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## **Testing for Stochastic Convergence: The Case of the Cohesion Countries**

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**Abstract:**

*In this paper, the issue of income convergence in the EU-15 is addressed. Our data set consists of annual log real GDP per capita for the four Cohesion countries and cover the period 1950-2007.*

*The empirical part of the paper applies complementary the Bernard and Durlauf (1995) and Nahar and Inder (2002) methodology.*

*Applying the former, we failed to accept the hypothesis of stochastic convergence of real per capita GDP of the four Cohesion countries towards the EU-15 average.*

*In contrast, the Nahar and Inder test provides strong evidence of convergence for Spain, Portugal and Greece.*

**Keywords:** *Times series, stochastic convergence, EU-15, cohesion countries.*

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## 1. Introduction

In this paper, the crucial issue of income convergence is addressed, in the context of the four cohesion EU members (whose Gross National Income falls below 90% of the EU average). Ireland and Portugal, together with Spain and Greece, form the group of ‘cohesion’ countries within the European Union. This definition was established with the enlargement of the EEC to southern Europe, in 1981 and 1986, and was born out of the consideration that the integration into the Communities of the peripheral countries would imply certain measures to take into account structural and economic differentials in development levels (Lains, 2006). In terms of GDP per capita, all four countries fall below 75% of the EU average and contain some of the poorest regions in the Union itself. In addition to the existing economic disparities, all four countries are on the periphery of the Union, while two of the four, Ireland and Greece, are geographically remote (Thalassinos *et al.*, 2015b; Chronis and Zombanakis, 2016).

All four are classified, for purposes of Structural Fund aid, as lagging behind the rest of the Union, in terms of development and as such qualify for higher rates of economic aid. The growth experience of the four countries seems to be different (Thalassinos and Dafnos, 2015; Thalassinos *et al.*, 2015a). Their long-term growth performance is associated with differences in the technical progress, the performance of the labor market, the level of education, the FDI and its share in manufacturing and service sectors, the tax regime for foreign profit earnings, etc.

The empirical part of the paper applies two different tests of convergence. In a first step, the Bernard and Durlauf (1995) methodology is used, according to which the existence of a Unit Root in the series of the differences between per capita GDP of a country and the average per capita GDP of EU-15 implies divergence. In a second step, a new procedure proposed by Nahar and Inder (2002) is applied.

The rest of the paper is organized as follows. Section 2 briefly discusses the convergence hypothesis and reviews basic models applied in the relevant literature. Section 3 deals with the data set and gives a graphical description of the development in real GDP per capita in the cohesion countries. The empirical results are presented in the Section 4, while some concluding comments are made in the final section.

## 2. The Convergence Hypothesis

In the literature researchers define the convergence hypothesis in several ways. Following Sala-i-Martin (1996) “*there is absolute  $\beta$ -convergence if poor economies tend to grow faster than rich ones*”.

Empirical tests of convergence fall into two categories. The first class of tests studies the cross-section correlation between initial per capita output levels and subsequent

growth rates for a group of countries. A negative correlation is taken as evidence of convergence as it implies that, on average, countries with low per capita initial incomes are growing faster than those with high initial per capita incomes.

Let us consider the following model:

$$g_{i,t+T} = a + \beta y_{i,t} + \varepsilon_{i,t} \quad i = 1, 2, \dots, N \quad (1)$$

where  $y_{i,t}$  is the logarithm of per capita output for economy  $i = 1, 2, \dots, N$  during period  $t$ , and  $g_{i,t+T} = (y_{i,T} - y_{i,t}) / (T - t)$  is economy  $i$ 's annual growth rate of GDP between  $t$  and  $T$ . A negative value for  $\beta$  provides evidence in favour of absolute  $\beta$ -convergence, whereas  $\beta \geq 0$  supports non-convergence. See, for example Baumol (1986), De Long (1988), Barro (1991), and Barro and Sala-i-Martin, (1992).

A second set of tests has examined the long-run behavior of differences in per capita output across countries. These tests interpret convergence to mean that these differences are always transitory in the sense that long-run forecasts of the difference between any pair of countries converges to zero as the forecast horizon grows. Convergence, according to this approach, has the strong implication that output differences between two economies cannot contain unit roots. Bernard and Durlauf (1995, 1996) state that countries  $i$  and  $j$  converge if  $y_{i,t} - y_{j,t}$  is a mean zero stationary process<sup>4</sup>.

A new procedure is proposed by Nahar and Inder (2002)<sup>5</sup>. The test is based on a regression of the squared demeaned GDP per capita (the per capita output gap between each country and the group average) on a time trend  $t$ , such as:

$$w_{i,t} = f(t) + u_{i,t} = \theta_0 + \theta_1 t + \theta_2 t^2 + \dots + \theta_{k-1} t^{k-1} + \theta_k t^k + u_{i,t} \quad (2)$$

where,  $w_{i,t} = (y_{i,t} - \bar{y}_t)^2$  (with  $y_{i,t}$  being the real per capita GDP of the individual country and  $\bar{y}_t$  is the group average). For convergence to hold,  $w_{i,t}$  should always be getting closer to zero; the rate of change in  $w_{i,t}$  with respect to time would be negative, i.e.

$$w_{i,t} > 0, \quad (\partial/\partial_t)w_{i,t} < 0 \quad \text{is consistent with } w_{i,t} \rightarrow 0 \text{ as } n \rightarrow \infty \quad (3)$$

<sup>4</sup>In general, time series approaches have rejected convergence (Bernard and Durlauf, 1995; Pesaran, 2004).

<sup>5</sup>Nahar and Inder (2002) find quite strong evidence of convergence of the output of all OECD countries except Norway to the mean of the group, over the period 1950-1998. See also Bentzen, 2005; Galanopoulos et al 2006; Giles and Feng, 2005.

In that case, for convergence to hold, the average slope of the estimated equation has to be positive and significant. The average slope in compact form may be written as:

$$\frac{1}{T} \sum_{t=1}^T \frac{\partial}{\partial t} w_{i,t} = \theta_1 + \theta_2 r_2 + \dots + \theta_{k-1} r_{k-1} + \theta_k r_k = r' \theta, \quad (4)$$

where,

$$r_k = \frac{k}{T} \sum_{t=1}^T t^{k-1} \quad \theta = [\theta_0 \ \theta_1 \ \dots \ \theta_{k-1} \ \theta_k]', \quad r' = [0 \ 1 \ r_2 \ \dots \ r_{k-1} \ r_k]$$

and

In that case, when testing for convergence the null hypothesis of no-convergence is:

$$\begin{aligned} H_0: r' \theta &\geq 0 \text{ against the alternative hypothesis} \\ H_1: r' \theta &< 0 \end{aligned} \quad (5)$$

The  $r$ -vector can easily be calculated from the trend values and the  $\theta$ -parameters are estimated from Equation (2) where the lag length is determined by e.g., the Akaike Information Criterion (AIC). Finally, a Wald-test is performed concerning the restrictions on  $\theta$  as stated in the  $H_0$  hypothesis with rejection of the null hypothesis interpreted in favour of convergence.

### 3. A Short Economic History of the Cohesion Countries' Economy

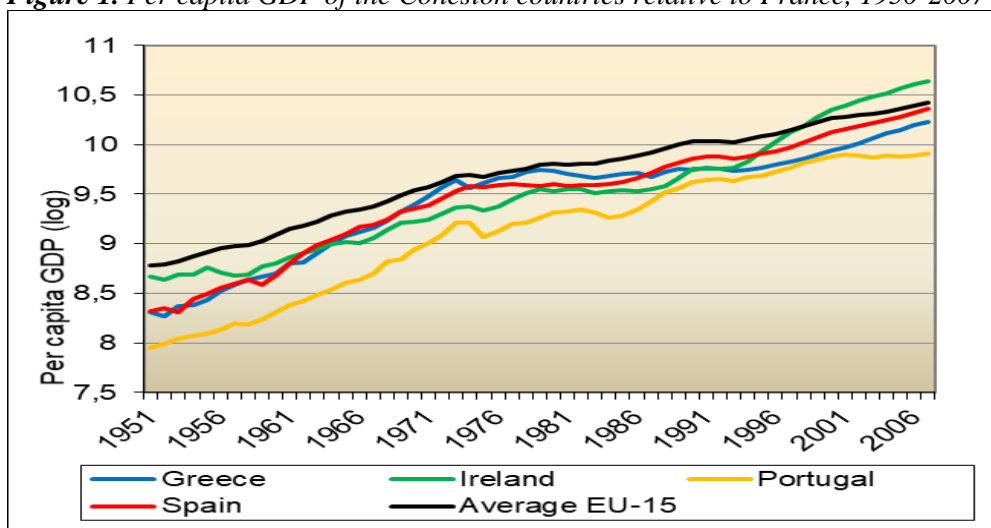
We obtained our data set from the Penn World Tables 6.3 of Heston *et al.* (2009). It consists of annual log real GDP per capita for the four cohesion countries and cover the period 1950-2007 (Figure 1). In the period 1950-1973, the three southern countries were the fastest growing economies in Western Europe, with real GDP per capita rising at an average annual rate close to 7 per cent, whereas Irish growth, although historically high, remained behind, at 3.7 percent (Lains, 2006). Performance in the period after 1973 was strongly influenced by the two oil shocks and by macroeconomic adjustment policies. Over the period 1973-1990 in Spain, performance was particularly poor compared with the previous period, while Greece fell back. In Portugal and notably Ireland, however, it was rather better. In fact, it is in this period that Ireland started to achieve the highest per capita GDP growth in Western Europe.

In the period 1990-2007, there were only slight gains in relative incomes in Spain and Greece, while the performance of Portugal is less satisfactory since 2000. In Ireland, the growth of real GDP per capita accelerated to an average annual rate of 6.6 per cent until 1998 and to a lower level during the last decade. Furthermore, three out of these four countries, experienced acceleration in growth after their accession, compared to their pre-accession growth trend (Figure 1). The Irish 5-year average growth rate after accession in 1973 was almost 1 per cent. Spain and Portugal experienced respectively a 3.6 per cent and 5.6 per cent increase in average

growth rates, after joining the EU in 1986. On the other hand, Greece's growth after 1981 was 3.2 per cent lower than before joining the EU (Brodzicki, 2003).

All three Southern countries, benefited from the restoration of democracy in the mid-1970s, but faced pressures for income redistribution that led to inflation, slower growth and balance of payments problems during 1975-84. However, whereas Portugal and Spain began adapting their institutions and policies in anticipation of EU (EC, then) entry, Greece delayed. Even after EU accession, Greece went for long grace periods, not rapid liberalization, and opted for an accommodating crawling peg rather than the ERM. Unlike Portugal and Spain, it used EU transfers to delay rather than promote fiscal and structural adjustment. (Alogoskoufis, 1995). The turning point for Spain, Portugal and Ireland came in the mid to late 1980s. Greece returned to consistent convergence only in the early 1990s (Barry, 2003).

**Figure 1.** Per capita GDP of the Cohesion countries relative to France, 1950-2007



*Source:* Authors' calculations.

Furthermore, Figure 1 shows clearly that, until 1990, the convergence process of these countries, with the EU average level, was weak. Secondly, it describes how much the paths of convergence of these countries have diverged. On one side is Ireland, with its extremely rapid convergence with the EU and, on the other are Spain, Greece and Portugal with a slower convergence process. Comparing with their starting levels in 1950, all four countries can be said to have succeeded in catching-up, at least to some extent, to the EU average. However, the experience of the four countries in this period was very different (Martin and Sanz, 2003).

At the start of the sample period, Greece's per capita GDP is lower of that of EU average, but during the period of high convergence in Europe, from 1950 to 1973, the gap had been quickly narrowing. According to Alogoskoufis (1995), the regime

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before 1974 was characterized by commitment and coordination mechanism that led to high investment and growth but low inflation, fostering private investment by guaranteeing property rights in the constitution and the law, by the tax laws and their implementation, and by direct state control of labour unions. These mechanisms guaranteed high returns to capital accumulation. The post-1974 regime created distortions that not only discouraged private investment, but also caused a reduction in the social return on the investment actually undertaken. These distortions included the financial system, fiscal policy, the labour market, the 'natural' monopolies and public enterprises, public administration, investment grants and EC transfers (Alogoskoufis, 1995). However, it looks that after 1998 a catch up took place. Only over the course of the 1990s, convergence performance improved, both in income per capita and labor productivity terms (Barry, 2003).

At the same starting time period, per capita GDP in Portugal was also consistently lower than that of the EU average. There has been a steady convergence of real per capita GDP to the EU average until 1973. The opening up to the European markets took off in 1959, with the accession to EFTA. Economic growth in Portugal during the EFTA years was led by the manufacturing sector and, in particular, by the textile industries and the heavy industrial sector. When Portugal joined the EEC in 1986, its manufacturing sector was already markedly different from the situation in 1973. The Portuguese economy opened up further to foreign trade and capital imports. Moreover, there were no relevant changes in the structure of manufacturing towards new and more productive industries of the kind we find in Irish growth in the 1990s (Lains, 2006; Freitas, 2005).

Spain has been converging rapidly towards the EU average in 1950-1973. This fact was the outcome of the removal of barriers to imports, while there was heavy public-sector involvement in industries, such as mechanical engineering, chemicals and energy production. However, the Spanish performance in relation to the EU average has been deteriorating in the period after the oil shock, (Martin and Sanz, 2003). Reforms in the areas of tax and financial systems, labor relations, education and state participation in industry began to take place in Spain ever since 1982. Furthermore, macro policies were reined in, and union-employer agreements in 1983 and 1985 introduced some degree of wage restraint, (Barry, 2003). As part of its 1986 accession, Spain liberalized its product market further and began to open and modernize its capital market. Monetary and fiscal policies were brought under control, and competition policy was strengthened in the later period. These reforms set the scene for a return to convergence, (Barry, 2003).

In the first period, Ireland failed to converge. During this period, Ireland, like the other cohesion countries, remained protectionist. Furthermore, labor-market inflexibilities are seen to have played a role in accounting for Ireland's poor convergence performance. During this period in Ireland, there was a coincidence of strong wage growth, high unemployment and high immigration. Irish wages were too high for labor-intensive industries to prosper, while the productivity growth rate

was lower than the EU average, (Barry, 2003). Convergence seemed to occur up to the early 1990s, with the country's per capita GDP being very close to the EU-15 average. Since the second half of the 1990's, Ireland has outperformed the EU-15 average, and has been consistently moving ahead of the average itself. According to Gottheil (2003), the first positive factor was the financial assistance from the European Communities, under the form of structural funds that were directed to infrastructural investments. More importantly, FDI from USA multinationals in computers, pharmaceutical and chemical industries expanded very fast in the 1990s. Other factor was the higher endowments in physical and human capital, as compared to the other cohesion countries (Lains, 2006). More specifically, the increase in the employment rate and labour supply by immigration, as Barry *et al.* (2001) conclude, led to the expansion of industries with higher productivity levels.

#### 4. Empirical Results

We define as  $y_{i,t}$  the real GDP per capita of each country  $i$  at each time  $t$ , and  $\bar{y}_t$  the average real per capita GDP of the EU-15. First, we test for convergence using the Bernard and Durlauf (1995) methodology, employing time series techniques. Table 1 reports the results of Augmented Dickey-Fuller unit root tests for the demeaned output. Recall that, according to Bernard and Durlauf (1995), rejection of the hypothesis of a unit root in output deviation implies convergence. In all cases, we can not reject the null hypothesis of existence of unit root, as the value of the test statistic is well short of the rejection region. This finding indicates absence of stochastic convergence of real per capita GDP of the four Cohesion countries towards the EU-15 average<sup>6</sup>.

**Table 1.** Augmented Dickey-Fuller Unit Root  $t$ -Tests (demeaned output  $y_{i,t} - \bar{y}_t$ )

Country	Lag length	Test statistic
Greece	4	-2.3660
Portugal	0	-1.6914
Spain	4	-1.8278
Ireland	0	1.5021

*Note:* Lag length was chosen by AIC. Models include constant but not time trend. 5% critical value for the ADF tests is -2.9167

Similarly, including a time trend in the unit root tests, according to the results of Augmented Dickey-Fuller unit root tests for the demeaned output (Table 2), none of the four countries is found to convergence stochastically to the EU average. The results of the Nahar and Inder (2002) methodology vary largely from the outcomes of the Bernard and Durlauf results. For convergence to hold, the rate of change in  $w_{it}$  with respect to time  $t$  needs to be negative; i.e.  $w_{i,t} > 0$ ,  $(\partial/\partial_t)w_{i,t} < 0$ . The

<sup>6</sup>Note that, stochastic convergence is a necessary but not a sufficient condition for  $\beta$ -convergence

convergence hypothesis was set as that the average slope function is negative. To test the convergence hypothesis let us define the following null hypothesis:

**Table 2.** Augmented Dickey-Fuller Unit Root  $t$ -Tests (demeaned output  $y_{i,t} - \bar{y}_t$ )

Country	Lag length	Test statistic
Greece	4	-2,2672
Portugal	0	-0,71650
Spain	4	-1,9862
Ireland	3	-0,99192

*Note:* Lag length was chosen by AIC. Models include constant and time trend. 5% critical value for the ADF tests is -3,4952

$H_0: r'\theta \geq 0$  against the alternative hypothesis

$H_1: r'\theta < 0$

Thus the null hypothesis was set as no convergence. To test this, Equation (2) was estimated by ordinary least squares (OLS), and then the Wald test was performed to test the restriction on the  $\theta$  vector. The AIC was used to select the appropriate value of  $k$  for each country in estimating Equations (2) and (4); the selected polynomial order for each country is reported in Table 3.

**Table 3.** Estimates of average slope for testing convergence (Squared demeaned output gap from EU-15)

Country	Polynomial order (k)	Average slope	Wald test	p-value
Greece	5	-0.004708	129.2393	0.000
Portugal	6	-0.008387	88.8476	0.000
Spain	6	-0.003293	48.1426	0.000
Ireland	6	0.001431	4.9983	0.025

*Notes:* The optimal lag length is determined by means of AIC selection criterion. Restrictions in Equation (5) were tested using the Wald test.

Table 3 represents the results of the convergence tests based on average slope estimates. Tests based on the squared demeaned output level indicate strong evidence in favour of the convergence hypothesis for each country except Ireland. In fact, Greece, Portugal, and Spain appear to be converging to the mean. The estimates of average slopes can be interpreted as the average rate of convergence for each country towards the EU average. Portugal is closing the gap with the EE average the fastest - at a rate of 0.84% annually while Greece and Spain show a more modest convergence pattern (0.47% and 0.33% respectively). On the opposite, Ireland has positive and significant average slope, suggesting divergence. The real GDP per capita of Ireland is moving away from the EU-15 at a moderate rate of 0.14% per year. In the case of Ireland, the rejection of the convergence case is mainly due to the very high growth rate of this economy, which creates a picture of divergence. In



fact, Ireland has not needed to converge, because convergence has already occurred prior to the sample period.

## **5. Conclusions**

In this paper, we examine income convergence of the Cohesion countries with the average of EU-15 countries, by means of time series techniques. More specifically, both Bernard and Durlauf (1995) as well as a more recently proposed by Nahar and Inder (2002) test of unconditional convergence were applied. The former reject the stochastic convergence hypothesis, of real per capita GDP of the four Cohesion countries towards the EU-15 average, throughout the period under investigation.

However, the results of the Nahar and Inder (2002) methodology vary largely from the outcomes of the Bernard and Durlauf results. More specifically, tests based on the squared demeaned output level provide strong evidence in favour of the convergence hypothesis for each country except Ireland. In fact, Greece, Portugal, and Spain appear to be converging to the average real per capita GDP of EU-15. In the case of Ireland, the rejection of the convergence hypothesis is mainly due to the very high growth rates of this economy, which create a picture of divergence.

Failure to accept unconditional convergence is not uncommon in the literature. It appears that the group of cohesion countries included in the study is so diverse and heterogeneous, that perhaps it is necessary to control for these differences and test whether each country has its own steady state. Further research could be extended by introducing additional variables, as physical and human endowments, openness, FDI, and institutional quality, presently not included.

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