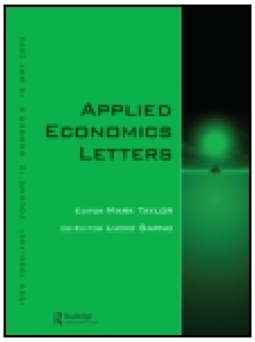

Applied Economics Letters

ISSN: 1350-4851 (Print) 1466-4291 (Online) Journal homepage: http://www.tandfonline.com/loi/rael20

Agricultural productivity convergence across Europe and the United States of America

Anthony N. Rezitis

Applied Economics Letters, 2005, **12**, 443–446

Routledge
Taylor & Francis Group

Agricultural productivity convergence across Europe and the United States of America

Anthony N. Rezitis

Department of Farm Organization and Management, University of Ioannina, 2 G. Seferi Street, Agrinio 30 100, Greece
E-mail: arezitis@cc.uoi.gr

This paper applies time series techniques to test for convergence in agricultural total factor productivity among the USA and a sample of nine European countries for the period 1973–1993. The data set used in this paper obtained from Ball *et al*. (2001). The wide spectrum of unit root test results obtained in the present study support the presence of convergence among the sample countries.

I. Introduction

Numerous empirical studies have examined the convergence hypothesis for various countries or regions around the world, e.g. McCoskey (2002), Happich and Geppert (2003) and Su (2003) among others. There are, however, much fewer studies examining convergence in agricultural sectors around the world, e.g. Ball *et al*. (2001). The objective of the present paper is to investigate convergence in agricultural total factor productivity (*TFP*) growth for the USA and nine European countries, i.e. Germany, France, Italy, the Netherlands, Belgium, the UK, Ireland, Denmark and Greece, over the period 1973–1993 and for the two subperiods 1973–1981 and 1982–1993. To this end, the paper utilizes exactly the same agricultural total factor productivity data as the study by Ball *et al*. (2001), but it uses time series techniques for investigating convergence. In particular, the time series approach used in the present study examines long-run behaviour of differences in productivity across countries and assumes convergence, if these differences are transitory, in the sense that they are *approaching zero* in the long run. This paper uses recently developed panel unit-root tests for testing convergence, while the paper by Ball *et al*. (2001) uses conventional cross-section techniques. The rest of the paper is organized as follows. Section II presents the basic model. In Section III, the estimation procedures and the results are discussed. Finally, Section IV summarizes the paper.

II. The Basic Model

The neoclassical growth model without technology asserts convergence in output per worker for similar, closed economies based on the accumulation of capital. However, if the exogenous technology process follows different long-run paths across countries, there will be no tendency for convergence. This paper follows the study by Bernard and Jones (1996) and considers a simple model of sectoral output in which convergence in output occurs due to the improvement in *TFP*. In this model, convergence in *TFP* across countries may occur, if relatively backward countries can grow more rapidly by efficiently using the same technologies that are available to the more advanced countries. Thus, following

Applied Economics Letters ISSN 1350–4851 print/ISSN 1466–4291 online © 2005 Taylor & Francis Group Ltd
http://www.tandf.co.uk/journals
DOI: 10.1080/13504850500109691

Bernard and Jones (1996) a Cobb–Douglas production function with constant returns to scale is given as

$$\ln Y_{i,t} = \ln A_{i,t} + \alpha \ln K_{i,t} + (1-\alpha)\ln L_{i,t} \qquad (1)$$

where $\ln Y_{i,t}$ is the log of the output in agriculture in country i at time t, $A_{i,t}$ is an exogenous technology process, $K_{i,t}$ is the capital stock, and $L_{i,t}$ is the number of workers in the sector. It is assumed that $A_{i,t}$ is given according to

$$\ln A_{i,t} = \gamma_i + \lambda \ln \frac{A_{US,t-1}}{A_{i,t-1}} + \ln A_{i,t-1} + \varepsilon_{i,t} \qquad (2)$$

where γ_i is the asymptotic rate of growth of agriculture in country i, the parameter λ represents the speed of catch-up, which is a function of productivity differential in agriculture in country i from that of the USA, i.e. one of the most productive countries, A_{US}, and $\varepsilon_{i,t}$ is the country-specific productivity shock, i.e. the error term. Equation 2 implies that *TFP* growth in country i may potentially grow either due to a sector-specific growth or because of technology transfer. In the case of the USA, Equation 2 becomes

$$\ln A_{US,t} = \gamma_{US} + \ln A_{US,t-1} + \varepsilon_{US,t} \qquad (3)$$

Combining Equations 2 and 3, the following model for the time path of *TFP* is obtained as

$$\ln \frac{A_{i,t}}{A_{US,t}} = (\gamma_i - \gamma_{US}) + (1-\lambda)\ln \frac{A_{i,t-1}}{A_{US,t-1}} + \hat{\varepsilon}_{i,t} \qquad (4)$$

where $\hat{\varepsilon}_{i,t}$ are i.i.d. error terms. If $1 > \lambda > 0$, the difference between the productivity levels between the country i and that of the USA will be stationary, indicating evidence of convergence and implying that productivity differences should vanish in the long run. Alternatively, if $\lambda = 0$, productivity levels would grow at different rates permanently and show no tendency to converge. In that case the difference between the productivity in country i and that of the USA will be nonstationary. The productivity data for estimating Equation 4 are obtained from Ball *et al.* (2001) (see p. 19, Table 8).

III. Estimation Procedures and Results

Recently, testing for convergence in panel data models is becoming more common, given both the ongoing theoretical investigation and the development of testing procedures (Chiang and Kao, 2002; Harris and Sollis, 2003). In this section several panel unit root tests are considered to test the convergence hypothesis. All of the tests presented in this study, except the one by Hadri (1999), test the null hypothesis of nonstationarity, i.e. the presence of a unit root, against the alternative of stationarity. In contrast, Hadri (1999) tests the null of stationarity against the alternative of nonstationarity. It should be stated that during the remainder of this paper, the notation

Table 1. Panel unit root tests

Test name	Model	Hypothesis
LL_1	$\Delta y_{it} = \rho y_{i,t-1} + e_{it}$	H_0: $\rho = 0$; H_1: $\rho < 0$;
LL_2	$\Delta y_{it} = \rho y_{i,t-1} + \delta_0 + e_{it}$	H_0: $\rho = \delta_0 = 0$; H_1: $\rho < 0$;
LL_3	$\Delta y_{it} = \rho y_{i,t-1} + \delta_0 + \delta_i t + e_{it}$	H_0: $\rho = \delta_i = 0$; H_1: $\rho < 0$; $\delta_i \in R$ for all i
LL_4	$\Delta y_{it} = \rho y_{i,t-1} + v_t + e_{it}$	H_0: $\rho = 0$; H_1: $\rho < 0$;
LL_5	$\Delta y_{it} = \rho y_{i,t-1} + \alpha_i + e_{it}$	H_0: $\rho = \alpha_i = 0$; H_1: $\rho < 0$; $\alpha_i \in R$ for all i
LL_6	$\Delta y_{it} = \rho y_{i,t-1} + \alpha_i + \eta_i t + e_{it}$	H_0: $\rho = \eta_i = 0$; H_1: $\rho < 0$; $\eta_i \in R$ for all i
LL_7	$\Delta y_{it} = \rho y_{i,t-1} + e_{it}$, with serial correlation	H_0: $\rho = 0$; H_1: $\rho < 0$;
LL_8	$\Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + u_{it}$	H_0: $\rho = 0$; H_1: $\rho < 0$;
LL_9	$\Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + \alpha_i + u_{it}$	H_0: $\rho = \alpha_i = 0$; H_1: $\rho < 0$; $\alpha_i \in R$ for all i
LL_10	$\Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + \alpha_i + \eta_i t + u_{it}$	H_0: $\rho = \eta_i = 0$; H_1: $\rho < 0$; $\eta_i \in R$ for all i
IPS97_1	$\Delta y_{it} = \rho_i y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + \alpha_i + u_{it}$	H_0: $\rho_i = \alpha_i = 0$ for all i; H_1: $\rho_i < 0$; for at least one i and $\alpha_i \in R$
IPS97_2	$\Delta y_{it} = \rho_i y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + \alpha_i + \eta_i t + u_{it}$	H_0: $\rho_i = \eta_i = 0$ for all i; H_1: $\rho_i < 0$; for at least one i and $\eta_i \in R$

Notes: e_{it} and u_{it} are error terms; δ_0 is an intercept; t is a time trend; α_i represents individual specific effects; v_t represents time specific effects.
LL stands for the Levin and Lin (1992, 1993) tests. IPS stands for the Im *et al.* (1997) tests.

$y_{i,t}$ will be used to refer to the variable $\ln A_{i,t}/A_{US,t}$ of Equation 4, for facilitating the presentation of the panel unit root tests.

Table 1 presents seven forms of the Levin and Lin (1992) test (LL_1-LL_7) considered in this paper. Under the null hypothesis, all i series in the panel contain a unit root, while the alternative hypothesis is that all individual series are stationary. Levin and Lin (1992) showed that as $N \to \infty$ and $T \to \infty$ the panel regression unit root *t-statistic* converges to the standard normal distribution $N(0,1)$, which makes possible statistical inferences about the value and significance of the parameter ρ. Levin and Lin (1993) developed panel unit root tests that resolve the problems of heteroscedasticity and autocorrelation that are present in the Levin and Lin (1992) tests by allowing the presence of different lags for each cross section series. Table 1 presents three forms (LL_8-LL_10) of the Levin and Lin (1993) test considered in this paper.

Harris and Tzavalis (1999) created a test based on the assumption that T is fixed and they found that this test had better power properties when T was small. In this paper three forms of this test, are considered. The first test (HT_1) corresponds to LL_1 test; the second (HT_2) corresponds to LL_5 test; and the third (HT_3) corresponds to LL_6 test. Breitung (2000) showed that the methods used to estimate panel models with fixed effects for performing the Levin and Lin tests suffer from a severe loss of power. As a result Breitung (2000) suggested a test –UB- with a constant and without fixed effects in the model and showed that this test is more powerful than the Levin and Lin tests.

The Im *et al.* (1997) test allows the coefficient ρ in Levin and Lin tests to be free to vary across each cross sectional series in the panel. The null hypothesis is that all i series in the panel contain a unit root, while the alternative hypothesis is that at least one of the individual series is stationary. Table 1 presents two forms of this test (IPS97_1 and IPS97_2) considered in this paper. Im *et al.* (1997) also proposed an LM test based on a lagrange multiplier test. Again, two forms of this test (IPSLM_1 and IPSLM_2) are considered which correspond to IPS97_1 and IPS97_2, respectively. Finally, Hadri (1999) proposed a residual-based LM test for a null that the time series for each cross section are stationary around a deterministic trend, against the alternative of a unit root in the panel. In this paper, two forms of the Hadri (1999) –H- test are considered, one (H_1) with individual specific effect without time trend and the other (H_2) with individual specific effect and individual time trend.

Table 2. Panel unit root test results

Test name[a,b]	Deterministic components	Test statistic[c] [Significance level for rejection]		
		Period: 1973–1993	Period: 1973–1981	Period: 1982–1993
LL_1		−12.171 [0.000]	−7.382 [0.000]	−9.092 [0.000]
LL_2	δ_0	−15.924 [0.000]	−9.816 [0.000]	−12.568 [0.000]
LL_3	$\delta_0 + \delta_i t$	−15.893 [0.000]	−9.636 [0.000]	−12.517 [0.000]
LL_4	v_t	−11.911 [0.000]	−8.556 [0.000]	−9.931 [0.000]
LL_5	α_i	−13.789 [0.000]	−7.187 [0.000]	−10.400 [0.000]
LL_6	$\alpha_i + \eta_i t$	−13.679 [0.000]	−6.397 [0.000]	−9.425 [0.000]
LL_7		−30.630[9] [0.000]	−12.286[9] [0.000]	−13.997[9] [0.000]
LL_8		31.398 [0.000]	4.719 [0.000]	41.989 [0.000]
LL_9	α_i	11.629[16] [0.000]	36.764[14] [0.000]	79.672[12] [0.000]
LL_10	$\alpha_i + \eta_i t$	11.659[16] [0.000]	88.486[13] [0.000]	125.485 [0.000]
HT_1		−37.764 [0.000]	−15.136 [0.000]	−20.974 [0.000]
HT_2	α_i	−21.388 [0.000]	−8.477 [0.000]	−12.438 [0.000]
HT_3	$\alpha_i + \eta_i t$	−12.298 [0.000]	−4.208 [0.000]	−6.424 [0.000]
UB	δ_0	−7.572 [0.000]	−2.823 [0.002]	−2.823 [0.002]
IPS97_1	α_i	−10.699 [0.000]	−4.254 [0.000]	−6.963 [0.000]
IPS97_2	$\alpha_i + \eta_i t$	−9.633 [0.00]	−3.632 [0.00]	−5.667 [0.00]
IPSLM_1	α_i	11.616 [0.000]	2.982 [0.001]	6.105 [0.000]
IPSLM_2	$\alpha_i + \eta_i t$	7.679 [0.000]	0.583 [0.28]	3.242 [0.000]
H_1	α_i	−0.547 [0.292]	−0.377 [0.353]	−0.502 [0.308]
H_2	$\alpha_i + \eta_i t$	4.229 [0.000]	21.481 [0.000]	7.782 [0.000]

Notes: [a]Where applicable lag length is set at 1.
[b]LL stands for the Levin and Lin (1992, 1993) test statistics, HT stands for the Harris and Tzavalis (1999) test statistics, UB stands for the Breitung (2000) test statistic, IPS stands for the Im *et al.* (1997) test statistics, and H stands for the Hadri (2000) test statistics.
[c]All tests are (asymptotically or exactly) distributed under the standard normal distribution.

Table 2 presents the panel unit root test results which were estimated using the GAUSS econometric package with the subroutines from Chiang and Kao (2002). The majority of the panel unit root tests reject the hypothesis of nonstationarity for the whole period, i.e. 1973–1993, and for the two subperiods, i.e. 1973–1982 and 1983–1993. In particular, among the tests which do not support stationarity are the H_2 test for all periods under consideration and the IPSLM_2 test for the first subperiod.

IV. Conclusions

This paper tests for convergence in agricultural *TFP* among the USA and nine European countries for the period 1973–1993 and subperiods 1973–1981 and 1982–1993, using time-series techniques. The majority of the panel unit root test results support the presence of convergence in the series for the full period and for the two subperiods. In other words, the results indicate that the *TFP* difference as measured by the distance of each country's productivity level from that of the USA is stationary. In addition, the results were robust to specifications that take account of country specific effects, year specific effects and time trend. Finally, the findings of the present study are supported by that of Ball *et al.* (2001).

References

Ball, V. E., Bureau, J.-C., Butault, J.-P. and Nehring, R. (2001) Levels of farm sector productivity: an international comparison, *Journal of Productivity Analysis*, **15**, 5–29.

Bernard, A. and Jones, C. I. (1996) Productivity across industries and countries: time series theory and evidence, *Review of Economics and Statistics*, **78**(1), 135–46.

Breitung, J. (2000) The local power of some unit root tests for panel data, in *Nonstationary Panels, Panel Cointegration, and Dynamic Panels, Advances in Econometrics*, Vol. 15 (Eds), B. H. Baltagi, T. B. Fomby, and R. C. Hill, Elsevier Science, Amsterdam.

Chiang, M.-H. and Kao, C. (2002) *Nonstationary Panel Time Series Using NPT 1.3*, a user guide, Center of Policy Research, Syracuse University, New York.

Hadri, K. (1999) Testing for stationarity in heterogeneous panel data, *Econometrics Journal*, **3**, 148–61.

Happich, M. and Geppert, K. (2003) A note on regional convergence within the EU, *Applied Economics Letters*, **10**, 523–5.

Harris, R. D. F. and Tzavalis, E. (1999) Inference for unit roots in dynamic panels where the time dimension is fixed, *Journal of Econometrics*, **91**, 201–26.

Harris, R. and Sollis, R. (2003) *Applied Time Series Modeling and Forecasting*, John Wiley & Sons Ltd, Chichester.

Im, K. S., Pesaran, M. H. and Shin, Y. (1997) Testing for unit roots in heterogeneous panels, Working Paper, University of Cambridge.

Levin, A. and Lin, C. F. (1992) Unit root test in panel data: asymptotic and finite sample properties, discussion paper No. 92–93, University of California at San Diego.

Levin, A. and Lin, C. F. (1993) Unit root test in panel data: new results, Discussion Paper No. 93–56, University of California at San Diego.

McCoskey, S. K. (2002) Convergence in Sub-Saharan Africa: a nonstationary panel data approach, *Applied Economics*, **34**, 819–29.

Su, J.-J. (2003) Convergence clubs among 15 OECD countries, *Applied Economics Letters*, **10**, 113–8.