WWII and Long Run Convergence in the OECD

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Abstract

Existing evidence for unconditional convergence in the OECD is mixed, and depends largely on whether time series or cross sectional methods are used. In this paper we reconsider the evidence for unconditional convergence by dividing the long run data into several subperiods. We use a two stage approach in this work. We first model the growth rate of output directly and use this model to estimate the long-run growth rate for the countries in our sample. We then use the estimates of long-run growth in output to test for unconditional convergence and to test for equality of long-run growth across countries. GLS is used to explicitly take into account the sampling uncertainty inherent in our estimates of the long-run growth rate we found in the first stage of the process. The results show strong evidence for unconditional convergence in the post WWII period 1951-1974, but no evidence of convergence in the periods preceding or following this period. Moreover, it is difficult to reject the hypothesis that most of the countries in our sample had the same growth rate outside of this period. Thus find little evidence to suggest that absolute convergence has been a continuous long run process, and some evidence for the view that national policies mainly affect income levels rather than growth rates.

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1 Introduction

Over long periods of time, very small differences in countries' growth rates can have enormous consequences for standards of living. This simple fact makes the study of long run growth rates an important tool for understanding why welfare levels differ across countries. In particular, Abramovitz (1986) and Baumol (1986) used long run annual data on GDP per capita to compare the patterns of long run growth across countries. They found that since 1870, the poorest countries in the OECD had caught up to a considerable extent with the leaders.[1]

The subsequent convergence literature has followed two distinct approaches, however. The first approach extended the cross sectional comparisons of Baumol (1986) by including additional conditioning variables, Dowrick and Nguyen (1989), Barro (1991) and Mankiw, Romer and Weil (1992). This literature finds that conditional convergence (also called conditional β convergence) is a fairly robust result.

This cross section definition of convergence contrasts with the results the second approach, based on time series techniques developed by Bernard and Durlauf (1995). They define convergence as the forecast of an eventual disappearance of differences in per capita outputs between countries.[2] With a sample of 15 OECD countries, Bernard and Durlauf (1995) reject their convergence hypothesis for most pairs of countries, but do find evidence of a common stochastic trend among many countries.[3] Likewise Evans (1998) finds

[1] They argued that the long run pattern of growth supported the thesis of the advantage of relative backwardness - that there were significant international technological spill-overs between countries with similar levels of "social capability". See for example Gerschenkron (1952), Lewis (1955) and Ohkawa and Rosovsky (1973). De Long (1988) showed that that since the OECD sample was, ex-post, a sample of relatively wealthy countries, this sample selection created a strong bias in favour of finding convergence. This limits the extent to which we may draw inferences from the experience of this sample of countries. Nevertheless as emphasized by Baumol and Wolff (1988), the study of convergence in the OECD is interesting in its own right since there are very important welfare implications for the countries involved. Second focusing on the OECD is important as it stands out as an exception from the general pattern of divergence between the world's richest and poorest countries.

[2] Hence if the differences in output levels between two countries contain a unit root, a time trend or are co-integrated, then this type of convergence can be rejected.

[3] Similar results are also found by Campbell and Mankiw (1989). For a general survey of the empirical

that there is no appreciable difference in trend growth rates across his sample of OECD countries.

It may be noted that the finding of no convergence of per capita incomes in the time series literature, is consistent with the very robust finding of conditional β convergence in the cross sectional literature. In particular if countries have different long run productivity growth rates or more generally, different steady steady state income levels, conditional β convergence may be consistent with absolute divergence of income levels, Durlauf and Quah (1999). For this reason the hypothesis of absolute convergence of per capita incomes (either unconditional β convergence or unconditional forecast convergence) is arguably more interesting than conditional convergence, particularly if the motive for studying convergence is to infer how welfare levels have changed over time in different countries.[4]

There are however several well known problems with the time series forecasting measures of convergence. First, Durlauf and Quah (1999) have pointed out that the techniques are not well suited to handling structural breaks or series where the data generating process is not time invariant.[5] Second, the criterion for convergence has been argued to be too strict, requiring an expectation of complete convergence in the future. From a welfare perspective it is also interesting to know whether countries have converged partially, over some finite time span. Third, unit root tests have low power when the data are generated by shocks that have high persistence. Thus typical time series convergence tests require long series, such as Maddison's data covering approximately the last 100 years, Maddison (1995).[6]

growth literature see Barro and Sala-i Martin (1995) and Durlauf and Quah (1999).

[4]As emphasized by Durlauf and Quah (1999), tests for convergence have little ability to discriminate among alternative schools of thought, since conditional and unconditional convergence can be generated by most growth theories.

[5]A discontinuity on the series will bias the results in favour of not rejecting the unit root hypothesis. Evidence of structural breaks in the time series of per capita GDP comes from Jones (1995), Ben David and Papell (1995), Li and Papell (1999), Ben David and Papell (2000).

[6]For example Cheung and Pascualy (2004) show that when the length of the series is restricted, the results of time series tests for convergence are very sensitive to whether the null hypothesis is convergence or non-convergence.

Given these restrictions, the time series approach does not easily permit the possibility that the process of convergence may changed at different points in history. This is unfortunate since Abramovitz (1986), using simple measures of the cross sectional variance of income levels, found that the rate of convergence had changed over the late 19th and 20th centuries.[7]

The aim of this paper therefore is to compare the relative growth performance of the OECD over the whole period, 1870-1998, and more particularly, also over several subperiods. To do this we use a two stage strategy. In the first stage we use the seemingly unrelated regression model to estimate long-run growth rates for each country in our sample from annual time series data. In the second stage we use these estimated long-run growth rates to test for conditional β convergence and equality of growth rates across our sample of countries. We account for the sampling uncertainty inherent in stage one by using generalized least squares in stage two. The advantage of this method is that it does not depend on the outcome of any pre-tests for non-stationarity of the data. We obtain efficient estimates of growth rates with relatively small sub-samples of the long run data.

We find first, that we even though the standard errors on estimated growth rates tend to be quite large, we can reject the hypothesis that all of the 16 OECD countries had the same long run growth rate for the whole sample period. Moreover we find that there is a significant negative relationship between the initial income levels and subsequent growth rates, for the group as a whole. Thus, even allowing for time series variance our results support the Baumol hypothesis and reject common growth rates.

When we break down the sample period into subperiods however, a different story emerges. In particular we find that the convergence result for the entire period, 1870-

[7] Abramovitz (1986) shows that the variance in income levels, as measured by the coefficient of variation, declines rapidly in the post-WWII recovery era, but increases in the period leading up WWII. The variance declines slowly in late 19th century and the late 20th century.

1998 can be entirely explained by the post-war recovery era - there is no evidence of convergence in any of the remaining subperiods. The results tend to suggest that even within the OECD, unconditional convergence was the exception rather than the norm.

Our second set of results relate to the tests for common growth rates. We reject the hypothesis of common growth rates over the remaining subperiods for the full sample of countries. Nevertheless we show that for a sub-sample of 13 of the 16 countries, it is very difficult to reject the hypothesis that each country had the same growth rates for any periods, except the post war recovery period, 1951-1974. This result tends to mirror the time series result such as Evans (1998) and Bernard and Durlauf (1995) that find long run growth rates are co-integrated.

We conclude that unconditional convergence was not a continuous process but a temporary event. Thus we view our results as casting some doubt on the view that convergence in the OECD was due to a continuous trend of technology catch-up. A plausible alternative source of convergence may simply be the exogenous political events after WWII. This is supported by the the finding that, apart from the post war period, most of the OECD countries followed very similar growth paths. Moreover these two findings go some way to reconcile the differing results found in the time series and cross sectional literature. Nevertheless we view our results as being generally supportive of the inferences drawn from the time series approach of Bernard and Durlauf (1995) and others, rather than the cross section approach.

2 Estimating Long Run Growth rates

Maddison (1995) presents real output per capita data for seventeen OECD countries for the period 1870 to 1995. Our data consists of this primary data, updated to 1998 using Maddison (2001). We are interested in estimating the long-run growth rate of output for each country in the sample. We start by modelling the data generating process of the annual (short-run) growth rate of real output. Thus, letting Q_t be the level of real output per capita and let $q_t = \ln Q_t$, we aim to model the time series properties of the percentage growth rate of real output $\mu_t = \Delta q_t$.

Figure 1: Growth Rates of Real Output: OECD (1870-1998)

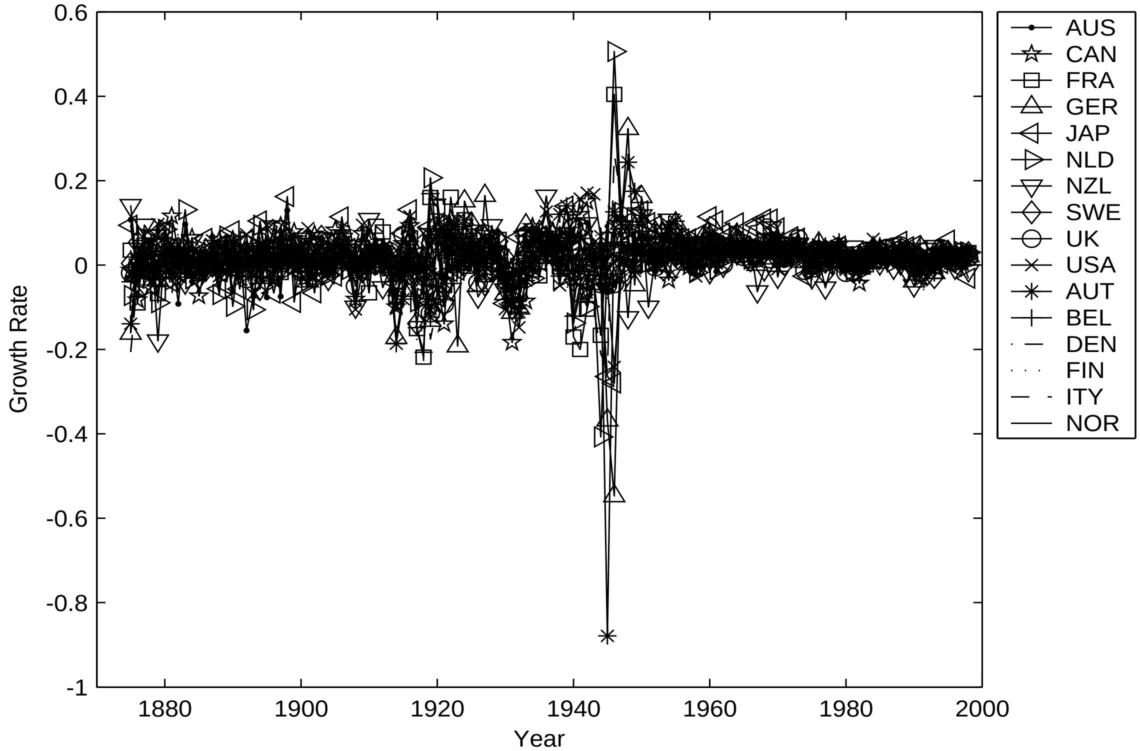


Figure 1 depicts the short-run growth rate time series used in this study. It is evident from this figure that the growth rate series potentially contains mild serial correlation and that there appears to be a reduction in variance in the latter part of the Twentieth Century.

In the first stage of our process we aim to calculate long-run growth rates for each country in our sample. It is common in the convergence literature to use either the average of the short-run yearly growth rates of output or the difference in output divided by the time period as the estimate of the long-run growth rate for a particular country. Using these measures of long-run output growth is equivalent to assuming that output follows a simple random walk. That is, the data generating process for output is

$$q_t = \alpha + q_{t-1} + \epsilon_t,$$

where y_t is the level of output in period t.

Then an estimate of α, the underlying drift in the time series $y = \{y_t\}_{t=-\infty}^{\infty}$ is

$$\hat{\alpha} = \frac{1}{T-1} \sum_{t=2}^{T} \mu_t \equiv \frac{1}{T-1} \left(q_T - q_1 \right).$$

Once calculated, these estimates of the long-run growth rates are then used in the second stage of the problem as regressors in various regression analyses used as tests various forms of convergence.

There are a number of potential problems with this approach. First, the long-run growth rates calculated in the first stage are only estimates and are affected by sampling error. The sampling error is potentially different across the countries in the sample thus leading to heteroscedasticity in the second stage regressions. Second, this estimate of the long-run growth rate is only valid if there are no short-run dynamics present in the underlying data generating process for the growth rate of output. Ignoring the presence of short-run dynamics would lead to biased estimates of the long-run growth rate. Finally, given that the sample we are looking at covers a large period of time there is a problem, discussed in Maccini and Pagan (2003), of a reduction in the variance of output over time.

The method described below aims to account for the last two of these three potential problems with the current literature. We describe a model that allows for short-run dynamics in the growth rate of output and allows for a reduction in the time series variance of output over time.

Consider the following autoregressive, levels in volatility (ARVL) model for short-run growth,

$$(\mu_t - \overline{\mu}) = \sum_{j=1}^{p} \theta_j(\mu_t - \overline{\mu}) + \sigma_t \epsilon_t, \tag{1}$$

where $\overline{\mu}$ is the unconditional mean of the time series, $\{\mu_t\}_{t=-\infty}^{\infty}$, and σ_t is the conditional variance. Serial correlation in the time series is described by $(\theta_1, \ldots, \theta_p)'$ and ϵ_t is assumed to have mean zero and unit variance.

Following Maccini and Pagan (2003) we model the conditional variance, σ_t according to

$$\sigma_t = \sigma Q_{t-1}^{\delta}. \tag{2}$$

Thus, (1) and (2) describe the DGP of short-run growth used to estimate the long-run growth rate, $\overline{\mu}$. The estimation of $\overline{\mu}$, and its variance, is a two step procedure. In the first step (1) is estimated using OLS.[8] Residuals from this regression are then used to estimate δ. If δ is significantly different from 0, the data is then re-weighted using Q_{t-1}^{δ} as the weight for period t.

The second stage of the estimation procedure involves estimating

$$\mu_t = \alpha + \sum_{j=1}^{p} \theta_j \mu_{t-j} + \epsilon_t \tag{3}$$

using the re-weighted data. In only three cases, Denmark, Germany and Norway, δ was not significantly different from 0. In those cases, a standard AR(p) was used. For all other countries, an ARVL(p) model was used.

[8]The lag length parameter, p, is chosen to minimize the Schwarz Bayesian Information Criterion (SBIC).

To improve efficiency the individual equations were estimated using a Seemingly Unrelated Regression (SUR) estimator. Once estimated, the long-run growth rate is calculated as

$$\overline{\mu} = \frac{\alpha}{1 - \sum_{j=1}^{p} \theta_j}. \tag{4}$$

These long-run growth rates are then used to test for the existence of unconditional β convergence and to test for the equality of long-run growth rates across countries in the O.E.C.D. Estimates of the long-run growth rates, both for the full sample and for various sub-periods can be found in the next Section.

3 Testing for Unconditional β Convergence

First, we estimate the long-run growth rate, $\overline{\mu}$ for the full period (1870-1998) for all countries in our sample. The estimated long-run growth rates, together with their 95% confidence intervals are depicted in Figure 2. The vertical full line depicts the median growth rate for this period while the dashed lines depict the first and third quartiles.

This figure shows that the variance of the growth rates of each country is quite large relative to the differences in growth rates across countries. There is approximately a 1.5 percentage point difference between the slowest growing country in the sample, Australia and the fastest, Japan. The 95% confidence interval for most countries is around 4-5 percentage points however. Thus for most pairs of countries there is a substantial overlap of the confidence interval these confidence intervals. This reflects the fact that annual deviations in growth rates from the trend are large. This variance cannot be ignored however. Its presence indicates that there is considerable uncertainty surrounding point estimates of trend growth rates.

The estimated long-run growth rates are then used to check for convergence in our data set.

Figure 2: 95% Confidence Intervals for Long Run Growth Rates: 1875-1998 (Full Sample)

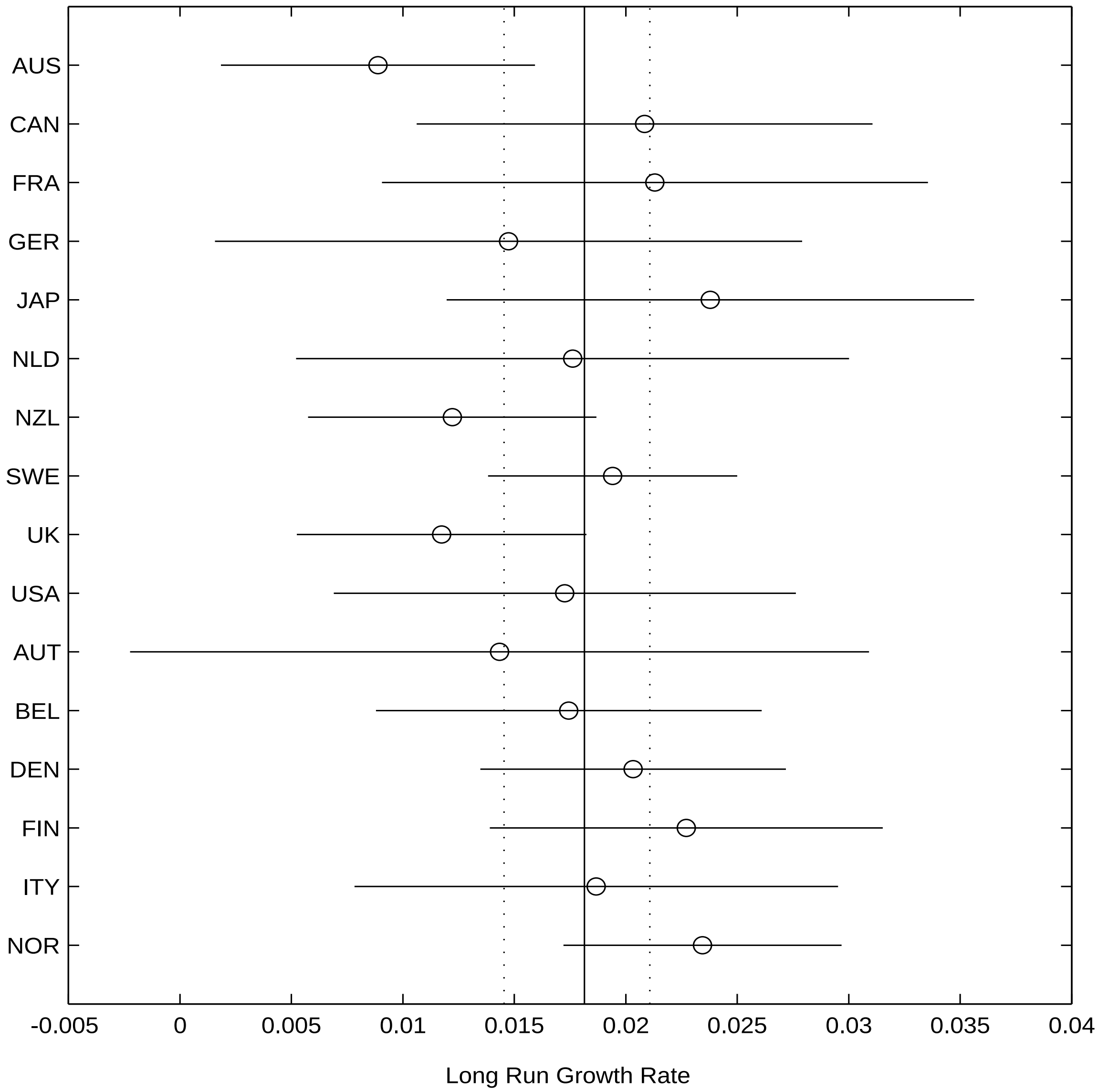
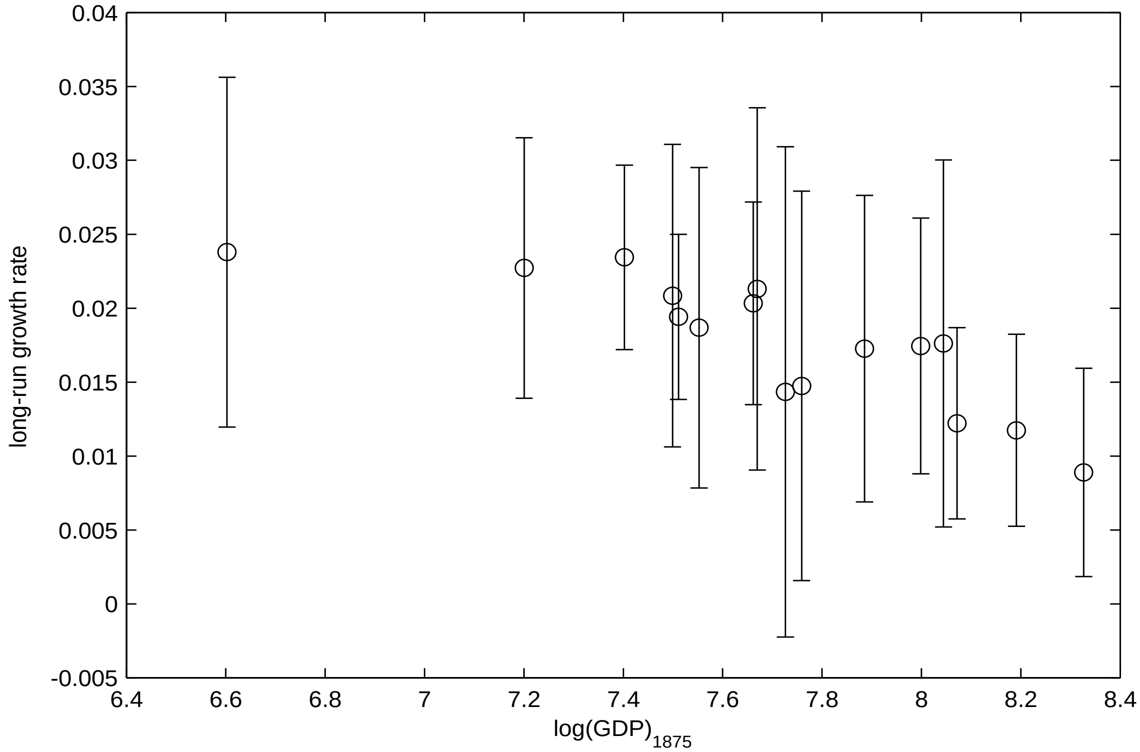


Figure 3: Long Run Growth Rates vs Initial GDP per Capita: 1875-1998



The first task, therefore, is to consider how this time series variance affects the standard cross sectional convergence result of Baumol (1986). Figure 3 shows the standard "Baumol" scatter plot of growth rates against the logarithm of the 1870 levels of GDP per capita, for each country. In addition however, the graph shows the 95% confidence intervals from Fig 2. As with previous studies there is a negative relationship between the point estimates of the long-run growth rates, and the initial level of output, indicating that countries with lower levels of income in 1870 tended to grow faster over the subsequent decades. Nevertheless the size of the standard errors around each estimate, considerably weakens the confidence that one may have in the significance relationship. For example there is a substantial overlap of the confidence intervals of most and least wealthy countries in 1870.

Next we consider this relationship for subperiods. We identify four major sub-periods.

The first period is the period preceding the start of World War I (WWI), 1870-1913. As emphasized by De Long (1988), the pre 1914 data tend to be less reliable than subsequent data due to historians efforts to reconstruct data back to WWI. Moreover, this period corresponds to the gold (or other precious metal) monetary standard.

The second period includes the years from the start of WWI until the end of World War II (WWII), 1914-1949. As noted by Abramovitz (1986) there was a significant amount of financial and political instability in the aftermath of WWI, culminating in WWII. This period therefore includes the two great wars and the Great Depression. All countries in our sample were affected in some way or another by these three great events. We refer to this period of instability as the "War" period.

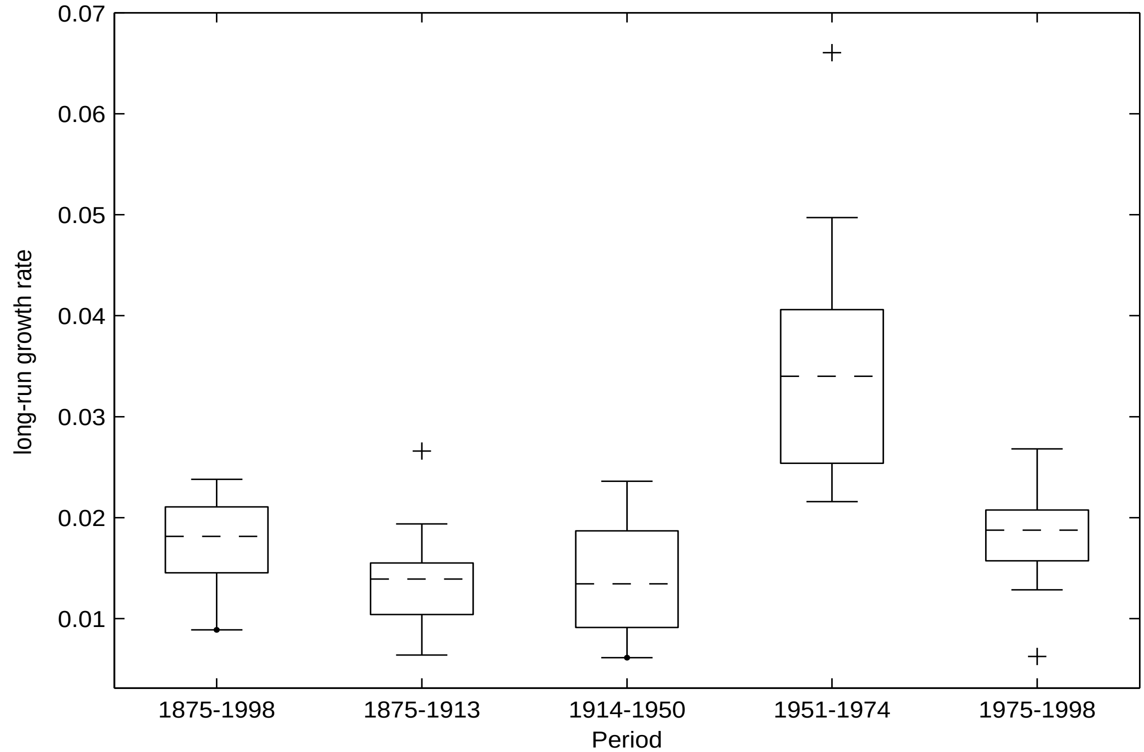
The post WWII years are divided into two periods. The first is years following WWII up until the breakdown of the Bretton-Woods agreement in 1974, and the oil price shocks.[9] We denote this as the "Post War Recovery" period. The final period covers the years 1975 to 1998 and will be referred to as the "Post Bretton-Woods" period. This period also contains the beginning of the productivity slowdown.[10]

The differences across the four sub-periods can easily be seen in Figure 4, which depicts the distribution of the estimated mean long-run growth rates for each sub-period. The boxes represent the interquartile range while the stems depict the largest and smallest value that is not more than 1.5 interquartile ranges away from the first or third quartile. Outliers are depicted with a '+' symbol and are estimated long-run growth rates that are more than 1.5 interquartile ranges away from the first or third quartiles. In the "Gold

[9]The choice of 1974 as the end of Bretton-Woods is arbitrary but is consistent with transition dates used in the macroeconomic literature. Specifically Bretton-Woods began to fall apart in the early part of the 1970's with the U.S.A pulling out in 1973.

[10]It should be noted that the choice of break points was not the result of formal testing. However, standard Chow-type tests do find that the estimated long-run growth rates for these four periods are significantly different from each other. Ben David and Papell (1995) and Li and Papell (1999) do testing for the presence of structural breaks and find evidence of breaks in the growth rates for a similar sample of countries centering on WWII for war affected countries, and in the late 1920's for non war affected countries. These tests however do not permit more than one such break.

Figure 4: Distribution of Estimated Long-Run Growth Rates by Sub-Period



Standard" period Canada is the outlier with a substantially higher mean long-run growth rate. In the "Post-War Recovery" period Japan is the outlier and in the last period New Zealand is the outlier. The line in the middle of the box is the median of the distribution.

It is clear from this Figure that the distribution of long-run growth rates changes over the sample period. First, there appears to be a general increase in the median long-run growth rate over time. Second, the dispersion of growth rates is bigger for the two middle sub-samples. The "Post-War recovery" period clearly contains the biggest variation of the four sub-periods and also the largest median long-run growth rate. We interpret this to be the result of the large variation in outcomes across countries, of both the war and the post-war reconstruction. This period of great flux had the effect of "re-shuffling" the relative positions of countries and displacing them their long-run balanced growth paths.

Figures 5 through 8 plot the estimated long-run growth rates, and their 95% confidence intervals, against the logarithm of the initial level of income, for these subperiods. It can be seen that the only period in which there appears to be a negative relationship between the estimated long-run growth rate and output is the post war recovery period, 1945-1974. In all other periods, a visual inspection does not reveal any clear relationship between long-run growth and the initial level of income.

Figure 5: Estimated LR Growth Rates vs Log Initial Income: 1875-1913

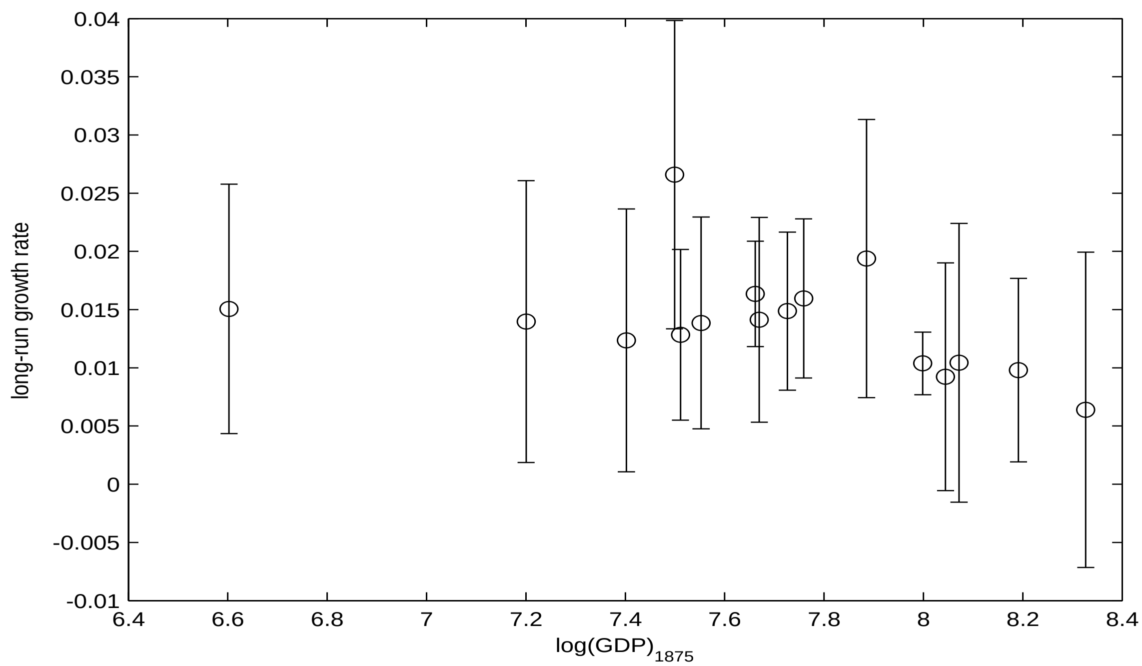


Figure 6: Estimated LR Growth Rates vs Log Initial Income: 1914-1945

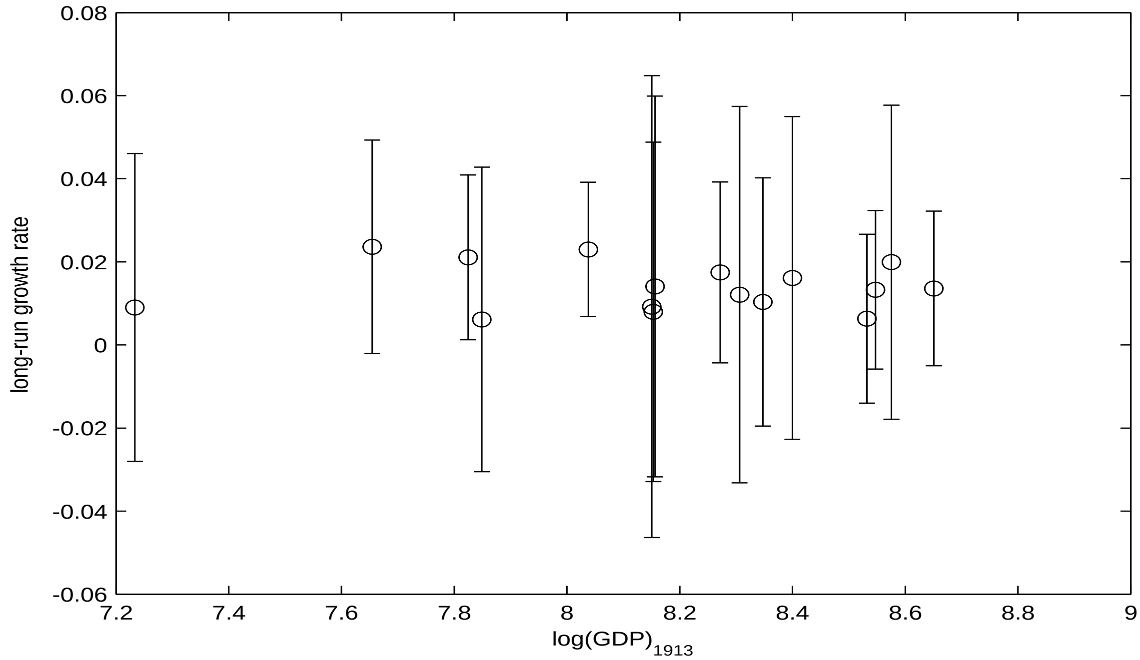


Figure 7: Estimated LR Growth Rates vs Log Initial Income: 1946-1974

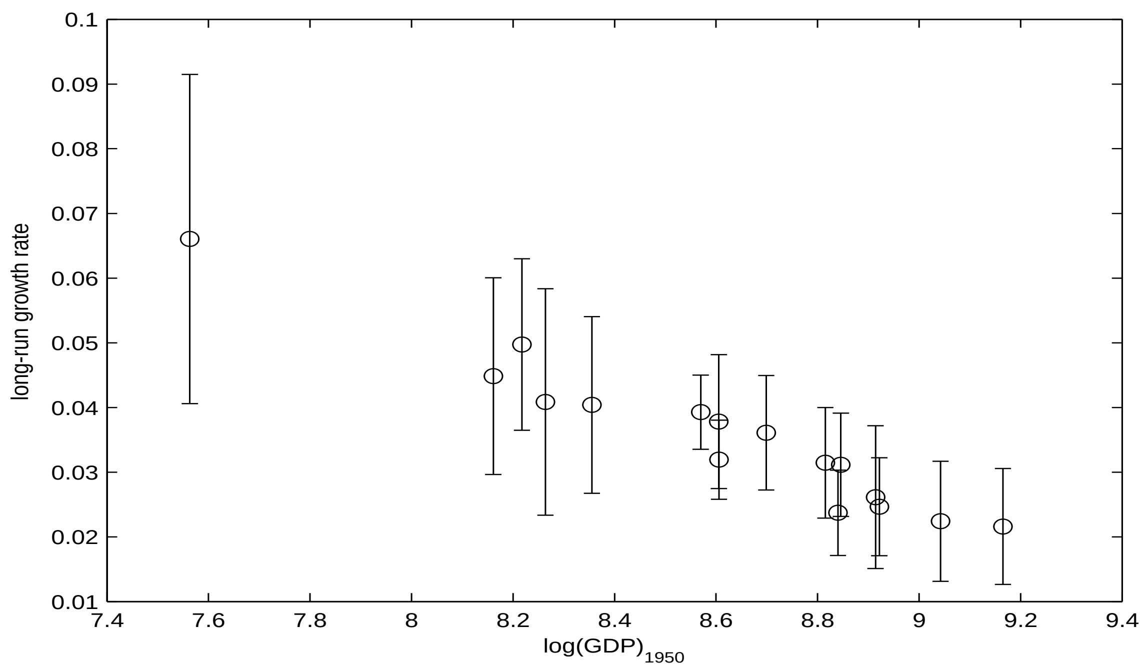
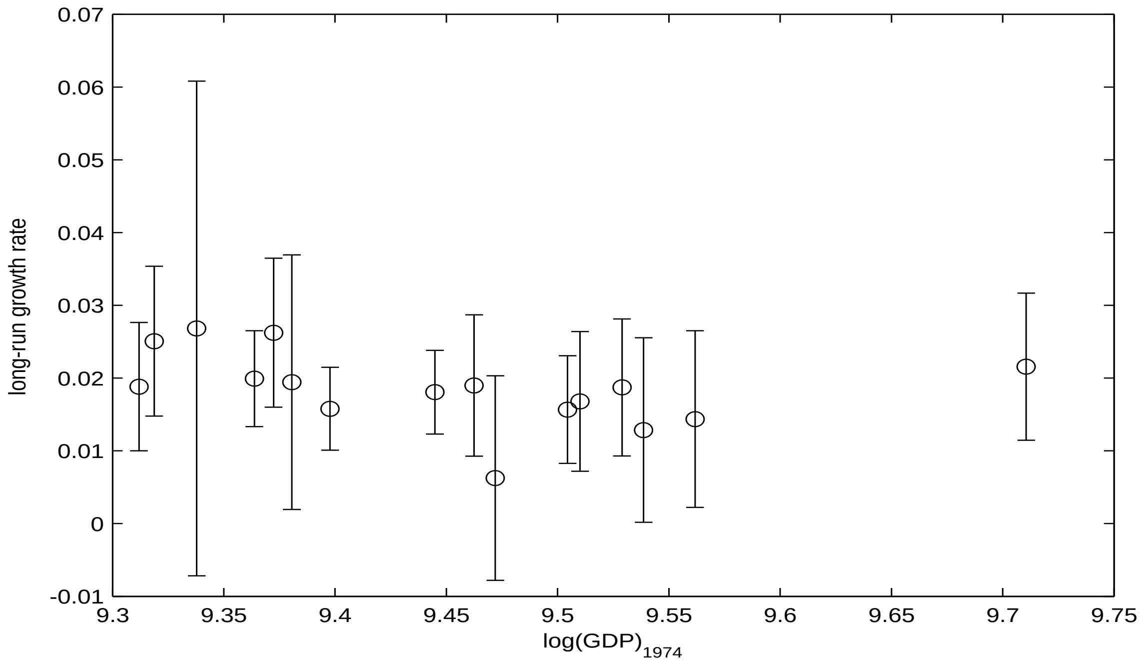


Figure 8: Estimated LR Growth Rates vs Log Initial Income: 1975-1998



3.1 Estimates of unconditional β convergence rates

It may be noted that the existence significant negative slope in the preceding diagrams indicates convergence is the sense used by Baumol (1986). As put eloquently by Durlauf and Quah (1999), this definition differs from the time series definition, in that it refers to a reduction in contemporary differences in levels of GDP per capita, as opposed to the expectation of their eventual disappearance. Our interest however is primarily in the historical issue of whether convergence actually occurred over a given period. Thus the unconditional β convergence definition - whether countries that were initially poorer grew faster over the period - is relevant. As noted, this is a weaker concept of convergence than the forecasting definition, since it does not imply that income levels of any pair of countries must eventually be equal. Nevertheless it may have important welfare consequences, even if the stronger definition of eventual equality of income levels is not satisfied.

In our model, however, we nevertheless allow for the fact that the underlying long run productivity growth rate is observed with noise. Specifically, random technology and policy shocks may causes the observed growth rate to deviate from the underlying long run growth rate. In view of this the following regression equation was estimated for each sample:

$$\overline{\mu}_i = \alpha + \beta \ \log(GDP)_{i0} + \epsilon_i, \tag{5}$$

where $\overline{\mu}_i$ is the long-run growth rate calculated using the method described above, and GDP_{i0} is the initial level of real output.

This specification is superficially very similar to Baumol (1986). Note however that we do not observe the true value of $\overline{\mu}_i$, only the estimated mean $\overline{\mu}_i^*$ where

$$\overline{\mu}_i^* = \overline{\mu}_i + \nu_i.$$

The equation that is estimated is therefore

$$\mu^* = \alpha + \beta \ \log(GDP)_{i0} + \varepsilon_i, \tag{6}$$

where $\varepsilon_i = \epsilon_i + \nu_i$. Note that the standard least squares assumptions still apply here as GDP_{i0} is not used to estimate the long-run growth rate in the first stage of the process. Hence we do not suffer from a generated variable problem and the error term, ε_i, is still uncorrelated with the regressor. Hence OLS is still consistent but not efficient as (6) suffers from known heteroscedasticity.

The first column of Table 1 shows the results of OLS estimates for (6), where the dependant variables are simply the point estimates of the growth rates for each country. It can be seen that there is evidence of convergence over the entire period, and also over each subperiod except the modern Post Bretton Woods era, 1975-1998. The results also show however that the rate of convergence was much higher during the post WWII recovery, 1951-1974, than in any of the other periods. Next consider the second row of Table 1 which reports GLS estimates of (6) that explicitly take into account the uncertainty in the estimates of the long-run growth rate, using Monte Carlo methods.

Table 1: Estimated β convergence coefficients and t-values

Period	OLS	GLS
1875-1998	-0.009	-0.009
	(-5.56)	(-2.84)
1875-1913	-0.005	-0.005
	(-1.80)	(-1.50)
1914-1950	-0.001	-0.001
	(-0.24)	(-0.20)
1951-1974	-0.028	-0.028
	(-14.68)	(-5.11)
1975-1998	-0.018	-0.018
	(1.53)	(-1.16)

As might be expected the results show that, once we allow for the time series variance in the per capita GDP data, the standard errors of the estimated convergence rates become much larger. Despite this there is still a significant estimated convergence coefficient on for the entire period 1870-1998, and also for the post-WWII recovery. The convergence estimates for the remaining three periods, which are all marginally significant under OLS, however become very insignificant when uncertainty in the estimates of μ are explicitly modelled.

The results therefore seem to reject the view that there was a continuous time invariant process of convergence with poorer countries growing steadily faster than the richer countries. As suggested by Abramovitz, the process of convergence was quite varied. Our results not only verify this in a somewhat more formal manner, but suggest that, the experience of convergence, in any statistically significant sense, was entirely confined to the Post WWII recovery era.

4 Testing for the equality of growth across countries

If we accept that there was essentially no convergence over most eras of last century, this leaves open the possibility that each country was experiencing the same long run productivity growth rate for extended periods exceeding 20 years. In particular, a number of studies have found evidence that the output series of many of the OECD countries are following a common stochastic trend.[11] Co-integration of GDP per capita series for different countries implies that in the very long run their growth rates will be the same. Nevertheless it is possible that long run growth rates may be the same over some extended periods, which are interrupted by structural breaks.

To investigate this we consider whether we can reject the hypothesis that $\overline{\mu}_i$, are equal across countries. For each country, j, the equation that was estimated was

$$\mu_{jt} = \alpha_j + \sum_{k=1}^{p} \theta_{jk}\mu_{jt-k} + \xi_{jt},$$

so that the long-run growth rate is given by

$$\overline{\mu}_j = \frac{\alpha_j}{1 - \sum_{k=1}^{p} \theta_{jk}}.$$

For a given time period the null and alternative hypotheses are

$$H_0 : \overline{\mu}_1 = \overline{\mu}_2 = \ldots = \overline{\mu}_{16} \quad v. \quad H_A : \ \overline{\mu}_i \neq \overline{\mu}_j \text{ for some } i \neq j. \tag{7}$$

The null hypothesis can then tested using a non-linear Wald test.

Table 2, shows the p-values and Wald statistic for the whole period, 1875-1998, and each

[11] In particular see Evans (1998) who finds that the levels of GDP per capita in a sample of 13 OECD countries were co-integrated.

Table 2: Wald Tests for Equality of Growth Rates: Full Sample 16 Countries

Period	Statistic	p-value
1875-1998	29.77	0.01
1875-1913	22.97	0.08
1914-1950	12.36	0.65
1951-1974	91.94	0.00
1975-1998	59.01	0.00

of the subperiods. The results show that for the whole period, 1875-1998, the Wald statistic was 29.77 with a p-value of 0.01, and hence the null can be rejected the 1% level. This is consistent with the earlier finding of significant convergence across the whole sample period. Likewise, in the post war era 1951-74, the null is strongly rejected, consistent with our earlier findings.

Of greater interest are the remaining subperiods where there was no evidence of convergence. Here we find that the null can also be strongly rejected for the modern post Bretton Woods era, 1975-1998. For the pre-WWI or Gold standard era, 1875-1913, the null can be rejected at the 10% level. The strongest evidence for equal growth rates in Table 2 is the "War" period 1914-1950. Here we find that the null hypothesis that the growth rates are equal cannot be rejected at any reasonable level of confidence(p=0.65).

These results then contrast with the finding that these output series are co-integrated. In particular Evans (1998) finds that all the per capita output series of the countries in his sample are following a common stochastic trend, while Bernard and Durlauf (1995) find this holds for many pairs of countries. Though a common stochastic trend does not imply that countries will have the same growth rate over any given finite period, $t - t_0$, it does imply that the the growth rates converge as $t \to \infty$. In view of this, given sufficiently long time periods, one may expect to find similar growth rates among these countries.

In view of this we then considered whether the finding, that the null hypothesis of equal growth rates can be rejected in most subperiods, was robust to small changes in the sample of countries. We find in fact that the rejection of the null is not robust to these changes. To illustrate this, Table 3 and Table 4 report the convergence results and the Wald tests, for a sample of 13 OECD countries.[12]

Table 3: Estimates of β from Convergence Regression: Sub Sample 13 countries

Period	OLS	GLS
1875-1998	-0.008	-0.008
	(-4.87)	(-2.50)
1875-1913	-0.004	-0.004
	(-1.96)	(-1.06)
1914-1950	-0.001	-0.001
	(-0.25)	(-0.11)
1951-1974	-0.028	-0.028
	(-13.04)	(-4.44)
1975-1998	-0.016	-0.016
	(-1.63)	(-0.96)

Table 4: Wald Tests for Equality of Growth Rates: Sub-sample 13 countries

Period	Statistic	p-value
1875-1998	22.71	0.03
1875-1913	14.69	0.26
1914-1950	10.83	0.54
1951-1974	79.20	0.00
1975-1998	13.47	0.34

First the results show that convergence results still hold. Under GLS there is no evidence of convergence in any subperiod, except the post war reconstruction era. With respect to the Wald tests for equality of growth rates across countries, however, the results have changed quite dramatically. The p-values for the three sub periods, other than the post-war period, are now 0.26, 0.34 and 0.54. Thus, for 13 countries in our sample of 16, it is

[12] The countries excluded are Canada, New Zealand, and Germany.

very difficult to reject the null hypothesis of equal growth rates with any confidence.

The results then, are quite consistent with the finding of co-integration among most of the OECD countries, as found by Bernard and Durlauf (1995).[13] Unconditional convergence of per capita outputs appears to have been a rare event event for most OECD countries, over the last 100 years, and confined to the post war era. For the rest of the time there are differing growth experiences overall, though we have also shown that for a sub-sample of 13 of the 16 countries, it is difficult to reject the null hypothesis of common long run growth rates.[14]

Our results also broadly correspond to Abramovitz (1986) who gives rich narrative of the relative economic performances for the OECD countries. In contrast to Abramovitz however, our more formal tests finds no support for convergence prior to the Post War Recovery era.[15] This fact, combined with the inability to reject tests for equality of growth rates across most countries, suggests that national growth rates for this group are primarily determined by international, rather than domestic factors. Thus the results also provide some empirical support for recent models that emphasize the importance of international links in determining national productivity growth rates.[16]

[13] Evans (1998) finds a common trend for all the countries in his sample, however his sample size is 13 rather than 16.

[14] Clearly it is interesting to speculate what might explain the differing experiences of the omitted countries. New Zealand has experienced slow growth since 1974, but the reasons why are debated extensively. Canada is an outlier due to the Wheat boom in the first sub-sample. However a thorough analysis of these countries relative experience is clearly warranted, and could provide useful policy insights.

[15] According to Abramovitz (1986), the forces of convergence existed since the late 19th century, but were unleashed by social changes following WWII.

[16] For example see Eaton and Kortum (1996), Parente and Prescott (2000) and Acemoglu and Ventura (2001). They are also consistent with Jones (2002), who shows that the USA growth rate has been approximately constant over the post war era, despite a very large expansion of research sectors in the USA and the G5 countries.

5 Conclusion

Identifying differences in long run growth rates and in particular, convergence of income levels between countries, helps in understanding the sources of contemporary differences in income levels, and hence standards of living across countries. The existing evidence for unconditional convergence in the OECD is mixed however. There is substantial evidence for conditional and unconditional β convergence in the cross country literature, yet little evidence of forecast convergence in time series literature. The purpose of this paper has been to consider how evidence for β convergence in the OECD, has changed throughout the last century, taking account of fact that the true growth rate is observed with noise. Moreover, by working with first differences (in the logarithm of GDP per capita) we avoid the need for pre-tests for stationarity, and our tests for convergence are not predicated on the assumption that the data generating process is time invariant.

These features of our method allow us to consider relatively short periods of time. Thus we divide the sample period 1870-1998 into for periods associated with known structural changes. Comparing growth rates across OECD countries we find that, like Baumol and Abramovitz and others, than there was unconditional β convergence hypothesis in our sample across the entire period. Nevertheless, we also find that all of this convergence occurred in the Post War Recovery era. For the remaining periods there is no evidence of convergence. In addition we find that for 13 of the 16 OECD countries in our sample, the hypothesis of equal growths cannot be rejected at reasonable confidence levels.

The results are consistent with both the the unconditional forecast convergence literature, and the cross sectional literature. Cross-country β convergence did occur, but there is no evidence that this is a long run trend. We conclude therefore that convergence as not been a steady process. Rather the Post War period of convergence, is flanked by periods of non-convergence, and for many of the OECD countries in our sample, periods of parallel growth paths.

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