

OUTPUT CONVERGENCE: THE CASE OF CURRENT AND FORTHCOMING MEMBERS OF THE EUROPEAN UNION

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1. Introduction

The construction of the European Union is based on the idea that its existence is a guarantee for increased growth and welfare for the member countries taken as a whole. However, it is not clear that the geographical distribution of these beneficial effects is necessarily fair. In fact, there exists two opposite strands of thought, based on very different growth models and international trade theories.

According to some authors, economic integration increases regional and in general geographical disparities, because the production factors will be concentrated in the more developed regions as a result of increasing returns to scale and externalities. This is the postulate of the agglomeration theory of Krugman (1990) and of the endogenous growth models of Romer (1986 and 1990). On the other hand, under free factor mobility and international diffusion of technological knowledge, the more traditional international trade and growth models - based on comparative advantage and Solow framework (Solow, 1956 and subsequent literature) -, predict that economic integration will automatically promote economic convergence.

If economic convergence is automatic and takes place fast enough, free market forces would promptly erode regional inequalities and there would be no need for transferring funds from

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the richer to the poorer members of an economic union. On the contrary, if this convergence does not take place or is not sufficiently rapid, an explicit regional policy in favour of the less developed regions is fully justified, as long as its implementation effectively contributes to reduce the inequalities.

As far as the European economic union is concerned, three relatively poorer countries joined the EEC in the eighties: Greece entered in 1981, Spain and Portugal in 1986. In September of 2002, the European authorities agreed upon the enlargement of the Union with the entrance of ten new countries in 2004. Eight of these ten countries belonged to the former communist block and are the following: Estonia, Latvia, Lithuania, Hungary, Poland, Check Republic, Slovak Republic and Slovenia. Two more countries will also join the EU: Cyprus and Malta. The common characteristic of these ten countries is that their per capita income is far below the present EU average.

With the incorporation of Greece, Spain and Portugal in the eighties, the regional inequalities within the frontiers of the European economic union became more evident. Partly in response to that, the Single Act, signed in 1987, established the principle of Economic and Social Cohesion, and explicitly declared that the European Community will make special efforts in reducing regional differences. The authorities took for granted that the market forces alone would not solve the regional inequalities and the decision was taken at a European level to help the less developed regions in their efforts². A new design of the European Regional Policy resulted from it, and the first big reform in the distribution of the European Structural Funds was implemented. Four countries - the so called "cohesion countries" - were the major recipients of these funds: Greece, Spain, Portugal and Ireland. Two more reforms took place in the nineties, aimed at improving the efficiency of these funds.

Nowadays, the entrance of the ten new members from Eastern Europe will thoroughly modify the economic ranking of the European regions and the distribution of the Structural Funds:

² In fact, the European regional policy gained renewed impetus each time an enlargement took place and new geographical economic inequalities appeared. Correspondingly, the amount of funds devoted to regional policy also increased.

these new members will stand in 2004 in a similar or worse position than the "cohesion countries" at the time of their own entrance in the EU more than a decade ago.

In such a context, it is useful to determine the extent to which the European Union constitutes a zone of automatic economic convergence or not. In particular, it is of interest to analyse first if belonging to the EU and being recipients of Structural Funds significantly helped the "cohesion countries" to converge towards the richer economies; second, it is interesting to examine to what extent the coming members share similar convergence characteristics and could benefit from the European Regional Policy.

For that purpose, in this chapter, econometric "convergence tests" are applied on the data of per-capita outputs of both existing and future member countries of the EU, splitting the sample in the late eighties when appropriate. From the results, some conclusions may be drawn about the possible benefits for the incoming countries of being a member of the European Union and a recipient of Cohesion Funds.

Given the time span and the frequency of the available data for all these countries, it is important to use a testing procedure which takes full profit of all the sample information. This is the reason why we opt for multivariate tests which make use of the sample information from both the time-series and the cross-section dimensions. These multivariate tests are derived from unit root tests developed in the econometric and statistical literature (often called "panel unit-root tests").

However, some caution is required when specifying the null and the alternative hypothesis in the testing procedure. This aspect, which is often overlooked in the convergence empirical literature, is discussed in details in this chapter. On the other hand, most panel unit root tests are theoretically justified under the assumption of no contemporaneous correlation between the cross-section units. In convergence studies, this assumption is hardly defensible when the number of countries is low and when they moreover belong to the same geographical and/or economic area. In such a case, the practical implementation of the test has to

account for this cross-section correlation. This is carried out in this chapter by means of bootstrap techniques which are also described and justified.

The rest of the chapter is structured as follows. Section 2 focuses on the econometric methodology. It contains a discussion on the specification of the hypotheses to be tested and on how panel-unit root tests, as well as the convergence tests derived from them, can be improved with bootstrap critical values. Section 3 is devoted to the empirical results. The first part of Section 3 analyses the convergence process of the present members of the EU with a special emphasis on the possible effects of the intensification of the European regional policies from 1987 onwards. The second part centres on the convergence characteristics of some of the future members of the EU, taking into account the thorough institutional change that these countries experienced in the late eighties and early nineties, when they switched from a planned to a more liberal economy. Section 4 offers our conclusions.

2. Econometric aspects of testing output convergence

2.1. About the null and the alternative hypotheses of interest

Let Y_{nt} , $n = 1, \dots, N$, $t = 1, \dots, T$ be the log real GDP per capita in country n at time t . If the long run growth path of country n is a_{nt} , it must be that $(Y_{nt} - a_{nt})$ contains only non-permanent shocks, because this implies that the deviations of Y_{nt} around a_{nt} will vanish in the long-run. The simplest case of non-persistence of shocks consists of $(Y_{nt} - a_{nt})$ being an $I(0)$ variable. At the other extreme, if $(Y_{nt} - a_{nt})$ contains persistent shocks, which would be the case if it is an $I(1)$ variable, a_{nt} cannot constitute a relevant steady state path for country n . It is however impossible to directly test whether $(Y_{nt} - a_{nt})$ is $I(0)$ or not, because the steady state path a_{nt} is not observable.

Often, the objective is to test whether a group of N countries or regions converge towards the same steady state path. This analysis sometimes is called "across-convergence", to distinguish it from the "within-convergence" which refers to the convergence of a given

country towards some long-run path³. For *absolute* (across-)convergence, all the N countries must share an identical long run path: $a_{nt} = a_t \forall n$. In this case, $(Y_{nt} - a_t)$ must be I(0) around a zero mean, $\forall n$. For *conditional* (across-)convergence, the N countries share parallel steady state paths: $a_{nt} = a_t + c, \forall n$. The deviation $(Y_{nt} - a_t)$ is then I(0) around a mean that is not necessarily zero. This mean would basically reflect that worse initial conditions would prevent an economy from reaching the same *level* of GDP per capita as a better-endowed country, although he would share the same *growth rate*.

The path a_t however is not observed. So it is also impossible to directly test whether $(Y_{nt} - a_t)$ is I(0) or not. Note however that it can easily be cancelled out. There are in fact two basic ways of cancelling it out: working with country deviations around the cross-section mean and working with bilateral differentials. These two approaches are not completely equivalent, as we will see.

1) *Bilateral differentials*

Let us consider the differential $d_{nm,t} = Y_{nt} - Y_{mt}$ for countries n and m. If both countries converge to each other, they share the same (or parallel) steady state path a_t , so that $d_{nm,t}$ is also the differential of the deviations from their steady state path: $d_{nm,t} = (Y_{nt} - a_t) - (Y_{mt} - a_t)$. This differential must therefore be I(0) under convergence. An I(1) differential is symptom of divergence. Working on the differentials is related to the definitions of convergence of Bernard and Durlauf (1995); they call "convergence in multivariate output" the case in which the following condition is fulfilled:

$$\lim_{k \rightarrow \infty} E(y_{n,t+k} - y_{m,t+k} | I_t) = 0 \quad \forall n \neq m$$

If the differentials are I(0) around zero, this condition is fulfilled; on the other hand, I(1) differentials violate it.

When the study on convergence is carried out on the differentials, a reference country is usually chosen as country m, and the differentials of all the other countries with respect to

³ See for instance Islam(2003) for a recent survey.

country m are analysed. One of the drawbacks of this approach stands in the need of choosing a reference country. In most cases, the richer or more developed country of the group is chosen, mainly because it is somehow perceived as the model to be reached by the other countries.

Note that global convergence among all countries takes place only if all the differentials with respect to the reference country are $I(0)$. When only part of the countries converge to the reference one, some differentials will be $I(0)$ while the others will be $I(1)$. Let us call this situation "partial convergence". At the other extreme, when all countries diverge from the reference one, all differentials will be $I(1)$.

Therefore, if we are interested in detecting whether a given group of countries constitutes a convergence group or not, the natural null hypothesis is:

$$H_1 : d_{nm,t} \sim I(0) \text{ for all } i$$

whereas the alternative of interest is

$$H_2 : d_{nm,t} \sim I(1) \text{ for some or all } i$$

These are the null and alternative addressed in multivariate *stationarity* tests. Tests of this type have been developed recently for instance by Hadri (2000) and Hadri & Larson (2002) and are based on a multivariate extension of the stationarity KPSS test (Kwiatkowsky et al., 1992). They have not been used frequently so far. Moreover, the experience with these tests reported in the literature (see a.o. Chang, 2003) as well as the results of some simulations that we have ran indicate that they are not very powerful in detecting diverging units in moderate-size panels, as is typical of convergence studies. More research is in fact required to improve their power in small-sample conditions. In practice, as far as multivariate tests are concerned, what has been used most are panel *unit-root* tests. In these tests, the null hypothesis typically is:

$$H_0 : x_{n,t} \sim I(1) \text{ for all } n.$$

where $x_{n,t}$ is the series to be analysed that corresponds to the cross-section n . The alternative differs from one test to another. Two of the tests that have been extensively used are those due to Levine and Lin (1992, 1993) and to Im, Pesaran and Shin (1995, 2003). In what follows, we will refer to them as the LL and the IPS tests, respectively.

In the LL test, the null and the alternative are:

$$H_0 : x_{n,t} \sim I(1) \text{ for all } n \text{ against } H_A : x_{n,t} \sim I(0) \text{ for all } n$$

and it is tested on the basis of the t-ratio associated with an estimated value of ρ in the following equation:

$$\Delta x_{n,t} = c + \rho x_{n,t-1} + \sum_{i=1}^{p_i} \varphi_{n,i} \Delta x_{n,t-i} \quad n = 1, \dots, N$$

When $x_{n,t}$ is the differential variable $d_{nm,t}$, this test is then adequate for testing global convergence. It is however criticized for imposing the same value of ρ for all cross-section units, which comes to assuming that all the series of the panel exhibit the same first-order autocorrelation (see for instance Maddala and Wu, 1999). This criticism loses however intensity in view of the simulation results of a bootstrapped version of this test obtained in Chang (2003) to which we will refer below.

The IPS test allows first-order heterogeneity among the series by estimating a distinct ρ coefficient for each unit. For this reason it has been preferred to LL in recent studies. The counterpart of this heterogeneity is the form of the alternative:

$$H_A : x_{n,t} \sim I(0) \text{ for some } n$$

This test is therefore not apt for testing global convergence, but is better designed for discarding global divergence or detecting partial convergence.

This discussion stresses the importance of choosing the testing procedure which specifies the null and the alternative in full agreement with the precise objectives of the analysis. When the study is carried out on the deviations from a cross-section mean, it is also important to choose the right testing procedure, as we will see below.

2) *deviations from the cross-section mean*

As an alternative to the use of the differentials, another possibility of cancelling out the unobservable steady state path consists of working in deviation from the cross-section mean.

Let $\bar{y}_t = \frac{1}{N} \sum_{n=1}^N y_{nt}$ be the cross-section mean of the log real GDP per capita of the N countries

at time t. Note that under convergence of the N countries, $\bar{y}_t - a_t = \frac{1}{N} \sum_{n=1}^N (y_{nt} - a_t)$ is

necessarily I(0). But then the deviation $(y_{nt} - \bar{y}_t) = (y_{nt} - a_t) - (\bar{y}_t - a_t)$ is a sum of two I(0) variables and is therefore I(0) for all n. On the contrary, if $(y_{nt} - \bar{y}_t)$ is I(1), it is impossible that country n be converging with the other (N-1) economies towards the same steady state (or even towards parallel paths).

Evans and Karras (1996a) show that the process $\lambda_n(L)(y_{nt} - \bar{y}_t) = \delta_n + \varepsilon_{nt}$ will indeed have a unit root under divergence and will exhibit no unit root if the economies converge. So testing convergence comes to testing whether the series $(y_{nt} - \bar{y}_t)$ for the N countries exhibit or not a unit root. In this case too, the null and the alternative hypotheses have to be stated with caution and this aspect has been often overlooked in the literature.

To see this, let us first consider the case of only 2 countries: N=2. Their differential $d_{1,2,t} = y_{1t} - y_{2t}$ is I(0) if they converge. The deviation around the cross-section mean is $y_{it} - \frac{1}{2}(y_{1t} + y_{2t})$. It is equal to $\frac{1}{2}(y_{1t} - y_{2t})$ for n=1 and $\frac{1}{2}(y_{2t} - y_{1t})$ for n=2. Under convergence both must be I(0) and if one of them is I(1) the other is automatically I(1) too. So the relevant null and alternative hypothesis are:

$$H_0 : (y_{nt} - \bar{y}_t) \text{ is I(0) } n = 1,2 \quad H_1 : (y_{nt} - \bar{y}_t) \text{ is I(1), } n = 1,2$$

If N=3, the deviations from the cross-section mean are now:

$$(Y_{it} - \bar{Y}_t) = Y_{it} - \frac{1}{3}(Y_{1t} + Y_{2t} + Y_{3t}) = (1 - \frac{1}{3})Y_{nt} - \frac{1}{3}(\sum_{m=1, m \neq n}^3 Y_{mt}) \text{ for } n = 1, 2, 3$$

If all three countries converge, all these deviations are I(0). On the contrary, if only one of them diverge from the other two (who might converge to each other), all the three deviations will be I(1). To see this, let us suppose that country 1 and 3 converge to each other but country 2 does not. Then:

$(Y_{1t} - Y_{3t})$ is I(0) but $(Y_{1t} - Y_{2t})$ and $(Y_{3t} - Y_{2t})$ are I(1).

Therefore, $Y_{1t} - \bar{Y}_t = \frac{2}{3}Y_{1t} - \frac{1}{3}Y_{2t} - \frac{1}{3}Y_{3t} = \frac{1}{3}(Y_{1t} - Y_{2t}) + \frac{1}{3}(Y_{1t} - Y_{3t})$ is the sum of an I(0) and an I(1) variable and as such is necessarily I(1). The same holds for the deviation $(Y_{3t} - \bar{Y}_t)$. At the same time, $Y_{2t} - \bar{Y}_t = \frac{1}{3}(Y_{2t} - Y_{1t}) + \frac{1}{3}(Y_{2t} - Y_{3t})$ is necessarily I(1) because it is the sum of two I(1) non cointegrated variables. They are not cointegrated because the only cointegration relation that links Y_{1t}, Y_{2t} and Y_{3t} corresponds to a cointegration vector proportional to $(1, 0, -1)$.

As a result, the relevant hypothesis to be tested are:

$$H_0 : (Y_{nt} - \bar{Y}_t) \text{ is I(1) , for all } n \quad H_A : (Y_{nt} - \bar{Y}_t) \text{ is I(0) for all } n$$

This reasoning can easily be extended to any value of N, as well as to the case where the N countries are grouped in "convergence clubs". To see this, take N=4 and assume that countries 1 and 2 on the one hand, and countries 3 and 4 on the other constitute two different convergence clubs, so that countries 1 and 2 do not converge with countries 3 and 4. This implies that $(Y_{nt} - Y_{mt})$ is I(0) for $n, m=1, 2$ and for $n, m=3, 4$ but is I(1) for the other combinations of n and m . Consider then the deviation $(Y_{1t} - \bar{Y}_t)$. We have $Y_{1t} - \bar{Y}_t = \frac{1}{4}(Y_{1t} - Y_{2t}) + \frac{1}{4}(Y_{1t} - Y_{3t}) + \frac{1}{4}(Y_{1t} - Y_{4t})$, which is the sum of an I(0) $[\frac{1}{4}(Y_{1t} - Y_{2t})]$ and of two I(1) $[\frac{1}{4}(Y_{1t} - Y_{3t}) + \frac{1}{4}(Y_{1t} - Y_{4t})]$. Can this last sum be I(0)? The answer is no: the cointegration vector linking the variables Y_{1t}, Y_{3t} and Y_{4t} is $(0, 1, -1)$ whereas the coefficient vector in this last sum is proportional to $(2, -1, -1)$.

In summary, the preceding arguments indicate the following: in a given group of countries, the divergence of **any** member of the group implies that the deviations from the cross-section mean of **all** the countries will be $I(1)$.

This has several practical implications on how to test convergence with a panel of data in terms of the deviation from the panel mean, and on how to interpret the results.

The first implication concerns the type of test to be used. A panel unit-root or stationarity test that considers the units to be $I(0)$ under one hypothesis, and $I(1)$ under the other hypothesis is the right test for this case.

Second, if the panel unit root test concludes that the deviations are $I(1)$, the following step might consist of repeating the test on a new panel with a *new* cross-section mean, obtained after eliminating the country which exhibits most signs of divergence (these signs may be based on graphical inspection or on economic characteristics).

Third, it is often the case that univariate unit root or stationarity tests are applied on the difference between the GDP per capita of a given economic area "n" and the GDP of a larger economic area to which the first one belongs. For instance, it is the case when the difference of the per-capita income of a U.S region with respect the aggregate per capita US income is analyzed; it is also the case when the per capita output of a given European region or country is analyzed in difference from the average per capita output of the whole European Union. If the test concludes that this difference is $I(1)$, the preceding discussion indicates that this should not be interpreted as an indication that this particular area "n" is responsible for the divergence; it merely indicates that *some* of the small areas fail to converge to the long run path of the other areas.

Fourth, remember that an $I(1)$ country *differential* between the GDP per capita of two economies does indicate that these two specific countries do not converge to each other.

Therefore, if univariate unit-root or stationarity tests are used, the differential series are more informative than the deviations series.

2.2. Choosing a testing procedure

The convergence analysis of this work has to be carried out on a panel of countries of moderate size: the number of countries N as well as time span T are not very high (the maximum value for T is 60 and for N is 15). It is therefore important to take profit of all the relevant sample information, without sacrificing any dimension of the sample. It seems then reasonable to apply multivariate (panel data) convergence tests, rather than applying exclusively time-series univariate techniques. The analysis is carried out in terms of deviations from the cross-section mean, so that no reference country has to be chosen.

As explained in Section 2.1, when working with deviations, the units composing the panel are either all $I(0)$ or all $I(1)$. Note that unit root tests such as the "t-bar" unit-root test of Im, Pesaran and Shin (1997,2003), the stationarity tests of Hadri (2000,2002) or the general F-type panel unit-root tests for dependent panels recently proposed by Chang (2003) all consider under the alternative that some of the units may be $I(1)$ while others are $I(0)$. In other words, they do not test specifically overall stationarity versus overall non-stationarity.

By contrast, the test proposed by Evans and Karras (1996a), which is a modification of the LL test, *does* consider the null hypothesis that the deviations from the cross-section mean are *all* $I(1)$ against the alternative that they are *all* $I(0)$. We will first summarize Evans-Karras procedure and then consider its possible limitations and examine how to circumvent them.

2.2.1. The "EK" procedure: what it tests and how it can be improved under cross-section dependency

2.2.1.1. The procedure as proposed by Evans and Karras(1996a)

Consider the univariate process for the deviation of country n:

$$\lambda_n(L)(y_{n,t} - \bar{y}_t) = \delta_n + u_{n,t} \quad (1)$$

where the lag polynomial $\lambda_n(L)$ may be of infinite order, with coefficients that may differ across economies. This polynomial can be written as $\lambda_n(L) = \pi_n(L)D(L)$ where $\pi_n(L)$ has all its roots outside the unit circle with $D(L) = 1$ if the economies converge and $D(L) = (1-L)$ if some of them diverge. Equation (1) then becomes

$$\pi_n(L)D(L)(y_{n,t} - \bar{y}_t) = \delta_n + u_{n,t} \quad (1')$$

Approximating $\pi_n(L)$ by a q-degree polynomial, with q finite, equation (1') can be rewritten as

$$\Delta(y_{n,t} - \bar{y}_t) = \delta_n + \rho_n(y_{n,t-1} - \bar{y}_{t-1}) + \sum_{i=1}^p \varphi_{n,i} \Delta(y_{n,t-i} - \bar{y}_{t-i}) + u_{n,t} \quad (2)$$

In this equation, $\rho_n = 0$, $\varphi_{n,i} = \pi_{n,i}$, $p = q$ if $D(L) = 1-L$, that is, if the economies diverge.

However, $\rho_n = (\sum_{i=1}^{p+1} \pi_{n,i} - 1)$ and negative, $\varphi_{n,i} = -\sum_{j=i+1}^{p+1} \pi_{n,j}$, $p = q-1$ if $D(L)=1$, that is, if the economies converge.

The proposed testing procedure is as follows:

[1] apply OLS to (2) to obtain an estimate $\hat{\delta}_n$ of $\sigma_n^2 = V(u_{n,t})$ and use it to transform the data to $\hat{z}_{n,t} = (y_{n,t} - \bar{y}_t) / \hat{\delta}_n$

[2] obtain the OLS estimate of ρ and its t-ratio $\tau(\hat{\rho})$ applying OLS to

$$\Delta \hat{z}_{n,t} = \delta_n + \rho \hat{z}_{n,t-1} + \sum_{i=1}^p \varphi_{n,i} \Delta \hat{z}_{n,t-i} + \hat{u}_{n,t} \quad (3)$$

[3] If the t-ratio of step [2] is sufficiently negative, reject $H_0 : \rho_n = 0 \forall n$ in favour of $H_1 : \rho_n < 0 \forall n$. If H_0 is rejected, the economies converge

[4] If H_0 is rejected, test $H_0' : \delta_n = 0 \forall n$ against $H_1' : \delta_n \neq 0$ for some n in equation (2); for that purpose, estimate this equation for $n=1, \dots, N$; compute then $\Phi(\hat{\delta}) = \frac{1}{N-1} \sum_{n=1}^N [\tau(\hat{\delta}_n)]^2$ and reject H_0' if $\Phi(\hat{\delta})$ is too large, in which case convergence would be conditional. Otherwise, convergence is absolute.

Note that steps [1] to [3] come to testing for the presence of a unit root on the basis of a Weighted Least Squares estimation. It estimates a single ρ coefficient for all the units of the panel. This single estimation of ρ guarantees that the alternative is $H_A : \rho_n < 0$ for **all** n and not $H_A : \rho_n < 0$ for **some** n . In other words, this procedure assumes the same first order autocorrelation for all the deviations from the cross-section mean. Obviously, if all the economies converge but they exhibit very heterogeneous dynamics, this procedure may lack power in detecting convergence. However, if the degree of heterogeneity is reasonable, this procedure is preferable to others procedures which allow ρ to vary: if a different ρ is estimated for each cross-section, the alternative cannot be $H_A : \rho_n < 0$ for **all** n . Moreover, the simulations carried out by Chang(2003), commented in more details below, show that a single estimation of ρ used in combination with an appropriate critical value provides a reliable test result even under heterogeneity of the cross-section units.

Evans and Karras (1996a) demonstrate that, when N and T tend to ∞ , $\tau(\hat{\beta})$ and $\Phi(\hat{\delta})$ are asymptotically $N(0,1)$ and F , respectively. This result holds under the assumption that the errors in (2) are contemporaneously uncorrelated. The authors suggest improvements on these asymptotic values by obtaining critical values by simulations from Normal independent distributions. When the number of economies is low or moderate and they moreover belong to the same geographical or economic area, the assumption of independence required for the asymptotic distribution and used in Evans-Karras simulations is difficult to sustain.

2.2.1.2. The effect of cross-section dependency

Maddala and Wu (1999) showed with simulations that the LL test -from which the EK procedure is derived and is an extension- as well as the IPS test have substantial size distortions in the presence of cross-section correlation. The reason is that the asymptotic distributions obtained under the assumption of no cross-section correlation are not valid. They suggest bootstrapping the tests in order to obtain better approximations of the critical values.

Chang(2003) develops on this idea and obtains results that can be exploited in order to improve the EK procedure. She considers several unit-root tests for heterogeneous and dependent panels. She presents new F-type test statistics corresponding to the estimation of a different ρ_n for each cross-section unit. More concretely, she considers estimating $\rho_n, n = 1, \dots, N$ by Feasible Generalized Least Squares (FGLS) and by Ordinary Least Squares (OLS) from the following system of N equations:

$$\Delta x_{n,t} = \rho_n x_{n,t-1} + \sum_{i=1}^{p_n} \varphi_{n,i} \Delta x_{n,t-i} + \varepsilon_{n,t} \quad n = 1, \dots, N$$

where $x_{n,t}$ is a demeaned variable. She then constructs traditional F-type tests associated with these estimations aimed at testing:

$$H_0 : \rho_n = 0, n = 1, \dots, N \text{ against } H_1 : \rho_n \neq 0 \text{ for at least 1 } n$$

Since we are normally interested in a left-tailed alternative ($\rho_n < 0$), she also builds modifications of this statistic to transform them in left-tailed statistics. At the same time, she considers the one-tailed t-statistics corresponding to FGLS and OLS estimation of a single ρ for all units, as specified in the following system:

$$\Delta x_{n,t} = \rho x_{n,t-1} + \sum_{i=1}^{p_n} \varphi_{n,i} \Delta x_{n,t-i} + \varepsilon_{n,t} \quad n = 1, \dots, N$$

in order to test:

$$H_0 : \rho_n = 0, n = 1, \dots, N \text{ against } H_1 : \rho_n < 0 \text{ for all } n$$

She obtains the asymptotic distribution of these tests under cross-section correlation; these distributions are non-standard and depend heavily on nuisance parameters that define the cross-sectional dependency and the heterogeneous serial dependence.

She then proposes a bootstrap version of the different test statistics. The bootstrap samples are constructed from the residuals obtained with the unit root restriction $\rho_n = 0 \forall n$ imposed. The resampling is carried out so as to preserve the cross-correlation structure of the original data: the bootstrapped residuals are obtained from resampling the full N -dimensional vectors of OLS re-centred residuals for all the N units at a time, instead of resampling the residuals of each cross-section unit separately. More precisely, estimating the model under the null provides T ' scalar residuals for each economy n ; these residuals are then re-centred so that their sample mean is zero; after that, one way of resampling would consist of resampling them independently from the vector of T ' residuals of economy n' (where T ' is the effective number of residuals to be resampled, and $n, n' = 1, 2, \dots, N$, with $n \neq n'$); but this would destroy the cross-section structure of the data. In order to preserve it, instead of resampling T ' scalar residuals N times, T ' N -dimensional vectors of residuals are resampled once. In other words, if the re-centred residuals are put in a $T' \times N$ matrix, this matrix is resampled by row, instead of element by element in each column⁴. These bootstrapped residuals are then used to build new $\{x_{n,t}, n = 1, \dots, N, t = 1, \dots, T\}$ data that satisfy the null hypothesis (the so-called "bootstrapped" data $\{x_{n,t}^*\}$). The bootstrap critical values are obtained in the usual way: a large number of bootstrapped-data samples are generated; on each sample, the value of the test-statistics is computed. These values are then sorted so as to obtain an "empirical distribution" of the values of the test-statistic under the null. This empirical distribution serves as an approximation of the true (asymptotic) distribution of the statistic and provides therefore an approximation of the critical value that we need to conclude the test.

⁴ Note that this procedure was already advocated by Maddala and Wu (1999) .

Chang (2003) demonstrates the asymptotic validity of the bootstrapped tests that she proposes. In other words, she proves that the bootstrapped critical value is a valid approximation of the asymptotic critical value.

In order to evaluate the performance of these tests in finite samples, she also runs simulations for $N=5, 10$ and $T=100$. These simulations shed light on the relative qualities of the different tests. As far as the t-type tests are concerned, which are those of major interest for our purpose, her results indicate that these bootstrapped tests have the correct size and that they perform well in terms of power, unless the cross-sections exhibit substantial heterogeneity. These results also indicate that there is not much difference between the OLS-based and the FGLS-based statistics. The OLS-based statistics is even more powerful than the FGLS for larger values of N , that is when the dimension of the cross-section correlation matrix is large.

At this point, it is convenient to remember that the method proposed by Evans and Karras (1996a) in their procedure for the estimation of ρ is a Weighted Least Squares method, which is intermediate between the OLS and the FGLS: it does not estimate the full cross-section correlation matrix, which seems to be the cause of relative lower power of FGLS when $N=10$ in Chang's simulations, although it does take into account that the variances may vary from one cross-section to another.

2.2.2. A bootstrapped version of EK procedure under cross-section dependency

The results of Chang(2003) suggest a possible way of completing the EK procedure for testing convergence in moderate-size panels in which the cross-section units cannot be considered as independent. It would consist of bootstrapping the critical value of the test statistics by a resampling method that would preserve the cross-section dependency of the original sample of data.

It consists of the following steps for each statistic:

- 1) estimate the testing equation under the null, obtain the residuals and resample them preserving the cross-section dependency of the original data, proceeding as in Chang (2003)
- 2) generate the bootstrap samples by entering these resampled residuals in the testing equation in which the null is imposed and in which the remaining coefficients take the value that has been estimated under the null in step 1). Since the testing equation is dynamic, initial values for the data are required. These values are determined randomly while preserving the cross-section correlation⁵.
- 3) Step 2) is repeated many times, giving rise to a large number of bootstrap samples. The test statistic is then computed on each sample. The proportion of bootstrap statistics falling to the left⁶ of the value of $\tau(\hat{\beta})$ obtained in the original sample provides the probability value of the "divergence versus convergence" test. Similarly, the proportion of bootstrap statistics falling to the right⁷ of $\Phi(\hat{\delta})$ calculated in the original sample approximates the probability value of the test of "absolute versus conditional" convergence.

⁵ There are several ways of obtaining random initial values. Here we first generate initial values for the errors imposing on them a structure of cross-section correlation as estimated on the residuals from the estimations under the null on the observed data; we then use these initial errors to build up the initial observations data from the estimated moving average representation truncating the infinite MA polynomial after 30 terms (see Rayner, 1990, Berkowitz, Killian, 2000, section 2.1 and Maddala and Wu, 1999 for more details on this method).

⁶ Given the alternative hypothesis, the test based on $\tau(\hat{\beta})$ is left-tailed

⁷ Given the formula that defines $\Phi(\hat{\delta})$, this test is right-tailed.

3. Empirical results

3.1. The data

We have applied the bootstrapped EK procedure described in sections 2.2.1 and 2.2.2 on the log of GDP per capita of two panels of countries. The GDP per capita are expressed in constant and international (PPP) prices.

The first panel is made of semester data for 14 out of the 15 members of the current EU-15 zone⁸: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. GDP in PPP and population data come from the OECD STATISTICAL COMPENDIUM ed. 2002-2. GDP is available on a semester basis. Population data are annual. However, the population series are very smooth; as a consequence, semester frequency has been reached by linear interpolation⁹. The sample extends from the first semester of 1970 to the last semester of 2000. Over this period, various countries joined the Union. The United Kingdom, Ireland and Denmark entered in 1973. Greece joined in 1981, Spain and Portugal in 1986. Finally, Austria, Finland and Sweden in 1995.

The second panel refers to annual data of GDP per capita for the following countries: the Check Republic, Hungary, Poland together with the EU-15 countries excluding the main recipients of Structural Funds and Luxemburg (i.e. Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Sweden and the United Kingdom). The data are expressed in 1990 constant and international Dollars and cover the period 1950-2002. They have been derived from the database of the University of Groningen (University of Groningen and the Conference Board, GGDC Total Economy Database , July 2003).

⁸ Data on Luxemburg are not available

⁹ For Germany, the data correspond to West Germany till 1990.2 and to the re-unification from 1991.1. Therefore, the population by semester has been obtained by linear interpolation till 1990.2. After that, a cubic polynomial was fitted to the annual end-of-year data and the corresponding equation was used to “backcast” the value of the first semester of 1991.

The data of the log of GDP per capita are represented in Graph 1 for the first panel and in Graph 2 for the second panel.

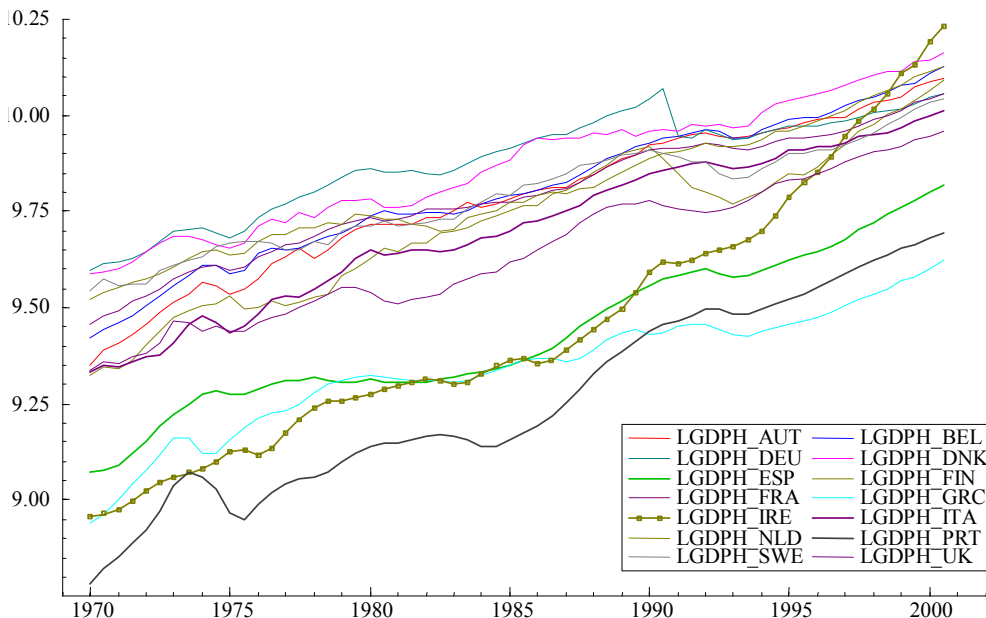
In Graph 1, some interesting features are readily observable: the series are upward-trending and non stationary; some sort of common trend seems present; however, Greece, Spain and Portugal seem to constitute a separate group from the richer countries which are more clustered together all over the sample period. Ireland is the only case where a country stands among the poorest countries in 1970 and ends up above any other EU-member by the end of 2000.

As far as Graph 2 is concerned, the possibility of two distinct groups is even more obvious. On the one hand, the richer countries stand together in the upper part of the graph and seem to converge, whereas Poland, Hungary and the Check Republic which seem to be diverging from the EU-countries at least till the early nineties.

Graph 1

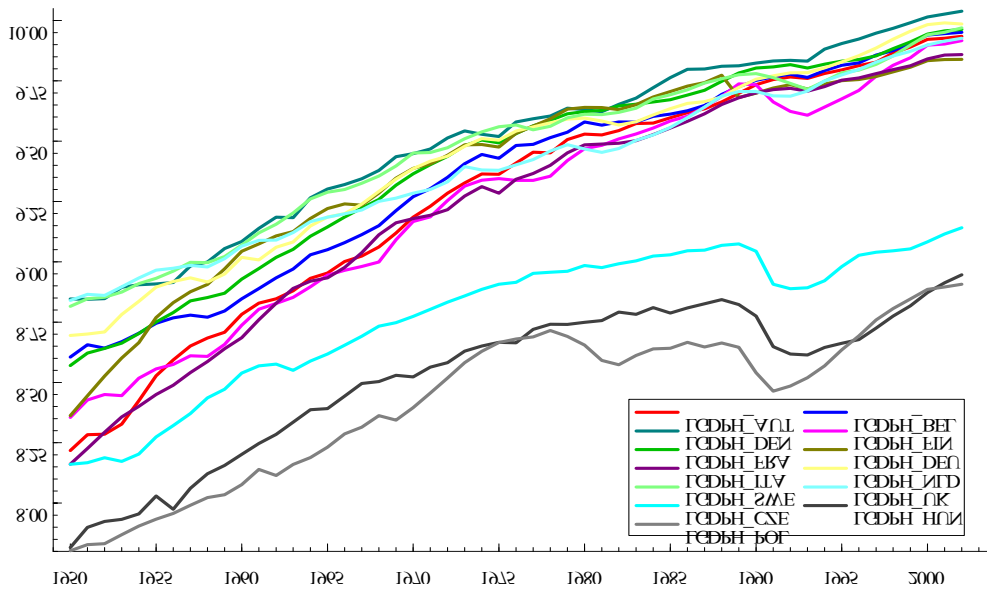
Log of GDP per capita

EU-15 except Luxemburg



Graph 2

Log of GDP per capita of historically richer EU countries(except Luxemburg), Poland, Check Republic and Hungary



3.2. The convergence tests

3.2.1. The case of the current members of the EU-15

Given the interest in checking a possible influence of the reforms in the European Structural Funds and of the Single Act on convergence, the sample has been split in 1987.¹⁰ As a consequence the convergence tests have been applied to two sample periods: 1970.1-1986.2, 1987.1-2000.2.

In applying the tests, a choice must be made as to the value of p in equations (2) and (3). The estimation has been ran for $p=0$ to 7 and Portmanteau tests of no-autocorrelation of the residuals have been applied.

The results of applying the tests on the group of the ten historically richer EU countries are reproduced in Table 1. The results are presented from $p=1$ to $p=7$. Those values of p for which

Table 1 : Convergence tests for the initially richer countries:
the whole group without Greece, Spain, Portugal and Ireland
OECD semester data
Probability values in %

Number of lags:		p=1	P=2	P=3	p=4	P=5	p=6	p=7	Conclusión
1970 -	$H_0: \rho = 0 \Rightarrow$ no cvgce $H_a: \rho < 0 \Rightarrow$ cvgce	4.2	6.2	4.4	10.5	4.1	1.8	15.6	Signs Of ABSOLUTE CONVERGENCE
	If $\rho < 0$, $H_0: \delta_n = 0 \forall n$ \Rightarrow absolute $H_0: \text{some } \delta_n \neq 0$ \Rightarrow conduit.	52.6	-	42.8	-	32.4	15.6	.	
1987 -	$H_0: \rho = 0 \Rightarrow$ no cvgce $H_a: \rho < 0 \Rightarrow$ cvgce	10.4	1.5	2.5	2.5	0.8	0.3	0.01	ABSOLUTE CONVERGENCE
	If $\rho < 0$, $H_0: \delta_n = 0 \forall n$ \Rightarrow absolute $H_0: \text{some } \delta_n \neq 0$ \Rightarrow conduit.	-	17.4	9.1	10.3	6.9	4.4	1.6	

The bold frames indicate a value of p for which the residuals for each country pass a no-autocorrelation Portmanteau test at 5%.

no autocorrelation is accepted at 5% for all countries are marked with a bold frame. When this condition is met by a vast majority of countries and some countries rejects no-autocorrelation at 5% but accept it at 2.5%, this is indicated by a discontinuous bold frame. In none of the estimated model the residuals are whitened for $p=0$, so that the results for this p are not reproduced here. For each sample period, the bootstrap probability values for the null $H_0: \rho_n = 0 \forall n$ of no convergence against the alternative $H_a: \rho_n < 0 \forall n$ of convergence are given in the upper row of the Table. For an easier and faster interpretation, the p-value favourable to convergence is marked in bold. When convergence is accepted, the p-value for the test of absolute against conditional convergence is provided in the second row. Here again, this value appears in bold if convergence is absolute.

¹⁰ This year is chosen because it is the year of the Single Act, which established the principle of Economic and Social Cohesion and from which the new design of the European Regional Policy emerged

According to the results of this table, the 10 richer countries of the EU-15 considered here did constitute a convergent group during the three last decades. This is particularly true for the 1987-2000 period; for the first period extending from 1970 to 1986, convergence is also the dominant results. If these results are maintained when the historically poorer countries are added to the sample, it would mean that there was no need for an external intervention in favour of the poorer countries.

To check this, Table 2 contains the results of the convergence tests applied to the previous panel of 10 countries extended with the data on Spain, Portugal, Greece and Ireland. This table shows that between 1970 and 1987, the 14 countries were in a situation of convergence, although this convergence was only conditional: these countries shared parallel but not identical steady state paths. In the subsample that covers the period 1987-2000, quite a different result emerges: the statistics unambiguously take value that are typical of divergence. This is at first sight somewhat surprising since the European authorities had adopted a cohesion policy aimed at helping the poorer regions and countries to improve their relative economic position

However, Graph 1 shows that the evolution of Ireland in the last decade might explain this unexpected result: since the late eighties, this country has experienced a unique and sustained growth, to the point of reaching the highest level of GDP per capita in the year 2000. One possible explanation is that the exceptional growth in Ireland in the last fifteen years has been fostered not only by European structural funds, but also by a very efficient national economic development strategy. Furthermore, the Irish economy has proven especially attractive, as an export base for the EU market to Foreign Direct Investment projects of US companies (for a policy evaluation of the economic success of Ireland in the last decades, see Braunerhjelm et al., 2000, chapter 5).

If we then exclude the special case of Ireland from the panel and repeat the analysis, the results are those reproduced in Table 3. It shows that convergence was conditional till 1986 and became absolute from 1987 onwards. Joining all of these results, the message seems clear: at the time of their entrance in EU, Greece, Portugal and Spain did not share the same

steady state as their EU partners, but belonging to the EU and benefiting from its regional policy contributed to change this feature.

There is therefore no evidence against the usefulness of the Structural Funds for a better cohesion within the EU: the countries which constitute today the EU were initially in a situation of conditional convergence, so that the public intervention in the form of explicit policies in favour of reducing regional disparities were justified, and the statistical evidence favours the hypothesis that these policies have been effective in narrowing the country differences.

Table 2:

Convergence tests for the whole group of countries

EU15 except Luxemburg - OECD semester data

Probability values in %

Number of lags:		p=1	p=2	P=3	p=4	P=5	P=6	P=7	Conclusion
1970 -	$H_0: \rho = 0 \Rightarrow \text{no cvgce}$ $H_a: \rho < 0 \Rightarrow \text{cvgce}$	0.9	8.7	3.3	1319	2.0	0.9	7.62	Signs of CONDITIONAL CONVERGENCE
	If $\rho < 0$, $H_0: \delta_n = 0 \forall n$ $\Rightarrow \text{absolute}$ $H_0: \text{some } \delta_n \neq 0$ $\Rightarrow \text{condit.}$	0.4	-	3.7	-	1.1	0.50	-	
1987 -	$H_0: \rho = 0 \Rightarrow \text{no cvgce}$ $H_a: \rho < 0 \Rightarrow \text{cvgce}$	29.7	45.4	17.8	18.6	6.5	2.1	21.9	DIVERGENCE
	If $\rho < 0$, $H_0: \delta_n = 0 \forall n$ $\Rightarrow \text{absolute}$ $H_0: \text{some } \delta_n \neq 0$ $\Rightarrow \text{condit.}$					-	5.2		

The bold frames indicate a value of p for which the residuals for each country pass a no-Autocorrelation Portmanteau test at 5%. A discontinuous bold frame indicates that most countries pass the no-autocorrelation test at 5% and a few of them at 2.5%.

Table 3 :
Convergence tests for richer countries plus Spain, Greece and Portugal
OECD semester data
Probability values in %

Number of lags:		P=1	p=2	p=3	p=4	p=5	p=6	p=7	Conclusion
1970	$H_0: \rho = 0$ no cvgce $H_a: \rho < 0$ cvgce	0.9	4.7	4.0	7.3	1.25	0.84	14.8	Signs of CONDITIONAL CONVERGENCE
-	If $\rho < 0$,								
1986	$H_0: \delta_n = 0 \forall n$ \Rightarrow absolute $H_0: \text{some } \delta_n \neq 0$ \Rightarrow condit.	0.2	11.7	5.2	-	1.6	1.5	-	
1987	$H_0: \rho = 0$ no cvgce $H_a: \rho < 0$ cvgce	0.10	1.5	2.5	2.5	0.8	0.04	0.0	ABSOLUTE CONVERGENCE
-	If $\rho < 0$,								
2000	$H_0: \delta_n = 0 \forall n$ \Rightarrow absolute $H_0: \text{some } \delta_n \neq 0$ \Rightarrow condit.	50.7	17.4	9.1	10.3	6.9	4.4	1.6	

The bold frames indicate a value of p for which the residuals for each country pass a no-autocorrelation Portmanteau test at 5%. A discontinuous bold frame indicates that most countries pass the no-autocorrelation test at 5% and a few of them at 2.5%.

3.2.2. The case of some future EU-members from Eastern Europe

Let us now analyse the relative position of the Eastern European countries in comparison with the ten initially richer EU-members. The data are annual and cover the period 1950-2002. These Eastern countries experienced profound structural and institutional changes at the end of the eighties: at that time they switched to a free-market economy and a more democratic political system. The impact of these changes on the output per capita is very apparent on graph 2. Ideally, we should then carry out a separate analysis on the data up to 1990 and on the data from that year onwards. Unfortunately, given the annual frequency of the sample, such a procedure is impossible since this would leave too little time-series information in the second subsample to estimate the testing equation. We have therefore proceeded as follows: we have tested convergence on the full sample 1950-2002 and on a shorter sample that stops in 1990. The difference in the results indicates whether the convergence capacity and characteristics of these countries might have changed in the last decade, after the institutional changes that they have carried out.

In order to avoid doubts about which countries might be held responsible for a divergence result, we first check whether the EU-10 countries constitute a convergence group or not. The results in Table 4 show that these countries exhibit strong signs of absolute convergence both over the full 1950-2002 and over the shorter 1950-1990 time periods.

Table 4 :
 Convergence tests for the initially richer EU-countries
 Annual data - 1950-2002
 (University of Groningen and The Conference Board GGDC,
 Total Economy Database, July 2003)
 Probability values in %

Number of lags:		p=1	p=2	p=3	p=4	P=5	P=6	p=7	Conclusion
1950 - 1990	H ₀ : $\rho = 0$ no cvgce H _a : $\rho < 0$ cvgce	0.2	0.0	0.2	1.5	9.5	12.0	10.6	ABSOLUTE CONVERGENCE
	If $\rho < 0$, H ₀ : $\delta_n = 0 \forall n$ ⇒absolute H ₀ : some $\delta_n \neq 0$ ⇒condit.	39.6	82.3	65.4	81.1	-	-		
1950 - 2002	H ₀ : $\rho = 0$ no cvgce H _a : $\rho < 0$ cvgce	0.0	0.0	0.0	0.0	0.0	2.6	2.5	ABSOLUTE CONVERGENCE
	If $\rho < 0$, H ₀ : $\delta_n = 0 \forall n$ ⇒absolute H _a : some $\delta_n \neq 0$ ⇒condit.		71.3	41.1	62.2	77.6	75.9	83.6	

The bold frames indicate a value of p for which the residuals for each country pass a no-Autocorrelation Portmanteau test at 5%. A discontinuous bold frame indicates that most countries pass the no-autocorrelation test at 5% and a few of them at 2.5%.

Let us examine now the situation of Poland, Hungary and the Check Republic. In Table 5, the results show that till 1990, these countries were diverging. However if we add the data since 1990, the results in the lower part of Table 5 show that these countries exhibit now rather strong signs of conditional convergence. It is as if the switch to a free-market economic system has enlivened the convergence forces of their economies.

Table 5 :
 Convergence tests Poland, Hungary and Check Republic
 Annual data - 1950-2002
 University of Groningen and The Conference Board GGDC Total Economy Database
 Probability values in %

Number of lags:		p=1	p=2	p=3	p=4	P=5	P=6	p=7	Conclusion
1950 - 1990	H ₀ : $\rho = 0$ no cvgce H _a : $\rho < 0$ cvgce	43.1	23.6	22.8	16.6	33.3	8.9	35.8	DIVERGENCE
	If $\rho < 0$, H ₀ : $\delta_n = 0 \forall n$ ⇒absolute H ₀ : some $\delta_n \neq 0$ ⇒condit.	-	-	-	-	-	-	-	
1950 - 2002	H ₀ : $\rho = 0$ no cvgce H _a : $\rho < 0$ cvgce	22.6	5.9	3.4	1.8	3.2	0.3	2.2	Signs of CONDITIONAL CONVERGENCE
	If $\rho < 0$, H ₀ : $\delta_n = 0 \forall n$ ⇒absolute H _a : some $\delta_n \neq 0$ ⇒condit.	-		6.5	2.8	4.7	0.2	1.2	

The bold frames indicate a value of p for which the residuals for each country pass a no-Autocorrelation Portmanteau test at 5%. A discontinuous bold frame indicates that most countries pass the no-autocorrelation test at 5% and a few of them at 2.5%.

In Table 6, the analysis of table 4 and 5 is repeated on the joint panel of rich EU-countries and Eastern European future members. From the results obtained in the previous two tables, what is expected is divergence till 1990, and at most conditional convergence when data till 2002 are added. This is exactly what comes out. We may therefore conclude that these three countries stand at the moment in a situation similar to that of the recipients of structural funds around 1987. With an efficient use of these funds and of the opportunities the EU market offer to these economies, they should obtain great benefits from entering the EU that should reflect in closer GDP paths within a few years.

Table 6:
Convergence tests for Poland, Hungary and Check Republic with the historically richer EU-15 countries - Annual data - 1950-2002
 University of Groningen and The Conference Board GGDC Total Economy Database
 Probability values in %

Number of lags:		p=1	P=2	p=3	p=4	P=5	P=6	p=7	Conclusion
1950 - 1990	$H_0: \rho = 0$ no cvgce $H_a: \rho < 0$ cvgce	8.5	13.5	13.0	26.0	36.0	18.8	33.7	DIVERGENCE
	If $\rho < 0$, $H_0: \delta_n = 0 \forall n$ \Rightarrow absolute $H_0: \text{some } \delta_n \neq 0$ \Rightarrow condit.	-	-	-	-	-	-	-	
1950 - 2002	$H_0: \rho = 0$ no cvgce $H_a: \rho < 0$ cvgce	1.2	1.7	1.6	5.3	13.8	13.9	11.4	More signs of CONDITIONAL CONVERGENCE
	If $\rho < 0$, $H_0: \delta_n = 0 \forall n$ \Rightarrow absolute $H_a: \text{some } \delta_n \neq 0$ \Rightarrow condit.	3.2	4.1	2.3	7.5	-	-	-	

The bold frames indicate a value of p for which the residuals for each country pass a no-Autocorrelation Portmanteau test at 5%. A discontinuous bold frame indicates that most countries pass the no-autocorrelation test at 5% and a few of them at 2.5%.

4. Summary and conclusions

In this chapter, we have discussed possible ways of determining whether various countries or regions are converging to each other or not by the use of multivariate unit root or stationarity tests. We have insisted on the differences between testing international output convergence by analysing the countries bilateral output-per-capita differentials and testing it on the basis of the deviations of each country per-capita output from the overall cross-section mean. In particular, we have shown the importance of specifying correctly the null and the alternative hypothesis. More specifically, we have shown that when deviations from an overall mean is used, these deviations are either all $I(0)$ or all $I(1)$, even when some countries of the panel converge to each other while others diverge; for a better testing procedure, it is convenient to use a test in which the null *and* the alternative hypotheses reflect this characteristic. On the other hand, working with bilateral differentials permits testing whether there is global convergence (in which all the countries converge to each other) as well as testing what we might call partial convergence (when at least some countries, but not necessarily all of them, converge).

On the other hand, we have also stressed the importance of accounting for the contemporaneous correlation that characterizes the output series of countries that belong to the same geographical and/or economic area. It is difficult to believe that the shocks that affect the output per capita of, say, France is not related to the shock that might affect the German output per capita in the same year. The panel unit root tests used to test convergence are however built on this premise: the critical values are obtained under the assumption that the shocks are contemporaneously uncorrelated. In order to circumvent this limitation, we propose here a bootstrapped version of the convergence testing procedure proposed by Evans and Karras (1996a). The bootstrapping is carried out so that it provides critical values that take into account the specific correlation structure of the data on which the tests are applied.

This bootstrapped procedure is applied in the second part of the paper on semester data of the current members of the EU-15. The results indicate that the richer countries of the

European Union have been in absolute convergence since 1970. The poorer countries who entered the Union in the eighties - Greece, Portugal and Spain - were only conditionally converging to their European partners at the time of their entrance: That is, their steady state path was parallel but not as high as those of the richer members. Since 1987, the situation has evolved so that the convergence tests applied on the data between 1987 and 2000 reveal signs of absolute convergence. This evolution points out that the Structural Funds that these countries have mostly received since 1987 may have been helpful. The case of Ireland is different, because this country experienced a very intensive growth process which may have resulted not only from an efficient use of the structural funds but also from the Foreign Direct Investment policy of the United States which have been using this country as an export base for their products towards the European countries. Ireland constitutes a case of such a fast catching-up process that it seems to have even "overshot" its goal of convergence, since it stands nowadays above the per capita output of any other EU member.

As far as the Eastern European countries are concerned, the analysis centres here on the case of Poland, Hungary and the Czech Republic, for which the available series of per-capita output cover a longer period than for any other forthcoming member. The tests indicate that these countries were diverging until 1990. However, since then, they have moved to a more liberal economic system, which has been accompanied by a different evolution of their per capita output. The statistical tests indicate that they are now in a situation of conditional convergence with respect to each other, as well as with respect to the EU members. This is similar to the situation of Greece, Portugal and Spain at the moment they joined the EU. So it is to be hoped that these future members will be able to take full profit of their belonging to the EU.

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