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Total Factor Productivity Convergence Amongst Italian Regions: Some Evidence from Panel Unit Root Tests

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Abstract

In this paper, we employ panel unit root tests to investigate convergence in Total Factor Productivity amongst Italian regions. These tests provide us with inference valid in the presence of heterogeneity and cross-sectional dependence, and when the cross-sectional dimension is smaller than the time dimension, allowing us to investigate convergence amongst different subset of regions. Our results add a futher dimension to the conventional view on growth dynamics in the Italian peninsula depicting a lack of regional TFP convergence not only at the national level, but also at the level of geographical disaggregations where regions are conventionally thought to converge.

Keywords: Total Factor Productivity; Regional Convergence; Panel Unit Root Tests.

JEL Codes: C33, D24, O47, R11.

Introduction

The income differential between the Northern and Southern Italian regions is a well known and long standing issue. This gap still persists despite recent evidence of growth in some regions of the country. Within Europe, Italy remains one of the countries with the widest regional growth differentials. This is clearly a matter of great concern for both national and local authorities. The main policy agenda of the past, the *Intervento Straordinario per il Mezzogiorno* (*Special Funding Plan for the Development of the Mezzogiorno Area*), was oriented towards increasing the amount of industrial investment through financial assistance and/or direct investment in public firms. There is now a general consensus among researchers and policymakers that whilst these policies may have been effective at generating convergence for limited periods of time, they have been unable to target structural differences (technological and financial, but also social and institutional differences) among regions and consequently to produce self-sustaining growth and convergence in the long run.

In the neoclassical framework, these structural differences affect Total Factor Productivity (TFP) and consequently long-run growth. Indeed, in the steady state, capital intensity (i.e. the capital-labour ratio) grows at the same rate of labour productivity, that in turn depends on TFP growth. Many authors (KLENOW and RODRIGUEZ-CLARE, 1997; HALL and JONES, 1999; PARENTE and PRESCOTT, 2000; EASTERLY and LEVINE, 2001) have recently asserted that international cross-country differences in labour productivity depend more on TFP than on capital intensity. For Italian regions, a similar result has been highlighted by AIELLO and SCOPPA, 2000; DESTEFANIS, 2001; ASCARI and DI COSMO, 2005. Therefore, it would appear that the process of convergence in Total Factor Productivity among Italian regions is a particularly interesting topic of investigation in order to better understand the dualistic nature of the Italian regional system.

In this paper, we depart from the traditional approach based on tests for beta and sigma convergence in a strictly cross-sectional regression, and rely more closely on the strand of literature originating from the work of EVANS and KARRAS, 1996, in which the time series properties of the cross sectional data are taken into account. Additionally, we exploit some of the recent innovations in the literature on panel unit root tests and incorporate three particular improvements with respect to the conventional methodology. Firstly, we account for the potential panel heterogeneity arising from the different economic structure of each region. Secondly, we consider the possibility that each region might be characterised by a different growth path. Finally, we incorporate the potential cross-sectional dependence due to common shocks hitting different sets of regions at the same time.

Bearing all this in mind, the remainder of the paper is organised as follows. The next section provides a brief preliminary discussion on regional convergence in Italy. The third section introduces the econometric methodology. The fourth section presents the empirical implementation and discusses the results. Finally, the fifth section concludes and makes suggestions for further research.

Regional Convergence in Italy

The literature on the empirical estimation of convergence in Italy developed after the work of BARRO and SALA-i-MARTIN, 1991. These authors estimated for Italy absolute convergence in GDP per capita at an average rate of 2 percent per annum during the period 1950-1985. This result contrasts starkly with the dualistic nature of growth in Italy and consequently led many researchers to question the robustness of these estimates. Indeed, later studies have highlighted how the results of BARRO and SALA-i-MARTIN, 1991, may well depend on the particular time period under consideration and also on the methodology adopted. There is now a widespread agreement that during the 1960s and the first part of the 1970s the process of convergence reached its apex, whilst the more recent decades are characterised by a tendency for regional economies to diverge (see DI LIBERTO, 1994;

MAURO and PODRECCA, 1994; PACI and PIGLIARU, 1995; CELLINI and SCORCU, 1997; PACI and SABA, 1998; MARGANI and RICCIUTI, 2001).

MARGANI and RICCIUTI, 2001, depart from the conventional BARRO and SALA-i-MARTIN approach and use the methodology suggested by EVANS and KARRAS, 1996, to analyse the process of convergence in regional GDP per capita during the period 1951-1998. These authors estimate a high rate of convergence for the entire period. However, they reject the hypothesis of absolute convergence and accept that of conditional convergence. Moreover, when they break the period into two sub-periods (1951 to 1973 and 1974 to 1998), they find evidence of absolute convergence for the first period and divergence for the second, a result that is common to other studies.

Most of the literature seems to identify a dualistic process of growth between the Centre/North and the Southern regions. Some studies (DI LIBERTO, 1994; MAURO and PODRECCA, 1994; PACI and SABA, 1998) reach this conclusion using a set of dummy variables in the estimation of a convergence equation to account for the greater homogeneity between regions characterised by geographical proximity. A similar result emerges in a strand of literature that uses data disaggregated at the level of Provinces in order to measure the process of convergence more accurately within geographical sub-units (see, for example, COSCI and MATTESINI, 1995; FABIANI and PELLEGRINI, 1997). In particular, ARBIA *et al.*, 2003, analyse convergence in GDP per capita of Italian Provinces during the period 1951-2000. They use models with spatial dependence, and show that two different spatial regimes characterise two different sub-periods. During the first period, between 1951 and 1970, only Provinces with relatively high income follow a process of convergence. During the second period after 1971 this result is completely inverted, and the incomes of poorer Provinces show a tendency to converge. It is interesting to note that while during the first period Provinces with a lower income are located in the South, but also in the Centre (Lazio, Umbria, Marche and Toscana) and the North-East (Friuli Venezia Giulia and Veneto), during the second period low income Provinces are only located in the South. This result is suggestive of a tendency for the Southern regions in general to converge along a unique growth path that drives them fatally away from the National average. On the other hand, the Centre-Northern regions seem to grow along different but virtuous paths.

The focus of these studies, however, is mostly on labour productivity and GDP per capita, while less attention is dedicated to TFP (for some exceptions, see MARROCU *et al.*, 2001; DI LIBERTO *et al.*, 2003, 2004; DESTEFANIS and SENA, 2005). We believe that this is a limitation of the existing literature. Indeed, TFP reflects a wide array of both tangible and non-tangible factors that determine the efficiency of the economy, and production in particular. Since the persistence of spatial differences in Italy can largely be rooted in the efficiency of the production system, an analysis of convergence which looks at TFP can be particularly interesting in order to analyse the structural nature of the process of convergence between regions in the peninsula.

Econometric Methodology

The traditional approach to testing for convergence applies Ordinary Least Squares (OLS) to regress the average growth rate of per capita output over a specified period, $\Delta\bar{y}_i$, on the initial level of per capita output, y_{i0}, and a number of country specific variables, x_{ik}, introduced to capture cross-country structural differences,[1] as follows:

$$\Delta\bar{y}_i = \alpha + \beta y_{i0} + \sum_{k=1}^{K}\delta_k x_{ik} + \varepsilon_i, \qquad (1)$$

where δ_k is the control variables' set of parameters and ε_i is an economy-specific random disturbance. In this specification, where the country/region specific factors are controlled for, the parameter β on the initial level of income measures the so-called conditional convergence. Clearly, there must be a negative correlation between the period average growth and the initial level of per capita output in order to conclude in favour of the convergence hypothesis, i.e. economies starting at a lower income must have grown more quickly than those starting at a higher income. This procedure is usually applied over the widest possible cross-section of economies.

However, EVANS, 1996, shows that if ε_i is correlated with y_{i0}, parameter estimates of equation (1) obtained via OLS are biased, unless $y_{it} - (1/N)\sum_i y_{it}$ is a stationary process and the cross-country or cross-regional differences are permanent (hence uncorrelated with ε_i). If these conditions are met, the N economies are said to converge, and inferences on the heteroskedastic-consistent t-ratio of β and the F-ratio from the δ_s of equation (1) are valid. Three further issues arise with respect to the traditional approach. Firstly, technology generally differs widely across economies (countries or regions). Secondly, the assumption that all the economies have identical first-order autoregressive properties relies on the further unlikely assumption that the set of variables x_k is able to control for all differences. These two assumptions imply that the traditional approach is valid only if the considered economies are homogeneous. Finally, a strictly cross-sectional regression of the equation (1) type throws away all of the time series variation of the series and disregards the dynamic properties of the problem.

To tackle these issues, EVANS and KARRAS, 1996, suggest testing for the stationarity of the demeaned series using the following regression:[2]

$$\Delta(y_i - \bar{y})_t = \theta_i + \varphi_i (y_i - \bar{y})_{t-1} + \sum_{s=1}^{T} \lambda_{is} \Delta(y_i - \bar{y})_{t-s} + \nu_{it}, \qquad (2)$$

where $\bar{y}_t = (1/N)\sum_i y_{it}$, θ_i is an individual-specific constant term (a fixed effect), λ_i is a set of parameters for the serial correlation terms, and ν_{it} is a series of randomly distributed shocks. It is further assumed that $\varphi_1 = \varphi_2 = ... = \varphi_i = ... = \varphi_n = \varphi$. Clearly, in this framework $\varphi = 0$ if the economies diverge, and $\varphi < 0$ if they converge.[3] However, the authors dispense from two critical facts. Firstly, they assume that ν_{it} are uncorrelated, an assumption that is likely to be untenable, especially for a finite cross-section of regional economies. Secondly, they do not exploit the fact that φ can be equal to zero even if only a fraction of the economies in the sample diverge.

In this paper, we intend to overcome some of these limitations exploiting recent advances in Panel Unit Root (PUR) tests. These tests, which dramatically increase the power of their univariate version by pooling cross sectional time series data, are particularly suited to test the notion of convergence introduced by EVANS and KARRAS. One of the first PUR tests was initially developed by LEVIN and LIN, 1993, and then refined in LEVIN *et al.* (LLC), 2002. This test is very similar to the one proposed by EVANS and KARRAS and can be essentially seen as a pooled Augmented Dickey-Fuller (ADF) test as follows,

$$\Delta\tilde{y}_{it} = \alpha_0 + \alpha_1^* \tilde{y}_{it-1} + \beta t + \sum_{j=1}^{p+1} \alpha_j^* \Delta\tilde{y}_{it-j} + \tilde{\varepsilon}_{it}, \qquad (3)$$

where $\tilde{y}_{it} = y_{it} - \bar{y}_t$, and α_0 and t are respectively a constant and a time trend that can be additionally included. As in the univariate ADF, under the null hypothesis the series are non-stationary or integrated of order one, $\tilde{y}_{it} \sim I(1)$. LLC derive a t-statistic (t^*), which is distributed as a standard normal under the null hypothesis of non-stationarity. Although, this test can account for individual effects, time effects, and possibly a deterministic trend, it still assumes that each cross-section in the panel shares the same auto-regressive coefficient, α_1^*, i.e. all series in the panel should exhibit the same degree of mean-reversion. For reasons discussed above in reference to EVANS and KARRAS, this may be potentially restrictive. Whilst the assumption that all series converge on average may be a plausible one, the restriction that all converge at the same speed may be unreasonable, especially in the presence of cross sectional heterogeneity. In this respect, the test developed by LEVIN *et al.*, 2002, does not differ from the approach of EVANS and KARRAS. The test imposes not only homogeneity of unit root under the null hypothesis, but also homogeneity of no unit root under the alternative. This issue may be particularly relevant in our case because differences in economic structure across Italian regions can be sizeable, with potentially relevant implications for empirical modelling (we discuss this issue further in the section below).

Another test widely used in the literature is the one proposed by IM, PESARAN and SHIN, 2003, (IPS). These authors have implemented a test where the alternative hypothesis is less “restrictive” than the one in LLC. IPS propose estimating individual-specific ADF tests and then pooling the t-statistic of each test (i.e. the $\bar{t}$ -statistic). They then compute the exact critical values of this statistic and, after adjusting for the size of NxT, produce a statistic ($W[\bar{t}]$) which has a standard normal distribution under the null hypothesis of non-stationarity. As in LLC, the test developed by IPS, after allowing for individual effects, possible time trends, common time effects and lags to account for serial correlation, assumes that all series are non-stationary under the null hypothesis. Unlike the LLC test, however, this test does not assume that all series are stationary under the alternative, but is consistent under the alternative that only a fraction of the series are stationary.

Other alternatives similar to the above tests are available, but these are the most commonly used in the PUR literature.[4] Within the context of panel time series, however, SARNO and TAYLOR (ST), 1998, have suggested an alternative to LLC and IPS that we believe to be especially useful when considering regional convergence. Sarno and Taylor develop a multivariate version of the augmented Dickey-Fuller test that employs Zellner's Seemingly Unrelated Regression (SURE) estimator which we consequently use to compare against our results from LLC and IPC. The ST test involves the hypothesis, for each equation, that the sum of the coefficients of the autoregressive polynomial is unity. The null hypothesis consists of the joint test that this condition is satisfied over the N equations. Hence, under the null hypothesis, all of the series in the panel are non-stationary stochastic processes. Since the asymptotic properties of the statistic are unknown, TAYLOR and SARNO, 1998, provide response surface estimates of the 5% critical values, derived from

Monte Carlo simulation. This test entails three main advantages. Unlike the other tests mentioned, by relying on SURE methods, it takes account of the potential cross-sectional dependence of errors.[5] This is particularly important in our analysis, since common shocks or spillovers are very likely to be correlated across regions with the effect of increasing the process of convergence among some regions or the divergence amongst others. Moreover, while the LLC test is more suited to small-T and large-N panels, as in standard SURE models, the ST test can only be applied to panels where the cross-sectional dimension is smaller than the time dimension. Hence, it is more suited to our case, where $T > N$. Finally, thanks to this last property, we can purposefully use it to gather meaningful evidence on convergence between smaller subsets of regions. As for the other tests, also for ST consideration of the null and the alternative hypothesis is important. Under ST, the null hypothesis of non-stationarity can be rejected even if just one of the series in the panel is stationary. Hence, rejection of the null cannot be taken as conclusive evidence that each of the series is stationary, and there is full convergence. On the contrary, if the null is not rejected, it is possible to conclude unequivocally that all the series in the panel are non-stationary and none exhibits a tendency to converge.

In the literature on PUR testing, KARLSSON and LÖTHGREN, 2000, have emphasized this point by highlighting the danger of rejecting the null when only a fraction of series is stationary and have called for a careful consideration of the null and the alternative hypotheses. In order to aid the interpretation of the panel tests, we also investigate the univariate behaviour of each of the regional TFP series using the unit root test developed by ELLIOTT , *et al.* (1996).

More recent developments in PUR tests have also attempted to account for cross-sectional dependence using factor models. Therefore, in order to gain further evidence we also compare the ST test to two additional tests. In particular, we are going to implement the tests proposed by BAI and NG, 2004, and by PESARAN, 2007. The PANIC (Panel Analysis of Nonstationarity in Idiosyncratic and Common) approach by BAI and NG, 2004, uses a factor structure to understand the nature of non-stationarity in a panel data set. This approach can allow us to determine whether non-stationarity in a series is pervasive or variable specific. In this case the panel time series is the sum of a cross section specific constant, a common factor and an idiosyncratic error term. PESARAN, 2007, instead, proposes cross sectionally augmented panel unit root tests in the case where a single factor deals with cross sectional dependence. In particular, cross sectional averages of the panel variables are included in the panel ADF test. We now turn to the empirical implementation.

Empirical Implementation

Measuring Total Factor Productivity

The literature on the computation of TFP is in rapid evolution and new methodologies are continuously suggested.[6] Yet, little consensus emerges on one specific method. In this paper, we adopt for our purposes the Growth Accounting methodology (GA) firstly proposed by SOLOW, 1957. The most evident limitations of this approach relate to the choice of a particular functional form, the assumption of constant returns to scale, perfect competition (as discussed by MORRISON, 1992), and constant factor shares and time invariability of the production technology.

In spite of these limitations, the choice of GA to compute TFP is motivated in our case by a number of considerations. The first and probably most binding relates to the limited availability of regional Italian data, in particular, with respect to accurate estimates of the capital stock at the sectoral level for each region, which would allow a more refined calculation of the TFP series. Still, we believe that in a study of regional convergence some important and interesting inference can be extracted from a regional aggregate perspective. For the purpose of this paper, the use of a general calculation of TFP based on a residual measurement allows us to study convergence over a broad number of factors. In agreement with HULTEN, 2001, we can consider the variation of the residual not only as technical change but, more generally, as a shift in the production function caused by "*technical innovations, organizational and institutional changes, shifts in social attitudes…*" (page 40, HULTEN, 2001). This interpretation of Solow's residual seems to us particularly appropriate in our case, given that some relevant differences between Italian regions do not only depend on technological factors, but also on unobserved and unobservable region-specific factors. Indeed, some of these factors are indicated in the recent literature as the main cause of the failure of the Special Intervention Strategy adopted in Italy until the early 1990s.

However, given the above discussion and the purpose of the analysis, a measurement error of TFP due to incorrect measurement of production factors would be a possibility. For this reason, with respect to the measurement of capital, the most important factor in the analysis, we have made a specific effort to obtain the net, rather than gross, capital accumulation (see the data appendix), in order to reduce the so called productivity "slowdown effect" (MORRISON, 1992, GITTLEMAN *et al.*, 2006). With particular reference to the assumption of constant returns to scale, such a hypothesis seems to us less binding for an aggregation of all the sectors in the economy (industry, agriculture, services), as in our case. In other words, it would have been more binding, had we imposed it on disaggregate sectoral data. Still, in order to substantiate this assertion, we have performed a robustness analysis to assess the validity of the Constant Returns to Scale (CRTS) assumption. This analysis, based on a non-parametric Data Envelopment Analysis (DEA) methodology that does not assume a specific functional form and allows for variable returns, does not provide evidence against the use of a functional form and the CRTS assumption.[7] Hence, we feel comforted to apply the GA methodology that we describe below.

Since the Italian Statistical Office (ISTAT) has recently provided the national time series of TFP for the period 1993-2003, but official data is not available at the regional level, we have adapted the GA methodology in order to obtain the series of TFP for 19 Italian regions from 1970 to 2001.[8] This approach starts from a conventional Cobb-Douglas production function with constant returns to scale:

$$Y = K^{1-\alpha}(AL)^{\alpha}, \tag{4}$$

where, suppressing the time subscript momentarily, Y is value added at constant prices, K is the stock of physical capital, L is labour measured in standard units, and A represents technical progress, which is assumed to be labour-augmenting (or Harrod neutral). Perfect competition is assumed in the inputs market. In this methodology, the main problem is to define a reasonable value for the labour income share (α). In many papers, this parameter is assumed to be a fixed value of 0.7 both over time and across units. Hence, the possibility of different regional economic structures is not taken into account. In order to overcome this criticism, which could be particularly binding in our case, we have used an estimate of the labour-income share as the ratio between labour costs and value added:[9]

$$\alpha = \frac{wL}{Y^{p}},$$

where w is the per capita income of employed workers, L is the overall number of workers (employed and self-employed) measured in standard units, and Y^{p} is the value added at current prices. This allows us to have labour income shares which vary both over time and across units.

[insert figure 1 about here]

Figure 1 illustrates the time variation in each region's labour-income share. Indeed, while in 1970 the average α across units was 0.7, it becomes 0.6 in 2001. This result is coherent with the hypothesis of a change in the underlying composition of the economy. From equation (4), we can obtain the value of the regional TFP, as:

$$A = TFP = \left[\left(\frac{Y}{L} \right) / \left(\frac{K}{Y} \right)^{\frac{1-\alpha}{\alpha}} \right]. \tag{5}$$

A, the Solow residual, measures the quantity of output that does not depend on the factors of production. Rearranging equation (5), the decomposition of labour productivity becomes evident:

$$\left(\frac{Y}{L} \right) = TFP \cdot \left(\frac{K}{Y} \right)^{\gamma}, \tag{6}$$

where $\gamma = (1-\alpha)/(\alpha)$.

[insert table 1 about here]

Table 1 shows the average value for each region and for macro areas of each component of equation (6) in the period 1970-2001. From this table, we can see a decrease in labour productivity from the North-West (9% above the national average) to the South (14% below the national average) of the country. A similar gap is estimated for TFP. On the other hand, the distribution of capital per unit of output seems to be more homogeneous among the macro-areas. Moreover, labour productivity is highly correlated with TFP and little with the ratio K/Y (0.80 and 0.26 correlation respectively). Hence, we believe that in order to explain the Y/L difference, it is more important to look at TFP rather than the ratio K/Y.

Figure 2 plots the regional time series for TFP obtained using the growth accounting methodology. A simple visual inspection seems to suggest a tendency for the series to converge from 1970 to 1980 and a persistence of the regional gaps over the subsequent period. Therefore, it seems particularly important to apply a testing methodology that can account for the time dynamics of the convergence process.

[insert figure 2 about here]

Results

Following the discussion in section 3, we have tried to identify convergence by performing the LLC, IPS, and ST panel unit root tests on the distance between each region's TFP and the cross sectional average, that is to say:

$$TFP_{it}^{*} = \ln(TFP_{it}) - \frac{1}{N}\sum_{i=1}^{N}\ln(TFP_{it}) \quad (7)$$

Firstly, however, it is important to discuss further the issue of panel heterogeneity. In cross-sectional comparisons, this issue may be particularly relevant because differences in economic structure can be sizeable with potentially relevant implications for empirical modelling. Two types of heterogeneity should be considered. “Type-one” heterogeneity is due to the potential “structural” differences between regions. “Type-two” heterogeneity is more relevant to the dynamic nature of the estimation and affects the slope coefficients of the mean-reverting term. Since the work of ROBERTSON and SYMONS, 1992, and PESARAN and SMITH, 1995, it has been noted in the literature that Fixed Effects (FE) estimation is potentially inconsistent when using dynamic equations under cross sectional heterogeneity. In contrast, an average panel estimator, such as the Mean Group (MG) estimator (see PESARAN and SMITH, 1995) or a Swamy's Random Coefficient Model (RCM) will provide consistent estimates of the average of the parameters from dynamic regressions although these estimates will be inefficient since we are not fully utilising all the potential advantages of poolability in the panel.

In our context, where regions and not countries are confronted, heterogeneity in general should in theory be less relevant. In practice Italian regions differ widely in economic structure and the possibility of both type one and two heterogeneity should be considered. While the three PUR tests we propose account for type-one heterogeneity by including an individual fixed effect to the estimation, a separate analysis should be made on type-two heterogeneity. Firstly, the three tests are affected differently by this issue. While the LLC imposes homogeneity under both the null and the alternative hypotheses, concluding for full convergence, IPS and ST are consistent under the alternative hypothesis with the possibility that only a fraction of the series (just one series in the ST case) is stationary. Hence, the consequences of heterogeneity will be smaller on the second and third tests. In order to explicitly examine panel poolability, we use a Hausman statistic[10] to compare the Fixed Effects (FE) and the Random Coefficient Model (RCM). The test indicates whether the FE estimates include a bias due to slope heterogeneity and therefore whether we can pool different groups into a single panel. As suggested by PESARAN *et al.*, 1996, the test statistic, distributed as a $\chi^2(k)$, has a null hypothesis of homogeneity, when FE estimates are equal to RCM estimates, and an alternative of heterogeneity. Where $\hat{\theta}$ is a (k x 1) vector of FE estimates and $\tilde{\theta}$ is a (k x 1) vector of RCM estimates under the null of homogeneity. The test statistic is of the form

$$(\tilde{\theta}-\hat{\theta})'[V(\tilde{\theta})-V(\hat{\theta})]^{-1}(\tilde{\theta}-\hat{\theta}) \sim \chi^2(k), \tag{8}$$

where $V(\theta)$ is the estimated variance of θ. We have used the Hausman statistic discussed above to perform a test of poolability of the data for the full sample and for different aggregations of regions. Table 2 shows that according to this test the slopes of the autoregressive parameters are homogeneous at any level of aggregation. This result is not too surprising since our measure of TFP is bound to capture the more persistent part of the growth dynamics.[11] Still, it reassures us with respect to the second type of heterogeneity, and we can proceed with the panel unit root tests, which are presented in table 3.

[insert table 2 and 3 about here]

The first test we apply to test for convergence is the LLC test. As discussed in section 3 this test takes into account differences between regions that are constant over time, but does not consider differences in the speed of convergence. Still, it provides us with useful evidence on the convergence process on average. Considering the full cross section, this test cannot reject the null of non stationarity in the series, leading us to conclude that there is no convergence in the Italian regional system as a whole. This result is in line with much of the literature and with conventional wisdom. Next, we partition the sample according to the geographical taxonomy conventionally used in the literature, where the Centre-North and the South are usually considered as separate blocks of regions, and investigate whether regions in sub-groups display any tendency to converge. Then, we further separate the Centre-North into a Central and a Northern block. Now, more interestingly, the same test applied first on the partition of the sample into two sub-groups, the South and the Centre-North,[12] concludes at the 5% critical level that there is no convergence among the Southern regions and convergence among the regions in the Centre-North. As a further check, we have refined the groupings into different disaggregations, dividing the Centre-North between Central and Northern regions.[13] Now, the test concludes that there is no convergence among Central regions and convergence among the Northern regions (at the 5% critical level). Therefore, the LLC test seems to conclude that most of the convergence picked up in the Centre-North grouping was coming through the convergence among the Northern regions, while the Southern regions do not show a tendency to converge.

The second panel unit root test is by Im, Pesaran and Shin (IPS). This test adopts a less restrictive alternative hypothesis than the LLC test and, hence, it is less affected by the second type of heterogeneity. Applied to the entire panel, according to this test we cannot reject the null of no stationarity, a result that mirrors the one obtained earlier. However, the tests do not suggest convergence even when we break down the sample into sub-groups of regions.

As discussed above, both previous tests are more suited to large-*N*-small-*T* panels and both do not account for the potential cross-sectional interdependence between the regions due to third factors, such as common macroeconomic shocks, or spillovers. The methodology suggested by SARNO and TAYLOR, 1998, relying on a SURE-type methodology, allows a step forward in both directions in that it is more suitable for small-*N*-large-*T* panels and accounts for cross sectional errors dependence. In this test, however, rejection of the null cannot be taken as conclusive evidence that all the series are stationary, but that at least one is (see TAYLOR and SARNO, 1998). On the other hand, not rejecting the null allows us to conclude that all series are nonstationary, hence no region is converging. Interestingly and in contrast to LLC and IPS, for the full cross section this test rejects the null hypothesis, leading us to conclude that some subset of regions could be in a process of convergence. When we look at the geographic groupings of regions, this test yields a similar result for the subsets of Southern, Central-Northern, and Central regions. Although interesting, an honest interpretation of this result cannot be considered as conclusive evidence of convergence, as it may simply be that some regions in the group are converging, while others are not.

As discussed in the third section, this was a criticism of PUR tests raised by KARLSSON and LÖTHGREN, 2000. In order to investigate this issue, we have analysed the time series behaviour of each regional series independently using the univariate root test proposed by ELLIOTT *et al.*, 1996.[14] We present these results in table 4.[15] For the TFP series demeaned by the national average, these tests suggest that all, but one (Sicily), of the series in the panel are non-stationary. This explains the conclusion of stationarity of the ST test. A similar result can be claimed for the Centre and the South sub groups. On the other hand the result of no convergence in the North, finds even further support.

[insert table 4 about here]

Hence, we confirm the most interesting result from this run of ST tests (i.e. the conclusion of no evidence of convergence amongst the regions in the Northern group). This test, as discussed above, is particularly telling with respect to the null of nonstationarity and it allows us to conclude that when cross sectional dependence is taken into account not a single series in the Northern group is stationary, i.e. converges towards the cross-sectional mean. This result is particularly novel in the literature on regional disparities and growth in Italy, where Northern regional economies are more often considered as part of a unique growth cluster.

Finally, we present the results of panel unit root test methods based on the analysis of potential common factors to take account of cross sectional correlation. Theses include the PANIC approach to non-stationarity in panels from BAI and NG, 2004, and the Cross Sectionally Augmented ADF (CADF) test due to PESARAN, 2007. The former can be considered more powerful evidence since it takes account of the possibility of non-stationarity in the common factor. Results for both of these tests are reported in Table 5. In all cases, that is both tests for any regional sub group, these cannot reject the null of panel non-stationarity.[16]

[insert table 5 about here]

Conclusions

The marked dualism between Northern and Southern regions of Italy is a well know issue. Past evidence on regional convergence in per capita income and labour productivity has confirmed this result. In this paper, we have investigated the issue of convergence with a focus on the long run structural determinants of growth, measured here by Total Factor Productivity.

As a first step, we have measured TFP for each region in Italy using the growth accounting methodology, which allows us to obtain a panel varying TFP. Secondly, along the lines of the literature due to EVANS and KARRAS, 1996, and exploiting recent advances in panel data methods, we have tested for convergence in TFP using a battery of panel unit root tests. These tests allow us to test not only for overall convergence, but also for convergence in subsets of regions, accounting for the heterogeneity in the structure of different regions. Using a panel unit root method based on a multivariate technique, in particular SURE, we are also able to incorporate the effect of cross-sectional interdependence.

The results provide us with interesting evidence. Both the Levin, Lin and Chu (LLC) and the Im, Pesaran and Shin (IPS) tests on the entire set of Italian regions conclude in line with the conventional wisdom that the full set of regions does not display a common process of convergence. When we apply the Multivariate Augmented Dickey Fuller (ST) test on the full panel, however, we reject the null hypothesis of no convergence. Upon careful consideration of the null and the alternative hypothesis of the three tests, we can conclude that, while there has been no overall convergence in Italy, results are consistent with the possibility of a process of convergence among a sub set of regions.

Therefore, as a second step, we have divided the original group of nineteen regions into geographical subgroups identified accordingly to the traditional convention. When we split the sample into Southern and Central-Northern regions, we find once more evidence of no convergence using LLC and IPS, but evidence of convergence when we account for cross sectional dependence using the ST test. A similar result is obtained on the Central-Northern group of regions. In order to clarify this point, we have further split the sample into Northern and Central regions. This separation shows that most of the convergence picked up by the ST test was among regions in the Centre, whilst the regions in the North do not exhibit any tendency to converge among each other. Further evidence from univariate unit root tests shows that the evidence of convergence in the South and the Centre cannot be considered as conclusive, and can be a consequence of the convergences of a small number of regions. On the other hand, the result of no convergence in the North seems to hold robust. To the best of our knowledge, this is a novel result in the literature on (the lack of) convergence in Italy. Additional tests, such as the PANIC by BAI and NG, 2004, and the CADF by PESARAN, 2007, strengthen this result and shift the balance of evidence towards a general conclusion of no convergence for all of the sub-groups of regions considered. Therefore, our tests provide substantial evidence against the usual portrait of convergence within geographical areas (the two or three Italies). Contrary to the conventional wisdom, each region seems to follow its own growth path.

The lack of convergence in Total Factor Productivity may explain why, as suggested in past studies, income convergence in Italy has occurred only for limited periods of time. Past policies have not been able to produce the much needed reduction in structural productivity differences at the root of the persisting regional gaps. Even further divergence is to be expected in the future, if policymakers will not make an exceptional effort to target these structural differences. However, some caveats apply to the present work. Despite our best attempts to reduce the consequences of some of the well known problems related to the Growth Accounting methodology, some of these limitations may still have a bearing on our results. Releasing some of the most stringent assumptions of this approach may yield insights on the result of no convergence.

Finally, some interesting extensions beyond the scope of this paper could help shed further light on what drives these conclusions and we propose them as a possible sequel of this work. Firstly, a more "refined" version of TFP ultimately developing from the micro level, may shed more light on the relationship between convergence or divergence and potentially differing degrees of returns to scale due to the sectoral decomposition across regions. Secondly, while in this paper we have followed a strictly time series approach to address the estimation of convergence, a natural step forward would be to look at the determinants of TFP and try to explain which factors may have contributed to convergence or divergence among Italian regions over the last thirty years.

Acknowledgements

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Data Appendix

Variables Definitions

K: stock of net physical capital.

Y: value added at constant prices;

Y^p: value added at current prices;

L: labour factor measured in standard units;

w: per capita income of employed workers;

α : total labour cost (wL) divided by Value Added at current prices (Y^p)

Sources

The regional series for value added (constant and current prices), labour and per capita income of employed workers were kindly made available by FELLI *et al.*, 2004, who have reconstructed these series for the period 1970-2001. The national stock of net physical capital for the period 1970-2001 from ISTAT National Accounts (*Contabilità Nazionale*) has been disaggregated to the regional level using a matrix of regional shares created from the regional stocks constructed by PACI and PUSCEDDU, 2000, available from the North South Centre for Economic Research (Centro Ricerche Economiche Nord Sud, CRENOS). All series were carefully inspected for potential inconsistencies and discrepancies.

We are particularly grateful to FELLI *et al.* for sharing their data and to PACI and PUSCEDDU for making their data available at http://www.crenos.it

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Table 1: Labour Productivity, Capital-Output ratio and Total Factor Productivity
Regional and Macro-Area Average (1970-2001)
Italy=1.00

Region	Y/L	$(K/Y)^{\gamma}$	TFP
Piemonte	1.06	1.08	1.09
Lombardia	1.13	1.18	1.12
Liguria	1.09	0.89	0.95
North West	1.09	1.05	1.05
Trentino A.A.	1.06	0.83	1.03
Veneto	0.98	1.08	1.15
Friuli V.G.	0.93	0.89	1.02
Emilia R.	1.02	1.05	1.05
North East	1.00	0.96	1.06
Toscana	0.99	1.01	1.04
Umbria	0.93	1.05	0.9
Marche	0.86	0.82	0.94
Lazio	1.14	0.79	1.2
Centre	0.98	0.92	1.02
Abruzzo	0.89	0.89	0.85
Molise	0.82	0.83	0.9
Puglia	0.82	1.02	0.82
Campania	0.86	0.78	0.92
Basilicata	0.79	0.98	0.76
Calabria	0.76	0.87	0.78
Sicilia	0.95	0.99	0.83
Sardegna	0.96	1.25	0.87
South	0.86	0.95	0.84

Table 2: Hausman Test Statistic for Slope Homogeneity – TFP*

All Regions (N=19)		
Statistic	P-value	Conclusion
0.00	0.968	Homogeneity

South (N=7) Basilicata, Calabria, Campania, Molise, Puglia, Sardegna, Sicilia		
Statistic	P-value	Conclusion
0.10	0.748	Homogeneity

Centre-North (N=12) Emilia Romagna, Friuli V.G., Liguria, Lombardia, Piemonte, Trentino A.A., Veneto, Lazio, Marche, Toscana, Umbria, Abruzzo		
Statistic	P-value	Conclusion
0.68	0.408	Homogeneity

Centre (N=5) Lazio, Marche, Toscana, Umbria, Abruzzo		
Statistic	P-value	Conclusion
0.57	0.449	Homogeneity

North (N=7) Emilia Romagna, Friuli V.G., Liguria, Lombardia, Piemonte, Trentino A.A., Veneto		
Statistic	P-value	Conclusion
0.00	0.999	Homogeneity

Notes: The Hausman test examines heterogeneity across cross-sections. The null hypothesis is accepted for high P-values.

Table 3: Panel Unit Root Tests of TFP

All Regions (N=19)

Test	Statistic	P-value	Conclusion
LLC	-5.69	0.0804	No convergence
IPS	-1.62	0.3140	No convergence
MADF	258.98*		Convergence

South (N=7)
Basilicata, Calabria, Campania, Molise, Puglia, Sardegna, Sicilia

Test	Statistic	P-value	Conclusion
LLC	-4.56	0.0888	No convergence
IPS	-1.88	0.1430	No convergence
MADF	29.26*		Convergence

Centre-North (N=12)
Emilia Romagna, Friuli V.G., Liguria, Lombardia, Piemonte, Trentino A.A., Veneto, Lazio, Marche, Toscana, Umbria, Abruzzo

Test	Statistic	P-value	Conclusion
LLC	-4.38	0.0264	Convergence
IPS	-1.56	0.4430	No convergence
MADF	89.36*		Convergence

Centre (N=5)
Lazio, Marche, Toscana, Umbria, Abruzzo

Test	Statistic	P-value	Conclusion
LLC	-2.78	0.0627	No convergence
IPS	-1.63	0.3940	No convergence
MADF	28.63*		Convergence

North (N=7)
Emilia Romagna, Friuli V.G., Liguria, Lombardia, Piemonte, Trentino A.A., Veneto

Test	Statistic	P-value	Conclusion
LLC	-3.88	0.0204	Convergence
IPS	-1.69	0.3130	No convergence
MADF	24.79*		No convergence

Notes: For the Sarno and Taylor (MADF) test, the critical value is 26.38 and test statistics significant at the 5% critical level are denoted with an asterisk (*). Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS) and MADF all have a null hypothesis of panel unit root.

Table 4: Univariate Unit Root Results for TFP Convergence

Region	Full Sample	Centre-North	North	Centre	South
Abruzzo	-1.608 (0)	-1.545 (0)		-1.703 (0)	
Basilicata	-1.164 (1)				-1.089 (1)
Calabria	-1.265 (1)				-1.267 (1)
Campania	-1.110 (1)				-1.158 (0)
Emilia R.	-0.053 (0)	0.157 (0)	-0.211 (1)		
Friuli V.G.	-1.118 (1)	-1.058 (0)	-1.177 (0)		
Lazio	0.041 (0)	0.288 (0)		0.282 (0)	
Liguria	0.265 (0)	0.572 (0)	0.451 (0)		
Lombardia	-0.418 (0)	-0.283 (0)	-0.518 (1)		
Marche	-0.574 (0)	-0.348 (0)		-0.903 (0)	
Molise	-1.218 (0)				-1.168 (0)
Piemonte	-0.693 (1)	-0.364 (1)	-0.621 (1)		
Puglia	-1.570 (0)				-1.840 (0)
Sardegna	-1.656 (0)				-1.679 (1)
Sicilia	-2.017 (0)*				-2.081 (0)*
Trentino A.A.	-1.432 (0)	-1.67 (0)	-1.752 (0)		
Toscana	-1.680 (0)	-2.824 (0)*		-1.99 (1)*	
Umbria	0.466 (1)	-0.587 (0)		-0.576 (0)	
Veneto	0.007 (0)	-0.583 (1)	-0.337 (1)		

Notes: This table presents convergence results for Italian Total Factor Productivity based on the univariate ELLIOT, ROTHEMBERG and STOCK, 1996, point optimal unit root test. The 5% critical value is -1.96 and cases when the unit root null is rejected are denoted with an asterisk (*). The lag length (in parentheses) is established by Modified AIC approach of Ng and Perron (2001).

Table 5: Factor Augmented Panel Unit Root Tests of TFP

All Regions (N=19)

Test	Statistic	Conclusion
Pesaran	-1.631	No Convergence
BN-ADF$_F$	-1.984	No Convergence
BN-PC$_e$	-1.770	No Convergence

South (N=7)
Basilicata, Calabria, Campania, Molise, Puglia, Sardegna, Sicilia

Test	Statistic	Conclusion
Pesaran	-1.656	No Convergence
BN-ADF$_F$	-1.396	No Convergence
BN-PC$_e$	-0.362	No Convergence

Centre-North (N=12)
Emilia Romagna, Friuli V.G., Liguria, Lombardia, Piemonte, Trentino A.A., Veneto, Lazio, Marche, Toscana, Umbria, Abruzzo

Test	Statistic	Conclusion
Pesaran	-1.567	No Convergence
BN-ADF$_F$	-0.921	No Convergence
BN-PC$_e$	-0.919	No Convergence

Centre (N=5)
Lazio, Marche, Toscana, Umbria, Abruzzo

Test	Statistic	Conclusion
Pesaran	-1.504	No Convergence
BN-ADF$_F$	-0.274	No Convergence
BN-PC$_e$	-0.108	No Convergence

North (N=7)
Emilia Romagna, Friuli V.G., Liguria, Lombardia, Piemonte, Trentino A.A., Veneto

Test	Statistic	Conclusion
Pesaran	-1.500	No Convergence
BN-ADF$_F$	-1.462	No Convergence
BN-PC$_e$	-1.981	No Convergence

Notes: The Pesaran test is a Cross Sectionally Augmented ADF (CADF) statistic which has a 5% critical value of -2.20. Bai and Ng (2004) BN-ADF$_F$ has a 5% critical value of -2.86. Bai and Ng (2004) BN-PC$_e$ critical value at the 5% significance level is 1.96. Both approaches are based on the assumption of one common factor, an assumption we consider in the text using BAI and NG's (2002) information criteria.

Figure 1: Labour-Income Share of Italian Regions

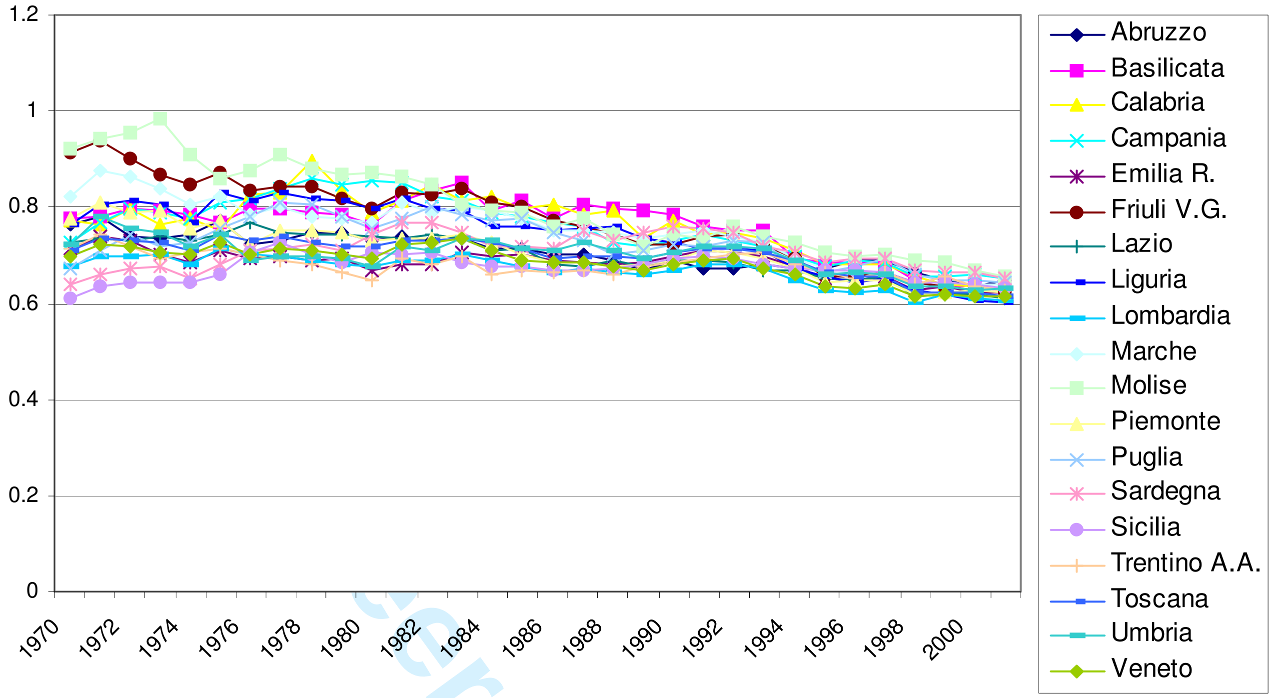
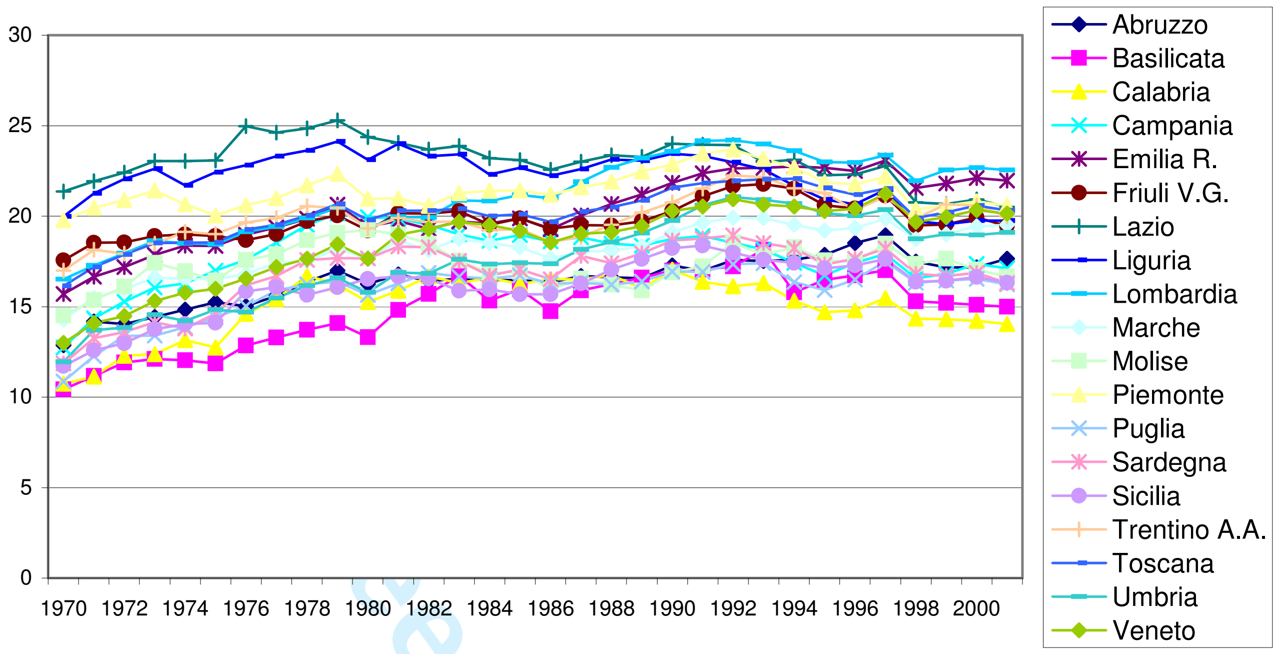


Figure 2: Total Factor Productivity of Italian Regions



Notes

[1] Lagged values or period averages are generally utilised.

[2] This approach has now evolved into a strand of literature that follows "strictly a time series" approach to test growth convergence (see ISLAM, 2003), in which the economy-specific factors (x_{ik} in equation 1) are omitted under the assumption that they are constant through time and hence they can be incorporated through the fixed effects terms in our panel estimation. Additionally we account for time varying common shocks through SURE analysis and our tests which utilise common factors.

[3] The notion of convergence introduced by EVANS and KARRAS, 1996, is essentially based on the claim that different economies converge if, and only if, they share a common stochastic trend.

[4] MADDALA and WU, 1999, for example, have proposed a test, which is similar to that of IPS, in that it combines the p-values from N independent unit root tests. The major advantage of this test is that it does not require the panel to be balanced, a property that is not required in our case. HADRI, 2000, on the other hand, develops a Lagrange Multiplier test where the test statistic is distributed as standard normal under the null of stationarity.

[5] The SURE approach has been also adopted recently to estimate panel monetary exchange rate models (see GROEN, 2000) and when testing Purchasing Power Parity (see CHEN, 2004).

[6] ISLAM, 2001, compares the time series, cross-sectional growth regression, and the cross-sectional growth accounting methodologies and comments that "*[…] the comparison of results reveals both similarities and dissimilarities. While similarities are heartening, dissimilarities should not prove discouraging […] The TFP, by definition is a complicated social phenomenon. It would rather be surprising if different approaches came out with too similar results*".

[7] A full discussion on the theory and the results of this analysis are available from the authors on request.

[8] As in most of the studies on Italian regions, we have omitted Valle d'Aosta from the sample, because of its modest size in absolute terms.

[9] This expression is obtained through a simple profit maximisation problem with Cobb-Douglas technology and constant returns to scales. See the Data Appendix for further details on how this parameter has been computed.

[10] Use of the Hausman test to check for heterogeneity is now common in the non-stationary panel literature (see for example the discussion in PESARAN *et al.*, 1999, and the applications in IMBS *et al.*, 2005 and BYRNE and DAVIS, 2005).

[11] Hence, this test simply concludes that the mean-reversion (or non-mean-reversion) properties of the series are similar.

[12] The South consists of Basilicata, Calabria, Campania, Molise, Puglia, Sardegna, Sicilia; the Centre-North includes Emilia Romagna, Friuli V.G., Liguria, Lombardia, Piemonte, Trentino A.A., Veneto, Lazio, Marche, Toscana, Umbria, Abruzzo.

[13] Central regions are Lazio, Marche, Toscana, Umbria, Abruzzo; norther regions are Emilia Romagna, Friuli V.G., Liguria, Lombardia, Piemonte, Trentino A.A., Veneto.

[14] According to ELLIOTT *et al.*, 1996, their testing procedure is more powerful than standard ADF tests in small samples with a large autoregressive parameter. For a sample size of 100 observations, they report rejection frequencies (i.e. the likelihood of correctly rejecting a false null test) of at most 30% with an autoregressive coefficient of 0.95, while the ADF test has a rejection frequency of approximately 10%. Yet, considerable power gains can be obtained by utilising a panel unit root approach compared to the univariate tests. For example, SARNO and TAYLOR, 1998, suggest that the rejection frequency in their test approached 100% as the sample size approaches 100. Even if the time span in our sample is smaller, the cross sectional dimension of the data will give greater power to the panel unit

root tests.

[15] We have also performed standard ADF tests (see DICKEY and FULLER, 1979) along with the more recent univariate tests due to and SAIKKONEN and LÜTKEPOHL, 2002, that examines whether rejection of the null is dependent on the inclusion of mean breaks in the series. The results of these tests are not fundamentally different from the ones obtained through the test of ELLIOT et al., 1996, and hence are not reported in the paper.

[16] However, these tests assume that there is one common factor. BAI and NG's, 2002, information criteria that accounts for potential cross sectional correlation suggests that the most appropriate model is one with no common factors and hence a factor model is not appropriate to deal with cross sectional correlation (These tests are not reported but are available on request by the authors.). This lends further weight to our MADF results which suggest that the feasible SURE analysis is an appropriate alternative, especially with large T, to the factor augmented panel unit root models.