econometric techniques didn't take into account some important parameters of the statistical facts.

It is often argued that the unit root tests applied to a panel of cross section units may improve the limited power of such tests. However, an important issue with the application of panel data methods to regional data is that the data exhibit substantial cross sectional dependence. In traditional panel data analysis such cross section correlation is accounted for by including a "time effect", i.e., a common factor that is constant across cross section units but varies in time. Such a time effect implies that the errors of all cross section units are correlated in a similar way and, therefore, the off – diagonal elements of the error covariance matrix are all the same. Such a specification is often violated in practice and seems overly restrictive in many applications using regional data, so it is important to specify the contemporaneous covariance matrix of the errors in a more general way.

This paper contributes to the ongoing research in this field by comparing different approaches and by introducing more analytically the use of Pesaran' s (2005) test, where the error term is assumed to have an unobserved one – common – factor structure accounting for cross – sectional correlation and an idiosyncratic component.

IV. DATA

The variables under examination are the Industrial Production, Inflation, Long Term Interest Rates[5], Unemployment and GDP per capita. The time span[6] of the data for Inflation is from 1995:1 to 2005:12 on monthly basis, for Long Term Interest Rates from 1997:11 to 2006:1 (for Slovenia 2004:8 – 2006:1) on monthly basis, for GDP per capita from 1999:1 to 2005:3 on quarterly basis, for Unemployment from 1998:1 to 2005:4 on quarterly basis and for Industrial Production from 1985:1 to 2005:12 on monthly basis. The ten new member states of the European Union are tested against the average of the three best performing EU countries according to the Maastricht criteria[7], the average of EU 15, the average of EU 25 and the average of the three best performing countries according to the index. The data were obtained from the International Monetary Fund's International Financial Statistics. All the differentials were computed as the difference between an individual index rate and the average of a whole group at time t.

V. METHODOLOGY

In the past years, a wide variety of empirical work on neoclassical growth model was undertaken. One branch of these studies has utilized time series methodology to test for the key proposition of convergence hypothesis and was based on unit root tests. It is widely known that univariate unit root tests suffer from low statistical power in finite samples. This might lead to failures in rejecting the null – hypothesis. Recently, panel unit root tests have

[5] Government bond yields (ten years maturity)
[6] The time spans of the time series may differ in some cases according to the country and the index.
[7] One country, in order to qualify for joining the EMU has to comply with the Maastricht criteria, and so: (a) must not devalue its currency within two years preceding entry into the monetary union, (b) must have an inflation rate not higher than 1.5% above the average of the three countries with the lowest inflation rates, (c) must have a long term interest rate not higher than 2 percentage points above the average of the three countries with the lowest inflation rates and (d) must have government deficits and debts not exceeding 3% and 60% of GDP respectively.

been adopted to address the issue, significantly increasing the power when testing for convergence.

The primary motivation behind the application of panel data unit roots, as opposed to standard univariate unit root tests, is to exploit the extra information provided by pooled cross – section time series in order to get more powerful procedures.

A number of unit root tests for panel data have been developed in the recent literature, including most notably those by Levin, Lin and Chu (2001), Im, Pesaran and Shin (2003) and Pesaran (2005).

Levin and Lin (2001) consider the following three models:

Model 1: $\Delta y_{it} = \delta\, y_{it-1} + \zeta_{it}$

Model 2: $\Delta y_{it} = \alpha_{0i} + \delta\, y_{it-1} + \zeta_{it}$

Model 3: $\Delta y_{it} = \alpha_{0i} + \alpha_{1i} t + \delta\, y_{it-1} + \zeta_{it,}$

where $-2 < \delta \leq 0$ for $i = 1,\ldots,N$

Their paper considers pooling cross-section time series data as a means of generating more powerful unit root tests. The test procedures are designed to evaluate the null hypothesis that each individual in the panel has integrated time series versus the alternative hypothesis that all individuals time series are stationary. The pooling approach yields higher test power than performing a separate unit root test for each individual. The panel-based unit root test proposed allows for individual specific intercepts and time trends. Moreover, the error variance and the pattern of higher-order serial correlation are also permitted to vary freely across individuals.

Their main hypothesis is

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{pi} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mi} + \varepsilon_{it}, \quad m=1,2,3.$$

and the null hypothesis of unit roots becomes

$H_o : \delta_i = 0$ for all i,

against the alternative,

$H_1 : \delta_i < 0$ for all i

However, since p_i is unknown, they suggested a three-step procedure to implement their test. In step 1 they carried out separate ADF regressions for each individual in the panel, and generated two orthogonalized residuals. Step 2 required estimating the ratio of long run to short run innovation standard deviation for each individual. In the final step they computed the pooled t-statistics.

The conventional regression t – statistic for testing δ=0 is given by

$$t_\delta = \frac{\hat{\delta}}{STD(\hat{\delta})} \text{ , } N\sim(0,1)$$

As a conclusion we can say that Levin & Lin developed a procedure utilizing pooled cross-section time series data to test the null hypothesis that each individual time series contains a unit root against the alternative hypothesis that each time series is stationary. As both the cross-section and time series dimensions of the panel grow large, the panel unit root test statistic has a limiting normal distribution. The Monte Carlo simulations indicate that the normal distribution provides a good approximation to the empirical distribution of the test statistic in relatively small samples, and that the panel framework can provide dramatic improvements in power compared to performing a separate unit root test for each individual time series. Thus, the use of panel unit root tests may prove to be particularly useful in analyzing industry-level and cross-country data.

The proposed panel based unit root test does have its limitations. First, there are some cases in which contemporaneous correlation cannot be removed by simply subtracting the cross sectional averages. The research reported in their paper depends crucially upon the independence assumption across individuals, and hence not applicable if cross sectional correlation is present. Secondly, Levin & Lin test requires δ to be homogenous. However, a panel data approach primilary deals with the problem of heterogeneity in intercepts and not with heterogeneities in the slopes. Therefore, the assumption that all individuals are identical with respect to the presence or absence of a unit root is somewhat restrictive.

We must also note that Levin & Lin test statistic converges more rapidly with respect to the time dimension T than with respect to the cross – section dimension.

The paper by Im, Pesaran and Shin (2003) proposes unit root tests for dynamic heterogeneous panels based on the mean of individual unit root statistics. In particular it proposes a standardized t-bar test statistic based on the (augmented) Dickey - Fuller statistics averaged across the groups. Under a general setting this statistic is shown to converge in probability to a standard normal variate sequentially with T (the time series dimension) ••, followed by N (the cross sectional dimension) ••. A diagonal convergence result with T and N •• while N/T•k, k being a finite non-negative constant, is also conjectured. In the special case where errors in individual Dickey - Fuller (DF) regressions are serially uncorrelated a modified version of the standardized t-bar statistic is shown to be distributed as standard normal as N •• for a fixed T, so long as T > 5 in the case of DF regressions with intercepts and T > 6 in the case of DF regressions with intercepts and linear time trends. An exact fixed N and T test is also developed using the simple average of the DF statistics. Monte Carlo results show that if a large enough lag order is selected for the underlying ADF regressions, then the small sample performances of the t-bar test is reasonably satisfactory and generally better than the test proposed by Levin and Lin.

The main hypothesis is

$$\Delta y_{it} = \delta_i y_{it-1} + \sum_{L=1}^{pi} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mi} + \varepsilon_{it}, \quad i= 1, \quad ,N \ , \ t= 1,\dots,T$$

and the null hypothesis of unit roots becomes

$H_o : \delta_i = 0$ for all i,

against the alternatives,

$H_1 : \delta_i<0, \quad i = 1, 2,\dots, N_1, \qquad \delta_i = 0, \quad i = N_1 + 1, N_1 + 2,\dots,N$

They also make the following assumptions:

Assumption 1: All the roots of $\varphi_i(z) = 1-\sum_{j=1}^{p_i+1} \phi_{ij} z^j = 0$, $i=1,2,\dots,N$, fall on or outside the unit circle, while all the roots of $\rho_i(z) = 1-\sum_{j=1}^{p_i} \rho_{ij} z^j = 0$, $i=1,2,\dots,N$, fall strictly outside the unit circle.

Assumption 2: $\varepsilon_{it,}$ $i = 1,2,\dots,N$, $t = 1,2,\dots,T$ are independently distributed as normal variates with zero means and finite (possibly) heterogeneous variances, σ_i^2 , and the initial values, $y_{i0}, y_{i,-1},\dots, y_{i,-pi}$,are given (either fixed or stochastic).

The t – bar statistic is formed as a simple average of the individual t statistic for testing $\beta_i=0$, namely

$$\text{t-bar}_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{iT}(p_i, \rho_i)$$

Where $t_{iT}(p_i,\rho_i)$ is given by

$$t_{iT}(p_i,\rho_i) = \frac{\sqrt{T-p_i-2}\,(y'_{i,-1}M_{qi}\Delta y_i)}{(y'_{i,-1}M_{Qi}y_{i,-1})^{\frac{1}{2}}(\Delta y'_i M_{xi}\Delta y_i)^{\frac{1}{2}}} ,$$

$\rho_\iota = (\rho_{\iota 1}, \rho_{\iota 2},\dots, \rho_{\iota pi})'$, $M_{Qi} = I_T - Q_i(Q'_i Q_i)^{-1} Q'_i$, $M_{xi} = I_T - X_i(X'_i X_i)^{-1} X'_i$ and $X_i = (y_{i,-1}, Q_i)$

When T is fixed, the individual ADF statistics, $t_{iT}(p_i,\rho_i)$, will depend on the nuisance parameters, ρ_i, i = 1,…,p_i ,even under β_i=0. Therefore, the standardization using $E\left[t_{iT}(p_i,\rho_i)\right]$ and $Var\left[t_{iT}(p_i,\rho_i)\right]$ will not be practical. But when T and N are sufficiently large it is possible to develop asymptotically valid t – bar type panel unit root tests that are free from the nuisance parameters.

Another alternative of practical relevance would be to carry out the standardization of the t - bar statistic using the means and variances of t_{it} (p_i, 0) evaluated under β_i = 0. This is likely to yield better approximations, since E [t_{it} (p_i, 0) / β_i = 0] , for example, makes use of the information contained in p_i while E [t_{it} (0, 0) / β_i = 0] does not. In view of this we propose the alternative standardized t - bar statistic

$$W_{tbar}(p,\rho)=\frac{\sqrt{N}\left\{t-bar_{NT}-\frac{1}{N}\sum_{i=1}^{N}E\left[t_{iT}(p_i,0)/\beta_i=0\right]\right\}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}Var\left[t_{iT}(p_i,0)/\beta_i=0\right]}}\xrightarrow{T,N}N(0,1)$$

The IPS test has significantly greater power compared to the LL test, especially when the number of countries, N, is small, but it also has better size properties than LL's when the choice of ADF order is misspecified. Differences in performance of these two techniques are caused mainly by the imposition of the homogeneity assumption in LL, which leads to false inference due to misspecification of the model. These disparities will grow as the degree of heterogeneity within the panels gets larger than used in the IPS simulations. Im, Pesaran & Shin propose an alternative testing procedure which allows for heterogenous δ_i, which means a difference in the speed of convergence among regions. While the null hypothesis of the IPS test is the same as for the Levin & Lin test, the alternative hypothesis is more flexible. It states that at least one of the series is stationary.

Although the LL and IPS tests have been used in a large scale by the researchers their concern is about the presumptions these tests assume. The most annoying presumption is the one that requires cross sectional independence, which is quite restrictive given the nature of economic panel data. This presumption is very powerful and during the measurement of convergence among the countries may not be valid. Such tests are likely to yield biased results if applied to the panels with cross sectional dependency and because of that these tests are not proper for empirical researches. For this reason we are going to use the following test by Pesaran which allows cross sectional dependence.

Pesaran (2005) adopted a different approach to dealing with the problem of cross section dependence. Instead of basing the unit root tests on deviations from the estimated factors, he augmented the standard DF (or ADF) regressions with the cross section averages of lagged levels and first-differences of the individual series. Standard panel unit root tests could now be based on the simple averages of the individual cross sectionally augmented ADF statistics (denoted by CADF), or suitable transformations of the associated rejection probabilities. The individual CADF statistics or the rejection probabilities could then be used to develop modified versions of the t-bar test proposed by Im, Pesaran and Shin (IPS), the inverse chi-squared test (or the P test) proposed by Maddala and Wu (1999), and the inverse normal test (or the Z test) suggested by Choi (2001).

The main hypothesis is

$$\Delta y_{it} = \delta_i y_{it-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mi} + \varepsilon_{it} \; \{1\} \;,\; i=1, \; ,N \;,\; t=1,\ldots,T$$

and the null hypothesis of unit roots becomes

$H_o : \delta_i = 0$ for all i,

against the alternatives,

$H_1 : \delta_i < 0, \;\; i = 1, 2, \ldots, N_1, \quad \delta_i = 0, \;\; i = N_1 + 1, N_1 + 2, \ldots, N$

Then Pesaran proceeded with the examination in two stages. At the first stage, CADF statistics, modified {1} to: $\Delta y_{it} = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + \sum_{j=0}^{p} d_{ij}\Delta \bar{y}_{t-j} + \sum_{j=1}^{p} \delta_{ij}\Delta y_{i,t-j} + e_{it}$ {2}, where $\bar{y}_t = \frac{1}{N}\sum_{i=1}^{N} y_{it}$ and computed a t–statistic for every i, which called $t_i \sim CADF_i$. The hypothesis examination for δ_i, namely H_0: $\delta_i=0$ and H_1: $\delta_i<0$ is based on critical values which are computed with the help of Monte – Carlo simulations. At the second stage, CIPS, we have the average of the CADF statistics of the previous stage, meaning CIPS ~ $\frac{1}{N}\sum_{i=1}^{N} CADF_i$, where the null hypothesis of unit roots becomes $H_o : \delta_i = 0$ for all i,

against the alternatives, $H_1 : \delta_i<0, \quad i = 1, 2,\ldots, N_1, \quad \delta_i = 0, \quad i = N_1 + 1, N_1 + 2,\ldots,N$. Because of the fact that CIPS doesn't follow a well known distribution the hypothesis examination is done again with critical values of Monte – Carlo simulations.

Our main purpose, in order to justify convergence, is to show that the differentials between the indexes of the 25 members of the European Union are stationary and as we have already mentioned we are going to use panel unit root tests. Unit root tests are often conducted after some kind of pre – test for the trend. Such pre – tests may be very informal, such as inspection of time plots of the data or may be implemented by testing the significance of the coefficient on the time trend in an equation fitted to the data.

Hall (1994, pp. 467 – 468) observed that: "Clearly there can be disagreement between the results of the tests due to the inherent variation in sampling. There are two alternative explanations that may need to be considered, however. First, if τ_μ is insignificant but τ_τ is significant, then it may be due to misspecification of the trend term. West (1987) demonstrated that if y_t is stationary about a linear time trend but the trend is omitted from the regression model, then τ_μ converges in probability to 0, so asymptotically one never rejects a unit root. Therefore I interpret this type of conflicting result as evidence against a unit root. Similarly, if τ_μ is significant but τ_τ is insignificant, then this may be due to the inclusion of a redundant regressor. Dickey (1984) demonstrated that if y_t is stationary about an intercept alone, then the inclusion of a linear time trend … leads to a considerable loss of power. Therefore I also interpret this type of conflict between the tests as evidence against a unit root".

The interpretive issue raised in the above comment arises in all applications of unit root tests and the procedure we propose is designed to provide a systematic resolution of the problem via evolution of the significance of the trend.

Since we are assuming that the degree of any polynomial trend that may be present in the data is unknown, the objective of the testing strategy should be to identify the class of model, that is, to test the unit root and determine the trend degree. To this end we consider the following strategy of the pre – test.

<u>STRATEGY S1</u>

1. Perform a preliminary unit root test invariant to quadratic trend under the null

2(a). If the unit root is not rejected at step 1, provisionally maintain this hypothesis and estimate $\Delta y_t = \beta^*_{01} + \beta^*_{11} t + \Sigma^{p}_{j=1} a_j \Delta y_{t-j} + e_t$, testing for the null that k=1, (that is $\beta_2=0$ in (9)) using the t – statistic on β^*_{11} referred to standard tables.

2(b). If the unit root is rejected at step 1, test for k=1 using the t – statistic on a_{22} in Eq. (2d), again referred to standard tables.

3(a). If k=1 was rejected at step 2, we stop, since the unit root test already conducted is the only one available which is invariant to the maintained quadratic trend.

3(b). If k=1 was not rejected and the unit root was not rejected perform a second provisional unit root test invariant to linear trend under the null.

3(c). If k=1 was not rejected, but the unit root was rejected at step 2, test for k=0 using the t – statistic on a_{11} in (2c) referred to standard tables and stop.

4. If the unit root was not rejected at 3(b), estimate $\Delta y_t = \beta^*_{01} + \beta^*_{11} t + \Sigma_{j=1}^{p} a_j \Delta y_{t-j} + e_t$, testing the null that k=0 using the t – statistic on β^*_{00}.

5(a). If k=0 is rejected at step 4, stop.

5(b). If k=0 is accepted at step 4, conduct a further provisional unit root test invariant to the mean under the null.

6(a). If the unit root is not rejected at 5(b), test the magnitude of the initial observation, y_1, relative to the increments in y using $y_1 / \sqrt{T^{-1} \Sigma (\Delta y_t)^2}$ referred to N(0,1).

6(b). If the unit root is rejected at 5(b), stop.

7(a). If y_1 differs significantly from zero, stop.

7(b). If y_1 does not differ significantly from zero, perform a unit root test which is not invariant to the mean under the null.

VI. RESULTS

i. THE ADF – GLS, CADF AND CIPS TESTS

A. LONG TERM INTEREST RATES

A1. NINE[8] NEW MEMBER STATES – AVERAGE OF EU 15

Regression results from the dataset tested against the average of EU 15 reject group convergence in all cases. According to the ADF – GLS process (Table 1) only Poland rejects the null hypothesis at 5% (when intercept and trend is included). We could state that there is a denial of the null hypothesis

[8] Slovenia was excluded because of the limited number of observations

for the long term interest rates according to the CADF process (Table 2) for the cases of Latvia and Estonia also, but only Poland shows this behaviour without the existence of intercept and trend.

Table 1

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-1.8529342	YES	NO
HUNGARY	-0.58910897	YES	NO
POLAND	-3.3332021**	YES	YES
MALTA	-0.23111252	NO	NO
CZECH REP.	-1.6092702	YES	NO
SLOVAKIA	-2.4089911	YES	YES
LATVIA	-0.82487020	YES	NO
LITHUANIA	-1.6155836	YES	NO
ESTONIA	-0.79342861	YES	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 2

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	-2.1301631(-3.2457845)	YES	NO
HUNGARY	-0.68397519(-3.2339224)	YES	NO
POLAND	-3.6798310**(3.2548871)	NO	NO
MALTA	-0.69382662(-2.5366345)	NO	NO
CZECH REP.	-1.1786301(-3.2480648)	YES	NO
SLOVAKIA	-2.5566744(-3.7624625)	YES	YES
LATVIA	-5.8447505**(3.7645441)	YES	YES
LITHUANIA	-0.59733757(-3.3264394)	YES	NO
ESTONIA	-4.4952770**(3.8600477)	YES	YES

CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-1.5527658	-1.2706840	-1.5380149

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9811231 (1%), -1.7109686 (5%) and -1.5760570 (10%) for Model 1, -2.6402738 (1%), -2.3608953 (5%) and -2.2230601 (10%) for Model 2, -3.1425034 (1%), -2.8702882 (5%) and -2.7547027 (10%) for Model 3

A2. NINE NEW MEMBER STATES – AVERAGE OF BEST THREE PERFORMING MEMBER STATES ACCORDING TO THE MAASTRICHT CRITERIA[9]

Regression results from the dataset tested against the average of the best three performing member states according to the Maastricht criteria reject group convergence in all cases. According to the ADF – GLS process (Table 3) only Poland rejects the null hypothesis at 5% (when intercept and trend is included). We could state that there is a denial of the null hypothesis for the long term interest rates according to the CADF process (Table 4) for the case of Latvia also, but only Poland shows this behaviour without the existence of intercept and trend.

Table 3

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-1.9942879	NO	NO
HUNGARY	-1.1732664	YES	NO
POLAND	-3.3504928**	YES	YES
MALTA	-0.27593220	NO	NO
CZECH REP.	-1.7813636	YES	NO
SLOVAKIA	-0.53872382	YES	NO
LATVIA	-0.93996674	YES	NO
LITHUANIA	-1.8734288	YES	NO
ESTONIA	-0.69878103	YES	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 4

[9] The tree countries referred are the Netherlands, France and Germany.

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	**-2.3403173**(-3.2330361)	YES	NO
HUNGARY	**-1.2538446**(-3.2624737)	YES	NO
POLAND	**-3.8219759****(3.2339224)	NO	NO
MALTA	**-0.61685067**(-2.6139085)	NO	NO
CZECH REP.	**-0.65150867(**-3.2446604)	YES	NO
SLOVAKIA	**-2.1679166**(-3.2744247)	YES	NO
LATVIA	**-6.5164266****(3.7624625)	YES	YES
LITHUANIA	**-1.1542979**(-3.2909029)	YES	NO
ESTONIA	**0.000000**(-3.2911494)	YES	NO

CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-1.2187798	-0.88334122	-1.9325449

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%
[2] The critical values referring to the CIPS Test are -1.9693852 (1%), -1.7117830 (5%) and -1.5687684 (10%) for Model 1, -2.6191835 (1%), -2.3719949 (5%) and -2.2304737 (10%) for Model 2, -3.1140093 (1%), -2.8682883 (5%) and -2.7430029 (10%) for Model 3

A3. NINE NEW MEMBER STATES – AVERAGE OF EMU

Regression results from the dataset tested against the average of the member states participating in the EMU reject group convergence in all cases, except for that of Model 1 (No intercept / No trend) where the null hypothesis is rejected at 10%, but we can't take this result as a strong sign of the existence of group convergence. According to the ADF – GLS process (Table 5) only Poland rejects the null hypothesis at 5% (when intercept and trend is included). We could state that there is denial of the null hypothesis for the long term interest rates according to the CADF process (Table 6) for the case of Latvia also, but only Poland shows this behaviour without the existence of intercept and trend.

Table 5

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-1.8070626	YES	NO
HUNGARY	-1.2552907	YES	NO
POLAND	-3.2762293**	YES	YES
MALTA	-0.25660732	NO	NO
CZECH REP.	-1.8407971	YES	NO
SLOVAKIA	-0.58578149	YES	NO
LATVIA	-0.90768391	YES	NO
LITHUANIA	-1.8317928	YES	NO
ESTONIA	-0.54456409	YES	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 6

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	**-2.3458540**(-3.2330361)	YES	NO
HUNGARY	**-1.2655366**(-3.2624737)	YES	NO
POLAND	**-3.6715185****(3.2339224)	NO	NO
MALTA	**-0.66909845**(-2.6139085)	NO	NO
CZECH REP.	**-0.54433508**(-3.2446604)	YES	NO
SLOVAKIA	**-2.2839455**(-3.2744247)	YES	NO
LATVIA	**-6.4632540****(3.7624625)	YES	YES
LITHUANIA	**-1.1744653**(-3.2909029)	YES	NO
ESTONIA	**0.000000**(-3.2911494)	YES	NO

CIPS TEST	**MODEL 1 (NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-1.6779652***	-1.3869343	-1.4143059

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9693852 (1%), -1.7117830 (5%) and -1.5687684 (10%) for Model 1, -2.6191835 (1%), -2.3719949 (5%) and -2.2304737 (10%) for Model 2, -3.1140093 (1%), -2.8682883 (5%) and -2.7430029 (10%) for Model 3

B. <u>INFLATION</u>

B1. TEN NEW MEMBER STATES – AVERAGE OF THE EMU

Regression results from the dataset tested against the average of the member states participating in the EMU accept group convergence in all cases. According to the ADF – GLS process (Table 7) Cyprus and Hungary reject the null hypothesis at 5%. We could state that there is partial convergence for the inflation according to the CADF process (Table 8) for the cases of Estonia, Slovenia and Slovakia also.

Table 7

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-4.5465890**	NO	NO
HUNGARY	-6.9958986**	NO	NO
POLAND	-0.16213877	YES	NO
CZECH REP.	-0.10997523	YES	NO
ESTONIA	-0.11937837	YES	NO
SLOVENIA	-0.12207255	YES	NO
SLOVAKIA	-0.12123657	YES	NO
LITHUANIA	-0.10965270	YES	NO
LATVIA	-0.099720177	YES	NO
MALTA	-0.097794772	YES	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 8

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	**-11.964159****(3.2359000)	NO	NO
HUNGARY	**-2.7874225****(2.6426000)	NO	NO
POLAND	**-1.7623769**(-3.2359000)	YES	NO
CZECH REP.	**-2.4322520**(-3.2359000)	YES	NO

ESTONIA	**-3.2730793****(3.2359000)	NO	NO
SLOVENIA	**-3.2672720****(3.2359000)	NO	NO
SLOVAKIA	**-3.4997039****(3.2359000)	NO	NO
LITHUANIA	**-3.1457366**(-3.2359000)	YES	NO
LATVIA	**-2.6724584**(-3.2359000)	YES	NO
MALTA	**-2.1807547**(-3.2359000)	YES	NO
CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-3.0408116*	-3.1558957*	-3.1990812*

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9366000 (1%), -1.7059000 (5%) and -1.5590000 (10%) for Model 1, -2.5389000 (1%), -2.3333000 (5%) and -2.2275000 (10%) for Model 2, -3.0268000 (1%), -2.8220000 (5%) and -2.7262000 (10%) for Model 3

B2. TEN NEW MEMBER STATES – AVERAGE OF THE BEST THREE PERFORMING MEMBER STATES ACCORDING TO THE MAASTRICHT CRITERIA

Regression results from the dataset tested against the average of the best three performing member states according to the Maastricht criteria accept group convergence in all cases. According to the ADF – GLS process (Table 9) Cyprus, Hungary, Czech Republic, Estonia, Slovakia, Lithuania and Malta reject the null hypothesis at 5%. But we must note that for Czech Republic and Estonia the test included intercept and trend. We could also state that according to the CADF process (Table 10) the null hypothesis is rejected for all the new member states except from Latvia, but we can say that there is partial convergence for the inflation index only for Cyprus, Hungary, Slovakia, Lithuania and Malta.

Table 9

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-4.5465890**	NO	NO
HUNGARY	-6.9958986**	NO	NO

POLAND	-1.7204486	YES	YES
CZECH REP.	-5.2203530**	YES	YES
ESTONIA	-3.8206781**	YES	YES
SLOVENIA	-0.93003804	YES	YES
SLOVAKIA	-2.4598168**	NO	NO
LITHUANIA	-4.5990598**	NO	NO
LATVIA	-0.26947265	YES	NO
MALTA	-4.1561208**	NO	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 10

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	**-11.964159****(3.2415000)	NO	NO
HUNGARY	**-2.7874225****(2.5859000)	NO	NO
POLAND	**-14.589310****(3.7135000)	YES	YES
CZECH REP.	**-10.166697****(3.7135000)	YES	YES
ESTONIA	**-5.7972014****(3.7135000)	YES	YES
SLOVENIA	**-4.6553819****(3.7135000)	YES	YES
SLOVAKIA	**-6.2008426****(3.2415000)	NO	NO
LITHUANIA	**-5.0578898****(3.2415000)	NO	NO
LATVIA	**-0.93187456**(-3.2415000)	YES	NO
MALTA	**-4.7453514****(3.2415000)	NO	NO
CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-3.5968988*	-4.1675786*	-4.4626095*

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9400000 (1%), -1.7100000 (5%) and -1.5600000 (10%) for Model 1, -2.5300000 (1%), -2.3200000 (5%) and -2.2100000 (10%) for Model 2, -3.0300000 (1%), -2.8300000 (5%) and -2.7200000 (10%) for Model 3

B3. TEN NEW MEMBER STATES – AVERAGE OF THE EU 15

Regression results from the dataset tested against the average of the EU 15 accept group convergence in all cases. According to the ADF – GLS process

(Table 11) Cyprus, Slovenia, Lithuania and Malta reject the null hypothesis at 5%. But we must note that for Slovenia the test included intercept and trend. We could also state that according to the CADF process (Table 12) the null hypothesis is rejected for all the new member states except from Czech Republic, but we can say that there is partial convergence for the inflation index only for Cyprus, Estonia, Lithuania, Latvia and Malta.

Table 11

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-5.0564856**	NO	NO
HUNGARY	-0.64750876	YES	NO
POLAND	-0.27895805	YES	NO
CZECH REP.	-1.8391035	NO	NO
ESTONIA	-1.0074362	YES	NO
SLOVENIA	-3.2508207**	YES	YES
SLOVAKIA	-1.2739656	NO	NO
LITHUANIA	-4.2241830**	NO	NO
LATVIA	-0.40887306	YES	NO
MALTA	-4.0524656**	NO	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 12

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	**-4.8365722****(3.2387543)	NO	NO
HUNGARY	**-7.3357035****(3.7371840)	YES	YES
POLAND	**-5.6296399****(3.7371840)	YES	YES
CZECH REP.	**-2.5671101**(-2.6244716)	NO	NO
ESTONIA	**-3.3630231****(3.2387543)	NO	NO

SLOVENIA	**-4.3959568****(3.7371840)	YES	YES
SLOVAKIA	**-3.8991405****(3.7371840)	YES	YES
LITHUANIA	**-6.5897290****(3.2387543)	NO	NO
LATVIA	**-4.9638272****(3.2580095)	NO	NO
MALTA	**-4.4121751****(3.2306055)	NO	NO

CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-4.4523575*	-4.7818786*	-4.9852190*

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9549646 (1%), -1.7009756 (5%) and -1.5757982 (10%) for Model 1, -2.5329818 (1%), -2.3319672 (5%) and -2.2167390 (10%) for Model 2, -3.0392435 (1%), -2.8393321 (5%) and -2.7262514 (10%) for Model 3

C. GDP PER CAPITA

C1. TEN NEW MEMBER STATES – AVERAGE OF THE EMU

Regression results from the dataset tested against the average of the member states participating in the EMU reject group convergence in all cases. According to the ADF – GLS process (Table 13) only Poland and Slovakia reject the null hypothesis at 5% (when intercept and trend is included). We could state that according to the CADF process (Table 14) the null hypothesis is also rejected in the case of Poland only.

Table 13

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
ESTONIA	-1.3227956	YES	NO
SLOVAKIA	-3.4435644**	YES	YES
CZECH REP.	-1.1066808	YES	NO
CYPRUS	-0.59445374	YES	NO
LATVIA	-0.71293084	YES	NO
LITHUANIA	-0.56985356	YES	NO
HUNGARY	-0.44142900	YES	NO

POLAND	-4.6237744**	YES	YES
SLOVENIA	-0.84492320	YES	NO
MALTA	-1.0792011	YES	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 14

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
ESTONIA	**-5.4780602E-007** (-3.3298689)	YES	NO
SLOVAKIA	**-5.5999069E-007** (-3.3298689)	YES	NO
CZECH REP.	**-1.3051764**(-3.3298689)	YES	NO
CYPRUS	**-5.1436156E-008** (-3.3298689)	YES	NO
LATVIA	**-4.8477733E-009** (-3.3298689)	YES	NO
LITHUANIA	**-9.9761645E-010** (-3.3298689)	YES	NO
HUNGARY	**-1.3647070**(-3.3298689)	YES	NO
POLAND	**-4.6089889****(3.8315532)	YES	YES
SLOVENIA	**-1.1380253**(-3.3298689)	YES	NO
MALTA	**3.0989821E-007** (-3.3205477)	YES	NO
CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-0.89069654	-1.6971332	-1.8012933

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9523621 (1%), -1.6966313 (5%) and -1.5556656 (10%) for Model 1, -2.5556502 (1%), -2.3365858 (5%) and -2.2088922 (10%) for Model 2, -3.0945481 (1%), -2.8541055 (5%) and -2.7301052 (10%) for Model 3

C2. TEN NEW MEMBER STATES – AVERAGE OF THE EU 15

Regression results from the dataset tested against the average of the EU 15 reject group convergence in all cases. According to the ADF – GLS (Table 15) and CADF process (Table 16) none of the new member states reject the null hypothesis.

Table 15

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
ESTONIA	-0.26154399	YES	NO
SLOVAKIA	0.12206372	YES	NO
CZECH REP.	-0.91561678	YES	NO
CYPRUS	-0.37791892	YES	NO
LATVIA	0.023747080	YES	NO
LITHUANIA	-0.43126184	YES	NO
HUNGARY	-0.24460368	YES	NO
POLAND	0.52094985	YES	NO
SLOVENIA	-0.72723229	YES	NO
MALTA	-1.0030622	YES	YES

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 16

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
ESTONIA	**-1.7351348**(-3.3298689)	YES	NO
SLOVAKIA	**-0.77109534**(-3.3298689)	YES	NO
CZECH REP.	**-0.64791435**(-3.3298689)	YES	NO
CYPRUS	**-2.6400355**(-3.3298689)	YES	NO
LATVIA	**-2.5384914**(-3.3298689)	YES	NO
LITHUANIA	**-2.5516672**(-3.3298689)	YES	NO
HUNGARY	**-0.36108343**(-3.3298689)	YES	NO
POLAND	**2.8111293E-008**	YES	NO

	(-3.3298689)		
SLOVENIA	**-0.59678180**(-3.3298689)	YES	NO
MALTA	**4.1434921E-008** (-3.8476089)	YES	YES

CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-0.76954525	-2.1036381	-1.6331135

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9523621 (1%), -1.6966313 (5%) and -1.5556656 (10%) for Model 1, -2.5556502 (1%), -2.3365858 (5%) and -2.2088922 (10%) for Model 2, -3.0945481 (1%), -2.8541055 (5%) and -2.7301052 (10%) for Model 3

C3. TEN NEW MEMBER STATES – AVERAGE OF THE EU 25

Regression results from the dataset tested against the average of the EU 25 reject group convergence in all cases. According to the ADF – GLS process (Table 17) only Poland rejects the null hypothesis at 5% (when intercept and trend is included). But, we could state that according to the CADF process (Table 18) the null hypothesis is not rejected in any case of the new member states.

Table 17

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
ESTONIA	-1.2997735	YES	YES
SLOVAKIA	-1.4812271	YES	YES
CZECH REP.	0.51766668	YES	NO
CYPRUS	-2.5633336	YES	YES
LATVIA	-0.70332202	YES	YES
LITHUANIA	-1.0199023	YES	YES
HUNGARY	0.79244565	YES	NO
POLAND	-4.5150746**	YES	YES
SLOVENIA	1.0140960	YES	NO
MALTA	-1.0038149	YES	YES

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 18

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
ESTONIA	**8.7478190E-006** (-3.8476089)	YES	YES
SLOVAKIA	**-3.5427644**(-3.8476089)	YES	YES
CZECH REP.	**1.4462910E-006** (-3.3205477)	YES	NO
CYPRUS	**-3.2764372**(-3.8476089)	YES	YES
LATVIA	**-2.3389163**(-3.8476089)	YES	YES
LITHUANIA	**-2.6145260**(-3.8476089)	YES	YES
HUNGARY	**-1.4792705**(-3.3205477)	YES	NO
POLAND	**-1.4792705**(-3.3205477)	NO	NO
SLOVENIA	**-4.0396091**(-3.3205477)	YES	NO
MALTA	**-7.2898592E-008** (-3.8476089)	YES	YES
CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-0.76954762	-2.1036426	-1.6331076

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%
[2] The critical values referring to the CIPS Test are -1.9523621 (1%), -1.6966313 (5%) and -1.5556656 (10%) for Model 1, -2.5556502 (1%), -2.3365858 (5%) and -2.2088922 (10%) for Model 2, -3.0945481 (1%), -2.8541055 (5%) and -2.7301052 (10%) for Model 3

D. UNEMPLOYMENT

D1. TEN NEW MEMBER STATES – AVERAGE OF THE EMU

Regression results from the dataset tested against the average of the member states participating in EMU accept group convergence in the cases of Model 2 (Intercept / No trend) and Model 3 (Intercept & Trend) at 5%. According to the ADF – GLS process (Table 19) only Poland rejects the null hypothesis at 5%. But, we could state that according to the CADF process (Table 20) the null hypothesis is not rejected in any case of the new member states.

Table 19

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-0.070161985	YES	NO
MALTA	-0.47270808	YES	NO
CZECH REP.	-1.1433896	YES	NO
LATVIA	-1.0846438	YES	NO
POLAND	-2.0014400**	NO	NO
HUNGARY	-1.0474898	YES	NO
LITHUANIA	-1.5310181	YES	NO
SLOVAKIA	-1.5149833	YES	NO
ESTONIA	-1.9177428	NO	NO
SLOVENIA	-0.88615048	YES	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 20

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	**0.098469316**(-3.3418754)	YES	NO
MALTA	**1.0197149E-006** (-3.3418754)	YES	NO
CZECH REP.	**-0.30815138**(-3.3418754)	YES	NO
LATVIA	**-1.2879846**(-3.3418754)	YES	NO
POLAND	**-2.8762319E-008** (-2.6729589)	NO	NO
HUNGARY	**1.3796197E-008** (-3.3418754)	YES	NO
LITHUANIA	**2.2977985E-008** (-3.3418754)	YES	NO
SLOVAKIA	**1.6339327-007** (-3.3418754)	YES	NO

ESTONIA	**-1.2911245E-008** (-2.6729589)	NO	NO
SLOVENIA	**2.9817520E-009** (-3.3418754)	YES	NO

CIPS TEST	MODEL 1(NO INTERCEPT, NO TREND)	MODEL 2 (INTERCEPT, NO TREND)	MODEL 3 (INTERCEPT & TREND)
Statistic	-1.3456798	-2.5278128**	-2.8879144**

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9311275 (1%), -1.6946777 (5%) and -1.5511114 (10%) for Model 1, -2.5613546 (1%), -2.3301243 (5%) and -2.2045792 (10%) for Model 2, -3.0865466 (1%), -2.8516972 (5%) and -2.7342355 (10%) for Model 3

D2. TEN NEW MEMBER STATES – AVERAGE OF THE EU 25

Regression results from the dataset tested against the average of the EU 25 reject group convergence in all cases. According to the ADF – GLS process (Table 21) only Poland rejects the null hypothesis at 5%. We could also state that according to the CADF process (Table 22) the null hypothesis is not rejected in any case of the new member states.

Table 21

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-0.15235140	YES	NO
MALTA	-0.080749030	YES	NO
CZECH REP.	-0.87065088	YES	NO
LATVIA	-1.1496366	YES	NO
POLAND	-2.1772997**	NO	NO
HUNGARY	-0.95758422	NO	NO
LITHUANIA	-1.4078162	NO	NO
SLOVAKIA	-1.0958930	YES	NO
ESTONIA	-1.7508559	NO	NO
SLOVENIA	-1.4577791	NO	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 22

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	**4.6314404E-007** (-3.3418754)	YES	NO
MALTA	**3.4310827E-006** (-3.3418754)	YES	NO
CZECH REP.	**-0.57484378**(-3.3418754)	YES	NO
LATVIA	**-1.9520994**(-3.3418754)	YES	NO
POLAND	**-3.4541646E-007** (-2.6729589)	YES	NO
HUNGARY	**1.4668573E-008** (-2.6729589)	NO	NO
LITHUANIA	**0.000000**(-2.6729589)	NO	NO
SLOVAKIA	**-7.4582079E-008** (-3.3418754)	YES	NO
ESTONIA	**2.6413035E-007** (-2.6729589)	NO	NO
SLOVENIA	**-8.8299177E-009** (-2.6729589)	NO	NO
CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-0.99800043	-1.7458243	-2.1074979

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9311275 (1%), -1.6946777 (5%) and -1.5511114 (10%) for Model 1, -2.5613546 (1%), -2.3301243 (5%) and -2.2045792 (10%) for Model 2, -3.0865466 (1%), -2.8516972 (5%) and -2.7342355 (10%) for Model 3

D3. TEN NEW MEMBER STATES – AVERAGE OF THE EU 15

Regression results from the dataset tested against the average of the member states participating in EMU accept group convergence in the cases of Model 1 (No intercept / No trend) at 10%, Model 2 (Intercept / No trend) at 1%

and Model 3 (Intercept & Trend) at 5%. According to the ADF – GLS process (Table 23) only Poland rejects the null hypothesis at 5%. But, we could state that according to the CADF process (Table 24) the null hypothesis is not rejected in any case of the new member states.

Table 23

ADF - GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
CYPRUS	-1.5349647	YES	YES
MALTA	-0.25078018	YES	NO
CZECH REP.	-0.93378659	YES	NO
LATVIA	-1.0822748	YES	NO
POLAND	-2.0671360**	NO	NO
HUNGARY	-0.97948471	YES	NO
LITHUANIA	-1.5794788	YES	NO
SLOVAKIA	-1.4320872	YES	NO
ESTONIA	-1.7821015	NO	NO
SLOVENIA	-0.83342507	NO	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 24

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
CYPRUS	**0.25199862**(-3.8421782)	YES	YES
MALTA	**-2.3627324E-008** (-3.3418754)	YES	NO
CZECH REP.	**-0.57484378**(-3.3418754)	YES	NO
LATVIA	**-1.9520993**(-3.3418754)	YES	NO
POLAND	**1.5931722E-008** (-2.6729589)	NO	NO
HUNGARY	**-7.9377304E-009** (-3.3418754)	YES	NO
LITHUANIA	**1.3212157E-006** (-3.3418754)	YES	NO
SLOVAKIA	**-2.8901606E-008**	YES	NO

	(-3.3418754)		
ESTONIA	**1.8515667E-009** (-2.6729589)	NO	NO
SLOVENIA	**-2.3114156E-008** (-2.6729589)	NO	NO

CIPS TEST	MODEL 1(NO INTERCEPT, NO TREND)	MODEL 2 (INTERCEPT, NO TREND)	MODEL 3 (INTERCEPT & TREND)
Statistic	-1.6647051***	-2.5661344*	-2.9122298**

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%
[2] The critical values referring to the CIPS Test are -1.9311275 (1%), -1.6946777 (5%) and -1.5511114 (10%) for Model 1, -2.5613546 (1%), -2.3301243 (5%) and -2.2045792 (10%) for Model 2, -3.0865466 (1%), -2.8516972 (5%) and -2.7342355 (10%) for Model 3

E. INDUSTRIAL PRODUCTION

E1. NINE[10] NEW MEMBER STATES – AVERAGE OF THE EU 15

Regression results from the dataset tested against the average of the EU 15 accept group convergence in all cases. According to the ADF – GLS process (Table 25) Cyprus (including intercept and trend) and Slovenia reject the null hypothesis at 5%. We could state that according to the CADF process (Table 26) the null hypothesis is rejected for the cases of Slovenia, Slovakia and Latvia, but there is partial convergence for the industrial production index only for Lithuania and Cyprus.

Table 25

ADF-GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
HUNGARY	-0.65978605	YES	NO
POLAND	-0.99850843	YES	NO

[10] Malta was excluded because of the lack of observations

SLOVENIA	-2.6128464**	NO	NO
CZECH REP.	0.29751901	YES	NO
SLOVAKIA	0.36929750	NO	NO
LATVIA	-0.95299012	YES	NO
ESTONIA	-1.2674149	YES	YES
LITHUANIA	-0.95374519	YES	YES
CYPRUS	-2.8691080**	YES	YES

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 26

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
HUNGARY	**-0.36706966**(-2.9269600)	YES	NO
POLAND	**-1.3485801**(-2.9269600)	YES	NO
SLOVENIA	**-5.0075203****(3.3836182)	YES	YES
CZECH REP.	**0.29686341**(-2.9301673)	YES	NO
SLOVAKIA	**-4.9523580****(3.4327262)	YES	YES
LATVIA	**-4.1775080****(3.4076298)	YES	YES
ESTONIA	**-2.6186124**(-3.4715996)	YES	YES
LITHUANIA	**-3.5250480****(2.9794379)	NO	NO
CYPRUS	**-2.6368684****(2.2645364)	NO	NO
CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-3.3215633*	-3.5708864*	-4.0597485*

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%
[2] The critical values referring to the CIPS Test are -1.9791369 (1%), -1.7141036 (5%) and -1.5767725 (10%) for Model 1, -2.5654413 (1%), -2.3583845 (5%) and -2.2307396 (10%) for Model 2, -3.0803034 (1%), -2.8682351 (5%) and -2.7497155 (10%) for Model 3

E2. NINE NEW MEMBER STATES – AVERAGE OF THE EMU

Regression results from the dataset tested against the average of the member states participating in the EMU accept group convergence in the cases of Model 1 (No intercept / No trend) at 1% and Model 2 (Intercept / No trend) at 5%. According to the ADF – GLS process (Table 27) Cyprus and Slovenia reject the null hypothesis at 5%. We could state that according to the CADF process (Table 28) the null hypothesis is rejected for the cases of Slovenia, Slovakia and Latvia, but there is partial convergence for the industrial production index only for Lithuania and Cyprus.

Table 27

ADF-GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
HUNGARY	-0.744448381	YES	NO
POLAND	-1.1222418	YES	NO
SLOVENIA	-2.5944252**	NO	NO
CZECH REP.	0.061000147	YES	NO
SLOVAKIA	0.16771667	NO	NO
LATVIA	-1.0334004	YES	NO
ESTONIA	-1.1887920	YES	YES
LITHUANIA	-0.94790821	YES	YES
CYPRUS	-2.4077233**	NO	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 28

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
HUNGARY	**-0.36401336**(-2.9269600)	YES	NO
POLAND	**-1.4164280**(-2.9269600)	YES	NO
SLOVENIA	**-4.6952568****(3.3836182)	YES	YES
CZECH REP.	**0.19755952**(-2.9301673)	YES	NO
SLOVAKIA	**-5.1090688****(3.4327262)	YES	YES
LATVIA	**-4.0889466****(3.4076298)	YES	YES

ESTONIA	**-2.6896548**(-3.4715996)	YES	YES
LITHUANIA	**-3.6038626****(2.9794379)	NO	NO
CYPRUS	**-2.6147829****(2.2645364)	NO	NO

CIPS TEST	MODEL 1(NO INTERCEPT, NO TREND)	MODEL 2 (INTERCEPT, NO TREND)	MODEL 3 (INTERCEPT & TREND)
Statistic	-2.4052343*	-2.4026408**	-2.4286371

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

[2] The critical values referring to the CIPS Test are -1.9791369 (1%), -1.7141036 (5%) and -1.5767725 (10%) for Model 1, -2.5654413 (1%), -2.3583845 (5%) and -2.2307396 (10%) for Model 2, -3.0803034 (1%), -2.8682351 (5%) and -2.7497155 (10%) for Model 3

E3. NINE NEW MEMBER STATES – AVERAGE OF THE BEST THREE PERFORMING MEMBER STATES ACCORDING TO THE INDEX[11]

Regression results from the dataset tested against the average of the best three performing member states according to the index accept group convergence in the cases of Model 1 (No intercept / No trend) at 1% and Model 2 (Intercept / No trend) at 10%. According to the ADF – GLS process (Table 29) only Slovenia rejects the null hypothesis at 5% (including intercept and trend). We could state that according to the CADF process (Table 30) the null hypothesis is rejected for the cases of Slovenia, Czech Republic and Latvia.

Table 29

ADF-GLS TEST			
Countries	**Statistic**	**Intercept**	**Trend**
HUNGARY	-0.27354313	YES	NO
POLAND	-0.49157199	YES	NO
SLOVENIA	-3.1500139**	YES	YES
CZECH REP.	-0.60860523	YES	YES
SLOVAKIA	-1.3448975	YES	YES
LATVIA	-0.67347434	YES	NO
ESTONIA	-1.5643255	YES	YES
LITHUANIA	-1.0989435	YES	YES

[11] The three countries referred are the United Kingdom, France and Germany.

CYPRUS	-0.34361917	NO	NO

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%

Table 30

CADF TEST			
Countries	**Statistic[Critical Values (5%)]**	**Intercept**	**Trend**
HUNGARY	**-1.1268360**(-2.9269600)	YES	NO
POLAND	**-1.5946666**(-2.9269600)	YES	NO
SLOVENIA	**-5.2840736****(3.3836182)	YES	YES
CZECH REP.	**-3.4484215****(3.4327262)	YES	YES
SLOVAKIA	**-3.1089570**(-3.4327262)	YES	YES
LATVIA	**-4.4722454****(3.4076298)	YES	YES
ESTONIA	**-2.1112033**(-3.4715996)	YES	YES
LITHUANIA	**-2.3483914**(-3.4715996)	YES	YES
CYPRUS	**-1.9679690**(-2.2645364)	NO	NO
CIPS TEST	**MODEL 1(NO INTERCEPT, NO TREND)**	**MODEL 2 (INTERCEPT, NO TREND)**	**MODEL 3 (INTERCEPT & TREND)**
Statistic	-2.5335756*	-2.3119627***	-2.3084467

Notes: [1] *reject null at 1%, **reject null at 5%, ***reject null at 10%
[2] The critical values referring to the CIPS Test are -1.9791369 (1%), -1.7141036 (5%) and -1.5767725 (10%) for Model 1, -2.5654413 (1%), -2.3583845 (5%) and -2.2307396 (10%) for Model 2, -3.0803034 (1%), -2.8682351 (5%) and -2.7497155 (10%) for Model 3

ii. THE LL & IPS TESTS

A. LONG TERM INTEREST RATES

In the case of long term interest rates and as we can see from Tables 31, 32 and 33 there are signs of group convergence referred only to the LL Test and no signs of convergence referred to the IPS Test. We must also state, that the null hypothesis (as for LL Test) is being rejected in the case where we compare the ten new members of the EU with the EU 15 and the trend is included. Furthermore the null hypothesis is being rejected in all the comparisons when neither trend, nor intercept are included, but this can't be a strong sign for the existence of convergence.

A1. TEN NEW MEMBER STATES – AVERAGE OF THE EU 15

Table 31

LL TEST			
	Intercept	**Intercept & Trend**	**None**
Statistic (Prob.)	-1.49106 (0.0680)	-1.95958 (0.0250)	-3.72302 (0.0001)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	-0.98082 (0.1633)	-0.71224 (0.2382)	

A2. TEN NEW MEMBER STATES – AVERAGE OF THE BEST THREE PERFORMING MEMBER STATES ACCORDING TO THE MAASTRICHT CRITERIA

Table 32

LL TEST			
	Intercept	**Intercept & Trend**	**None**
Statistic (Prob.)	-1.40056 (0.0807)	-1.41087 (0.0791)	-3.59286 (0.0002)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	-1.20464 (0.1142)	-0.95597 (0.1695)	

A3. TEN NEW MEMBER STATES – AVERAGE OF EMU

Table 33

LL TEST			
	Intercept	**Intercept & Trend**	**None**
Statistic (Prob.)	-1.15799 (0.1234)	-1.45313 (0.0731)	-3.86384 (0.0001)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	-1.12232 (0.1309)	-1.10522 (0.1345)	

B. <u>INFLATION</u>

In the case of inflation (as we can see from Tables 34, 35 and 36), when we compare the ten new member states with the EMU and the EU 15 we accept convergence in all the aspects of LL and IPS Tests. When we compare the ten new member states with the best three performing member states according to the Maastricht criteria the null hypothesis is being rejected in both the IPS models but only when intercept and trend is not included in the case of LL Test.

B1. TEN NEW MEMBER STATES – AVERAGE OF THE EMU

Table 34

LL TEST

	Intercept	Intercept & Trend	None
Statistic (Prob.)	-15.7689 (0.0000)	-19.6918 (0.0000)	-16.8448 (0.0000)
IPS TEST			
	Intercept	Intercept & Trend	
Statistic (Prob.)	-21.1721 (0.0000)	-21.8686 (0.0000)	

B2. TEN NEW MEMBER STATES – AVERAGE OF THE BEST THREE PERFORMING MEMBER STATES ACCORDING TO THE MAASTRICHT CRITERIA

Table 35

LL TEST			
	Intercept	Intercept & Trend	None
Statistic (Prob.)	2.64595 (0.9959)	4.74132 (1.0000)	-12.6072 (0.0000)
IPS TEST			
	Intercept	Intercept & Trend	
Statistic (Prob.)	-16.2585 (0.0000)	-18.1812 (0.0000)	

B3. TEN NEW MEMBER STATES – AVERAGE OF THE EU 15

Table 36

LL TEST			
	Intercept	Intercept & Trend	None
Statistic (Prob.)	-16.0628 (0.0000)	-15.5568 (0.0000)	-16.7894 (0.0000)
IPS TEST			

	Intercept	Intercept & Trend
Statistic (Prob.)	-21.1701 (0.0000)	-18.7694 (0.0000)

C. <u>GDP PER CAPITA</u>

In the case of GDP per capita (as we can see from Tables 37, 38 and 39), when we compare the ten new member states with the EMU the null hypothesis is being rejected only in the model, where trend is not included of the LL Test. When we compare with the EU 15 the null hypothesis is being rejected in the models where trend is included (for both LL and IPS Tests) and where only intercept is included (as for LL Test). In addition, when we compare with EU 25 the null hypothesis is being rejected only in the IPS Test model where trend is included.

C1. TEN NEW MEMBER STATES – AVERAGE OF THE EMU

Table 37

LL TEST			
	Intercept	**Intercept & Trend**	**None**
Statistic (Prob.)	-6.61445 (0.0000)	1.01487 (0.8449)	3.15986 (0.9992)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	-2.00887 (0.0223)	2.08655 (0.9815)	

C2. TEN NEW MEMBER STATES – AVERAGE OF THE EU 15

Table 38

LL TEST

	Intercept	Intercept & Trend	None
Statistic (Prob.)	-4.58471 (0.0000)	-7.17287 (0.0000)	6.39268 (1.0000)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	-0.68519 (0.2466)	-5.00977 (0.0000)	

C3. TEN NEW MEMBER STATES – AVERAGE OF THE EU 25

Table 39

LL TEST			
	Intercept	**Intercept & Trend**	**None**
Statistic (Prob.)	1.92979 (0.9732)	-1.18291 (0.1184)	4.90646 (1.0000)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	2.57033 (0.9949)	-5.29049 (0.0000)	

D. UNEMPLOYMENT

In the case of unemployment (as we can see from Tables 40, 41 and 42), when we compare the ten new member states with the EMU, the EU 25 and the EU 15 the null hypothesis is being rejected in the model, where only intercept is included of the LL Test and IPS Test and in the LL Test model where no intercept, nor trend is included. When we compare with the EU 15 the null hypothesis is being rejected in the models where trend is included (for both LL and IPS Tests) and where only intercept is included (as for LL Test). In addition, when we compare with EU 25 the null hypothesis is being rejected in the IPS Test model where trend is included.

D1. TEN NEW MEMBER STATES – AVERAGE OF THE EMU

Table 40

LL TEST			
	Intercept	**Intercept & Trend**	**None**
Statistic (Prob.)	-3.24105 (0.0006)	-1.29972 (0.0968)	-3.36741 (0.0004)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	-3.41582 (0.0003)	0.94230 (0.8270)	

D2. TEN NEW MEMBER STATES – AVERAGE OF THE EU 25

Table 41

LL TEST			
	Intercept	**Intercept & Trend**	**None**
Statistic (Prob.)	-2.84217 (0.0022)	0.38027 (0.6481)	-2.33134 (0.0099)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	-2.71381 (0.0033)	1.80424 (0.9644)	

D3. TEN NEW MEMBER STATES – AVERAGE OF THE EU 15

Table 42

LL TEST

	Intercept	Intercept & Trend	None
Statistic (Prob.)	-3.08872 (0.0010)	-1.09518 (0.1367)	-2.95136 (0.0016)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	-3.19562 (0.0007)	0.85564 (0.8039)	

E. INDUSTRIAL PRODUCTION

In the case of industrial production (as we can see from Tables 43, 44 and 45), there are no signs of convergence in all the aspects of the LL and IPS Tests.

E1. NINE[12] NEW MEMBER STATES – AVERAGE OF THE EU 15

Table 43

LL TEST			
	Intercept	**Intercept & Trend**	**None**
Statistic (Prob.)	5.90941 (1.0000)	0.68797 (0.7543)	3.09887 (0.9990)
IPS TEST			
	Intercept	**Intercept & Trend**	
Statistic (Prob.)	5.66031 (1.0000)	1.41597 (0.9216)	

E2. NINE NEW MEMBER STATES – AVERAGE OF THE EMU

Table 44

LL TEST			
	Intercept	**Intercept &**	**None**

[12] Malta was excluded because of the lack of observations

		Trend	
Statistic (Prob.)	5.39623 (1.0000)	0.39891 (0.6550)	2.62754 (0.9957)
IPS TEST			
	Intercept	Intercept & Trend	
Statistic (Prob.)	5.09157 (1.0000)	1.34218 (0.9102)	

E3. NINE NEW MEMBER STATES – AVERAGE OF THE BEST THREE PERFORMING MEMBER STATES ACCORDING TO THE INDEX

Table 45

LL TEST			
	Intercept	Intercept & Trend	None
Statistic (Prob.)	6.83187 (1.0000)	-0.27783 (0.3906)	3.33406 (0.9996)
IPS TEST			
	Intercept	Intercept & Trend	
Statistic (Prob.)	7.77158 (1.0000)	0.71910 (0.7640)	

iii. COMPARISON OF THE TESTS

In the examination of the Long Term Interest Rates index we have to state that the results are almost similar and show that there is no group convergence among the new and the rest member states of the EU. The only time that signs of convergence were revealed was in the comparison of the ten new members with the average of the EU 15, in the case of the LL Test when trend is included. Furthermore, we have to say that in the case of the CADF Test only Poland presented signs of partial convergence.

In the examination of the Inflation index the results from all the tests were similar, except from one case, and showed the existence of group convergence among the new and the rest member states of the EU. The only exception was when we compared the new members with the average of the best three performing countries according to the Maastricht criteria and the LL Test showed no convergence. In addition, we have to say that in the case of the CADF Test when we compared the new member states with the average of the EMU there were signs of partial convergence for Cyprus, Hungary, Estonia, Slovenia and Slovakia. When we compared the new members with the average of the best three performing countries according to the Maastricht criteria there were signs of partial convergence for Cyprus, Hungary, Slovakia, Lithuania and Malta and when we compared the new members with the average of the EU 15 there were signs of partial convergence for Cyprus, Estonia, Lithuania, Latvia and Malta.

In the examination of the GDP Per Capita index the ADF – GLS, CADF and CIPS Tests denied the existence of any group or partial convergence among the new and the rest member states of the EU. On the other hand, the observation of the LL and IPS Tests leads to the acceptance of convergence in three cases. The first one is when we compare the ten new members with the average of the EMU and the LL Test shows convergence when trend is not included, the second one is when we compare the new members with the average of EU 15 and the LL and the IPS Tests show convergence (with or without trend and with trend respectively) and the third one is when we compare the new members with the average of the EU 25 and the IPS Test accepts convergence when trend is included.

In the examination of Unemployment index the ADF – GLS, CADF and CIPS Tests show signs of convergence at 5% level of significance when we compare the new members with the average of the EMU and EU 15. On the other hand, the observation of the LL and IPS Tests leads to the acceptance of convergence in all the three comparisons when trend is not included.

In the examination of Industrial Production index the observation of the LL and IPS Tests leads to the denial of convergence in all cases. On the other hand, the ADF – GLS, CADF and CIPS Tests show signs of group convergence when we compare the new members with the average of the EU15 and signs of convergence (but when trend is not included) when we compare the new members with the average of the EMU and the average of the three best performing countries according to the index. Furthermore, when we compare with the average of the EU 15 and the EMU there is partial convergence for Lithuania and Cyprus and when we compare with the average of the three best performing countries according to the index there is partial convergence for Slovenia, Czech Republic and Latvia.

VII. <u>CONCLUSIONS</u>

In the present study, we presented an analysis of panel unit root tests concerning the relation among the ten New Member States[13] of the European Union and the rest countries of the EU in order to examine the existence or not of convergence among them. For this purpose we used new econometric techniques and compared the results with those of former tests which's econometric techniques didn't take into account some important parameters of the statistical facts.

This study contributes to the ongoing research in this field by comparing different approaches and by introducing more analytically the use of Pesaran' s (2005) test, where the error term is assumed to have an unobserved one – common – factor structure accounting for cross – sectional correlation and an idiosyncratic component.

The variables under examination are the Industrial Production, Inflation, Long Term Interest Rates, Unemployment and GDP per capita. The ten New

[13] The ten countries referred are Cyprus, Malta, Czech Republic, Slovakia, Slovenia, Hungary, Latvia, Lithuania, Estonia and Poland.

Member States of the European Union are tested against the average of the three best performing EU countries according to the Maastricht criteria, the average of EU 15, the average of EU 25 and the average of the three best performing countries according to the index. All the differentials were computed as the difference between an individual index rate and the average of a whole group at time t.

The results showed clearly the existence of group convergence only in the case of inflation where all the tests had similar results. Furthermore, according to the tests used there are no signs of convergence concerning the long term interest rates and the GDP per capita indices (except from some cases of LL and IPS Tests). In addition, we have ended with many interesting results concerning unemployment and industrial production which as a whole lead us to the conclusion that in a few cases there are some signs of convergence.

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