Evaluation of the Income Convergence Hypothesis in Ten New Members of the European Union[*]. A Panel Unit Root Approach

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Summary: In this paper, different tests of unit root in panel data are implemented for studying real economic convergence and catching-up in ten new members of European Union (EU) toward average EU per capita income and average of ancient members. We used the "EuroStat" quarterly real per capita output data on the period 1995 - 2005. The results support existence of absolute convergence and catching-up processes in sample countries towards EU standards.

Key words: Growth, European Union, Convergence, Panel unit root, Catching-up

JEL: C12, C33, O47, O52

Introduction

In 2004 ten new countries entered in European Union (EU). The common characteristic of these new members is that their per capita output is below the ancient fifteen member's average (Graph. 1).

During the past decade, the point of reference, to which most of these countries have been targeting their developmental goals, is Western Europe and in particular EU macroeconomic performances. In other words, one of the strategic policy goals of these economies is to achieve sustained and high rates of economic growth that would enable them to catch up with - to converge upon - the living standards of the developed market economies of Western Europe.

The focus of this paper, by using panel unit root tests, is to assess whether or not economic convergence and catching-up, has been a characteristic of economic growth in ten new members over the last decade.

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There are limited studies that examine real convergence prospects and existence of the catching-up process for these countries. While most of these studies do not provide comprehensive evidence on the type (nominal or real) of convergence. To our knowledge, more focus has been done on nominal convergence (For example see studies by Richards and Tersman (1996), Janachoa (2000), Brada and Kutan (2001) and Backe et al (2002)). Kocenda (2001) use panel unit root technique to study the convergence of macroeconomic fundamentals in transition economies. He finds considerable real convergence between these countries. Kutan and Yigit (2004) used IPS[1] (2003) panel unit root technique for studying real and nominal convergence between ten EU candidate countries. They find a strong evidence of price level convergence and lower of real convergence. Kocenda (2001) and Kutan and Yigit (2004) focus on real and nominal convergence, but only among transition economies; they find no convergence of these economies to those of the EU. Estrin et al (2001) test the convergence hypothesis in transition economies' per capita income to that of the EU average. They find none of the countries exhibited convergence with EU members for the period 1970-1998. Brada et al (2003) use industrial output as a proxy for real convergence. They find evidence of real sector convergence between some of the candidate countries and EU.

Graph 1. *Logarithm of Country per Capita Income for the Period 1995-2005 for Ten New Members of EU with Average of EU-25 and EU-15.*
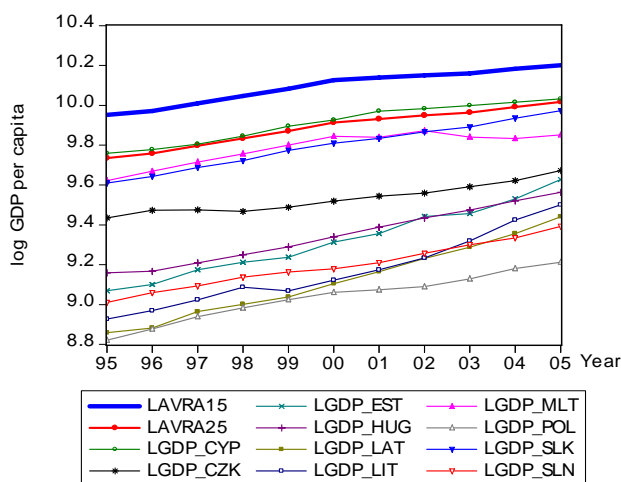
Source: The Penn World Table (Mark 6.2).

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[1] IM, Pesaran and Shin (2003).

This paper is organized as follows. Section 2 provides definitions of convergence and different evaluation methods of convergence hypothesis by focusing on panel unit root test methods. In section 3, we present a brief overview of panel unit root tests. Section 4 reports data definition and empirical results. Section 5 concludes.

1.   Definition of Convergence and Testing Methodology

The primary definition of convergence used in the modern growth literatures, is based on the relationship between initial income and subsequent growth. The basic idea is that two countries exhibit convergence if the one with lower initial income grows faster than the other (β-convergence). There is absolute convergence if countries per capita income converges to a steady-state value, irrespective of other conditions within a given country. Conditional convergence, on the other hand, allows each country to have a different level of per capita income towards which it is converging. Absolute convergence implies a tendency towards the equalization of per capita incomes (catching-up process).

The classical convergence approach consists in fitting cross-country regressions, relating the average growth rate of per capita income over some time period to initial per capita income and country characteristics (Barro and Sala-i-Martin (1992)). Then, convergence is said to hold if a negative correlation is found between the average growth rate and the initial income (Graph. 2). Friedman (1992) and Quah (1993) criticize cross-country growth regression on the basis of Galton's fallacy and Quah (1996) shows that the cross-sectional result of speed of convergence is a statistical illusion[2 and 3].

An alternative approach for testing convergence hypothesis is using time series econometric methods and focusing on direct evaluation of the persistence of transitivity of per capita income differences between economies (see Bernard and Durlauf (1995, 1996), Carlino and Mills (1993), Evans (1996), Evans and Karras (1996), Li and Papel (1999) for different applications of this approach).

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[2] See Islam (2003) for a more general discussion.

[3] In our case, a further problem that renders the cross-country approach inapplicable is that it requires many observations (countries), so the case with limited observations would not produce very powerful results.

Graph 2. *Average Growth Rate for the Period 1995-2005 vs. log of Initial per Capita Income for Ten New Members of EU with Regression Line. (Yearly Data)*
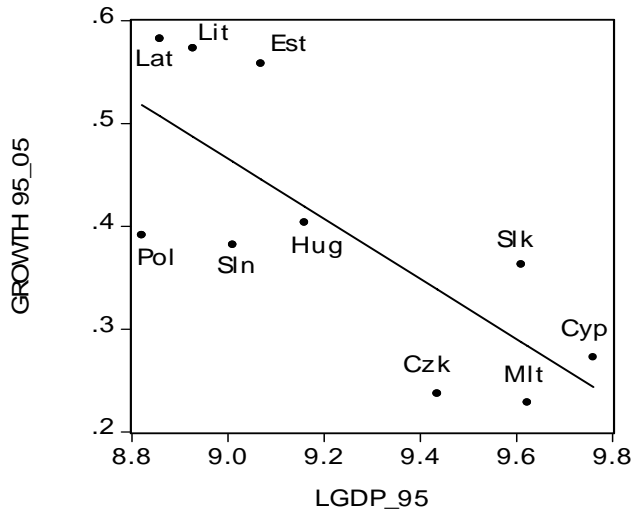
Source: The Penn World Table (Mark 6.2).

According this method, tests for convergence require cross-country per capita out-put differences to be stationary and non stationary difference is symptom of divergence. In the case of two economies, this definition of convergence is relatively unambiguous, but in the case of more than two economies, this is not so clear. In a multi-country situation, some researchers have taken deviations from a reference economy as the measure of convergence (In most case, the richer or the more developed country of the group is chosen such as reference country (Oxley and Greasley (1999)).

Other researchers have taken deviations from the sample average (Carlino and mills (1993, Ben David (1996)).

Given the time span and the limit of the available data, there is much evidence that methods of testing the unit root hypothesis, such as the ADF tests, have serious power problems[4]. One of the solutions for this problem is "increasing the sample size". Since the power of any test depends on the available information (sample size), and as Evans (1996) suggests, "exploiting both the time series and the cross section information included in the data of the per capita income is necessary to evaluate the convergence hypothesis", extra information for improving the performance of the unit root tests, can be gained by using panel data, i.e. by combining time series and cross sectional observations. The absolute convergence hypothesis requires panel unit root tests with no fixed in-

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[4] See Maddala and Kim (1998), Ch. 4.

dividual effects and the conditional convergence use panel unit root tests with fixed individual effects.

2. A Brief Overview of Panel Unit Root Tests

In this section, we briefly review some panel unit root tests. In general, unit root tests differ in whether the null is a unit root, like the Dickey Fuller test, or stationarity, like KPSS type tests; and whether serial correlation is removed parametrically, like ADF tests, or non-parametrically like Phillips-Perron testes[5].

Let us consider the Augmented Dickey Fuller (ADF) regression:

$$\Delta x_{i,t} = a_i + (\rho_i - 1)x_{i,t-1} + \sum_{z=1}^{L_i} \beta_{i,z}\Delta x_{i,t-z} + \varepsilon_{i,t}$$

or

$$\Delta x_{i,t} = a_i + b_i x_{i,t-1} + \sum_{z=1}^{L_i} \beta_{i,z}\Delta x_{i,t-z} + \varepsilon_{i,t} \quad (2)$$

$i=1,2,\ldots,$N and $t=1,2,\ldots,$T.

The unit root hypothesis, $\rho_i = 1$, implies that $b_i=0$, for all i. Given T sufficiently large, this can be tested by using the t ratio for b_i and the non-standard critical values.

Levin and Lin (1993) and Levin, Lin and Chu (2002), [LLC], consider a model in which the coefficients are restricted to be homogeneous across all units of the panel ($b_i = b \quad \forall i$).

$$\Delta x_{i,t} = a_i + b x_{i,t-1} + \sum_{z=1}^{L_i} \beta_z \Delta x_{i,t-z} + \varepsilon_{i,t}$$

Under condition that N and T go to infinity with $\dfrac{\sqrt{N}}{T}$ going to zero, they devise a test for the null H_0: $b=0$, against the alternative $b \prec 0$ for all $i=1,\ldots,$N. The assumption of homogeneity ($b_i = b \quad \forall i$) is clearly restrictive and subject to the possible homogeneity bias of the fixed effect estimator (Maddala and Wu (1999)). Im, Pesaran and Shin (1997, 2003), [IPS], allow to b_i to differ; they use the estimates of (2) directly calculate the average ADF statistics (t ratio for b_i) and provide simulated test statistics for the mean and variance of the average t ratio, which allows testing of the hypothesis H_0: $b_i=0$, for all i against the alternative $b_i \prec 0$ for some i. Maddala and Wu (1999), [MW], agree

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[5] See Smith and Fuertes (2004) for a more general discussion on the panel unit root tests.

that heterogeneous alternative is better but argue that averaging the ADF statistics is not the most efficient way to use the information. They propose a test statistics, based on a suggestion of Fischer which is $-2\sum_{i=1}^{N}(\ln p_i)$, where p_i is the *p value* for the ith test. Under the null hypothesis of $p_i=0$ for all *i,* this is distributed $X^2_{(2N)}$.

Their simulation suggests that, in a variety of situations, the MW's Fisher test is more powerful than the IPS test which is more powerful than the LLC test. Choi (1999) finds that the LLC, IPS and MW tests suffer from a dramatic loss of power, if a linear time trend is included in the model.

In this paper we focus on using these three tests for testing convergence hypothesis.

3. Data and Empirical Results of the Convergence and Catching-Up Test

Let $y_{i;t}$, *i*= 1, …, N and *t*= 1, …,T, be the log real GDP per capita in country *i* at time *t*, and $\bar{y}_t$ be the average EU real per capita GDP at time *t* (in log). As noted above, testing convergence hypothesis comes to testing whether the series $(y_{i,t} - \bar{y}_t)$ for N countries exhibit or not a unit root (Evans and Karras (1996)). Because, if $y_{i;t}$ converge to $\bar{y}_t$, it must be that $(y_{i,t} - \bar{y}_t)$ contains only non-permanent shocks (because this implies that the deviations of $y_{i;t}$ and $\bar{y}_t$ will vanish in the long-run) and the simplest case of non-persistence of shocks consists of $(y_{i,t} - \bar{y}_t)$ being an I(0) series.

Then, to test the convergence hypothesis, we use the following model:

$$\Delta(y_{i,t} - \bar{y}_t) = a_i + b_i(y_{i,t-1} - \bar{y}_{t-1}) + \sum_{z=1}^{L_i} \beta_{i,z}\Delta(y_{i,t-z} - \bar{y}_{t-z}) + \varepsilon_{i,t}$$

We use EuroStat quarterly per capita GDP (seasonally adjusted in terms of *Euro* per capita on 1995 market prices and exchange rates) for the new members of EU from 1995 to 2005[6].

Table (1) and table (2) report the LLC, MW and IPS test results for conditional convergence of nine countries.

Looking at the results, in sum, we can not reject the null hypothesis of unit root in this panel of countries at 5% level[7]. In other words, conditional convergence is rejected for these countries in this period.

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[6] We exclude Malta in the estimation, because the data relating to Malta is non available for our period. Thus our sample will be made up only of nine countries.
[7] In table (1) the null is rejected only by one of the three tests (MW test), then, in sum, we can not reject the "unit root" of the series.

Table 1. Panel Unit Root Test Results for Conditional Convergence Hypothesis
(towards Average EU-25 per Capita Income)

Method	Null Hypothesis	Statistic	Probability	Observation
Levin, Lin and Chu	Unit root (assumes common unit root process)	-1.405	0.08	372
Im, Pesaran and Shin	Unit root (assumes individual unit root process)	-0.794	0.214	372
MW Fisher chi-square	Unit root (assumes individual unit root process)	40.893	0.001***	372

The optimal lag length has been estimated by the AIC criteria.
*** indicates significance at 99% confidence level.

Table 2. Panel Unit Root Test Results for Conditional Convergence Hypothesis
(towards Average EU-15 per Capita Income).

Method	Null Hypothesis	Statistic	Probability	Observation
Levin, Lin and Chu	Unit root (assumes common unit root process)	0.104	0.541	377
Im, Pesaran and Shin	Unit root (assumes individual unit root process)	1.378	0.916	377
MW Fisher chi-square	Unit root (assumes individual unit root process)	13.739	0.746	377

The optimal lag length has been estimated by the AIC criteria.

In the next step, since the conditional convergence hypothesis is rejected, we apply panel unit root tests without intercept for examining the absolute convergence hypothesis. The results of LLC and MW tests are presented in tables (3) and (4)[8]. The null hypothesis of unit root can be rejected at 5% level. In other words, we observe significant absolute real convergence toward average per capita GDP of EU-15 and EU-25 member states and catching-up process in our sample.

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[8] In this step we can not use IPS test because this test needs a "constant term".

Table 3. Panel Unit Root Test Results: Absolute Convergence towards Average EU-25 per Capita Income

Method	Null Hypothesis	Statistic	Probability	Observation
Levin, Lin and Chu	Unit root (assumes common unit root process)	-3.166	0.001***	381
MW Fisher chi-square	Unit root (assumes individual unit root process)	33.738	0.014**	389

The optimal lag length has been estimated by the AIC criteria.
** (***) indicates significance at 95% (99%) confidence level.

Table 4. Panel Unit Root Test Results: Absolute Convergence towards Average EU-15 per Capita Income

Method	Null Hypothesis	Statistic	Probability	Observation
Levin, Lin and Chu	Unit root (assumes common unit root process)	-4.934	0.000***	377
MW Fisher chi-square	Unit root (assumes individual unit root process)	57.206	0.000***	377

The optimal lag length has been estimated by the AIC criteria.
*** indicates significance at 99% confidence level.

Conclusion

In this paper we have tested real convergence of the ten new member's economies to the EU average income by using quarterly real GDP per capita data from 1995 to 2005.

Application of the unit root tests for testing absolute convergence and catching-up make it possible to conclude that the new members of EU tend to converge towards the EU average income. By contrast, the conditional convergence hypothesis is rejected between these countries.

The existence of catching-up processes in ten new members of EU is a prove that there is a certain harmony, despite economic and financial diversity among countries. These results can be explained by the fact that these countries are confronting the same policy challenges: for eight of them, transition from central planning to market economics, reforming public finance, intensifying privatisation and deregulation, strengthening human resources, improving the

functioning of labour market, enhancing domestic and foreign investment and liberalizing external trade and payments.

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