

The Convergence Debate: Some Empirical Issues

by

Trevor Newton

B.Sc., University of Victoria

Essay Submitted In Partial Fulfillment
Of The Requirements For The Degree Of
Master Of Arts
in the Department
of
Economics

© Trevor Blake Newton 1993

Simon Fraser University
April, 1993

All Rights Reserved. This Work May Not Be Reproduced
In Whole Or In Part, by Photocopy Or Other Means,
Without Permission Of The Author.

APPROVAL

Name: Trevor B. Newton

Degree: M.A. (Economics)

Title of Essay: 1. The Convergence Debate: Some Empirical Issues
2. Why Western Economic Progress Surpassed that of the Rest of the World

Examining Committee

Chairman: Dr. Dennis R. Maki

Dr. Richard Lipsey
Senior Supervisor



Dr. Richard Harris
Supervisor

Dr. Steven T. Easton
External Examiner

Date Approved: MARCH 29, 1993

PARTIAL COPYRIGHT LICENSE

I hereby grant to Simon Fraser University the right to lend my thesis, project or extended essay (the title of which is shown below) to users of the Simon Fraser University Library, and to make partial or single copies only for such users or in response to a request from the library of any other university, or other educational institution, on its own behalf or for one of its users. I further agree that permission for multiple copying of this work for scholarly purposes may be granted by me or the Dean of Graduate Studies. It is understood that copying or publication of this work for financial gain shall not be allowed without my written permission.

Title of Thesis/Project/Extended Essay

The Convergence Debate: Some Empirical Issues

Author:

(signature)

Trevor B. Newton

(name)

March 29, 1993

(date)

Abstract

Several empirical considerations have emerged over the last decade, which are central to the debate on convergence of international income levels. For instance, there has been discussion over the use of total factor productivity, as opposed to income per capita or labour productivity, as the basis for convergence studies. Further, there is the question of sample selection: that is, what set of countries should be used. Many other considerations, such as the use of trended data, the robustness of results over time, the use of purchasing power parity estimates, and errors in estimation, are also at issue. This essay will examine these issues, and discuss them in the context of several well known empirical studies.

CONTENTS

Approval Page	page ii
Abstract	page iii
List Of Tables	page vi
List Of Figures	page vii
I. Some Empirical Issues Surrounding the	
Convergence Debate	page 1
i. Convergence of Income Levels, Labour Productivity Levels, or Total Factor Productivity?	page 1
ii. Sample Selection Bias	page 3
iii. Sample Size	page 5
iv. Period Considered	page 6
v. Purchasing Power Parity Estimates	page 6
vi. Measurement Error	page 8
vii. Trended Data	page 9
viii. Stability of Results Over Time	page 10
II. Results of Five Important Convergence Studies	
i. William J. Baumol, "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show" (1986)	page 11
ii. J. Bradford DeLong, "Productivity, Convergence, and Welfare: Comment" (1988)	page 12

CONTENTS (Continued)

iii.	W.J. Baumol and E.N. Wolff, "Productivity, Convergence, and Welfare: Reply"(1988)	page 17
iv.	Moses Abramovitz, "The Catch-Up Factor In Postwar Economic Growth" (1989)	page 20
v.	Steve Dowrick and D.T. Nguyen, "OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence" (1989)	page 22
III.	Reviewing the Studies in Light of the Empirical Issues Raised	page 25
	Notes	page 31
	Bibliography	page 33

LIST OF TABLES

Table 1: Regression's Using Maddison's Sixteen Countries	page 12
Table 2: Maximum Likelihood Estimation For The Once-Rich Twenty-Two, 1870-1979	page 15
Table 3: Maximum Likelihood Estimation For The Once-Rich Twenty-Two, 1913-1979	page 16
Table 4: Standard Deviations Of Log Output For Maddison's Sixteen And The Once-Rich Twenty-Two	page 17
Table 5: Comparative Levels Of Productivity, 1870-1986	page 20
Table 6: The Association (Rank Correlation) Between Initial Levels And Subsequent Labour Productivity	page 21
Table 7: The Dispersion Of Per Capita GDP Levels Among 24 OECD Countries	page 22
Table 8: Comparisons Of Trend Growth Rates Of The Richer And Poorer Halves Of The OECD Annual Average Percentage Rates Of Change Of Per Capita GDP	page 23
Table 9: Regression Analysis Of Relative Growth 1950-85	page 23
Table 10: Regression Analysis Of Growth Rates 1950-81: Samples Selected On 1950 Income Rankings Of GDP	page 24

LIST OF FIGURES

- Figure 1: Productivity Growth Rate,
1870-1979 vs. 1870 level page 11
- Figure 2: Per Capita GNP Regression For
Maddison's Sixteen page 13
- Figure 3: 1870 Per Capita Income And
Subsequent Growth For The
Once-Rich Twenty-Two page 14
- Figure 4: Maximum Likelihood Estimation
For The Once-Rich Twenty-Two,
1870-1979 page 15
- Figure 5: Maximum Likelihood Estimation
For The Once-Rich Twenty-Two,
1913-1979 page 16
- Figure 6: Coefficient Of Variation GNP Per
Capita, 1830-1913, Bairoch Countries,
1870 Ranking page 17
- Figure 7: Growth Rate, RGDP (1950-80)
vs. 1950 RGDP10-Country Moving
Averages, 72 Countries Ranked
By 1950 RGDP page 18
- Figure 8: Coefficient Of Variation, RGDP,
1950-81, For Sets Of Countries By
1950 RGDP Rank page 19

The debate regarding convergence of international income levels has, over the past several years, been characterised by many studies, several of which have concentrated on empirical evidence. A considerable part of the debate has focussed on how the evidence should be read, and what it actually says. As a result, there has been a wide range of discussion as to each study's validity. It will be the purpose of this paper to look at and perhaps add to some of the empirical issues surrounding the convergence literature.

I. Some Empirical Issues Surrounding the Convergence Debate

i. Convergence of Income Levels, Labour Productivity Levels, or Total Factor Productivity?

It seems curious that different studies of the convergence hypothesis have focussed on different economic variables. Although per capita income is the most common unit which we can check for convergence (Baumol and Wolff, "Productivity Growth, Convergence, and Welfare: Reply" [1988]), also looked at are labour productivity levels (Abramovitz, "The Catch-Up Factor In Postwar Economic Growth" [1989], Baumol, "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show" [1986], and so on), or total factor productivity (TFP) (Dowrick and Nguyen, "OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence" [1989]). Although labour productivity levels and per capita income levels are relatively good proxies of each other (at least according to Maddison's (1982) sample where there is a correlation between the two of .98)¹ and are thus frequently used interchangeably, what of TFP? It is necessary for the sake of consistency that we have a common unit of reference. If we are to check for convergence, there has to be a consensus on Convergence Of What?

Dowrick and Nguyen present compelling evidence for the use of TFP as the measure of choice. Although I will go into greater detail on this paper later, I will very briefly discuss their views here. Any

study, they warn, that reports on income levels yet fails to also report on TFP, will be incomplete². This is because TFP as a catch-up factor will account for any income convergence which may have taken place³. They show that increases in relative factor intensities are not the primary sources of catch-up. In many of the poorer countries, changes in relative factor intensities have partly masked any convergence in income levels which may have taken place via TFP catch-up, (for instance, low investment levels in many African and South American countries relative to growth in their population levels). They show that there has been a robust and steady tendency for TFP catch-up since 1950, and this includes the period from 1973-85. This result also holds for a larger sample size (sixty three countries) than many of the convergence studies to date (Baumol [1986], DeLong, "Productivity Growth, Convergence, and Welfare: Comment" [1988]). It would be erroneous to suggest that income levels for some sample have not converged without first analysing TFP⁴. Dowrick and Nguyen show that even though income levels may not have converged, the corresponding TFP levels do have this tendency. At least, this is their argument.

I have only briefly discussed Dowrick and Nguyen's paper, and I will return to it later, but at present we are concerned with the merits of using TFP as the variable of choice. Although their argument is interesting, there is another story. Dowrick and Nguyen's TFP estimates are very misleading. A study that only takes into account the quantity of capital and labour inputs (such as Dowrick and Nguyen's), and not the quality levels, is assigning far too much importance to TFP. This can be seen in Christensen, Jorgensen, and Cumming's in their "Economic Growth, 1947-73: An International Comparison". By taking the quantity and quality of Factor Input (where quality of labour is measured in terms of education, and quality of capital is measured in terms of the ratio of capital services to the capital stock) for nine industrialised countries from 1960 to 1973, Christensen et al. compare real Factor Input and TFP as determinants of growth in real Product. The result is that, for four of their countries, TFP is more important; for the

other five, however, Factor Input is more important. They then do the same experiment, but this time eliminating quality from the measure of Factor Input: they find that TFP is a more important determinant of real Product growth than is Factor Input for all nine countries. They conclude that

omission of changes in quality of capital stock and hours worked would result in a completely distorted view of the relative importance of growth in real Factor Input and growth in TFP in accounting for the growth of real Product.⁵

In addition, they also found that all nine countries in their sample experienced quality increases from 1960 to 1973, thus making it clear that any analysis which is based on capital and labour inputs and their role in real Product growth, but does not also incorporate quality changes, will end up assigning TFP a much larger role in explaining real Product growth than is warranted.

In light of this criticism, I believe that TFP alone cannot serve as a measure of convergence. Further, its usefulness is questionable, at least until a comprehensive study on international TFP comparisons is carried out which takes into account quality of Factor Input.

ii. Sample Selection Bias

The question of sample selection has been raised by several (Dowrick and Nguyen[1989], DeLong[1988]). That is, What criterion is to be used to select the countries which will be tested? Baumol (1986), which will be looked at in more detail later, uses an ex poste sample for 1870-1979, where the criterion was to include countries whose per capita incomes had reached a certain point by the end-point of 1979. This is necessary because he uses Maddison's (1982) sample, which is entirely made up of relatively rich countries. Countries which have not converged are systematically excluded from the sample. But clearly this amounts to fixing the outcome, in that obviously since the countries were all rich in 1979

then convergence would be shown to have occurred⁶. An outcome that shows convergence is therefore trivial; it does not show that convergence is a phenomenon that should or should not be expected in other countries. Clearly, a sample that is based on some ex ante criterion would be preferred. Indeed, it has been shown that when countries are chosen on the basis of such a criterion, the results are very different from Baumol's (see DeLong[1988], and Baumol and Wolff [1988], both of which will be discussed later).

As a somewhat minor additional point regarding sample selection bias, it should be noted that the existence of National Accounts is a luxury which, historically, only the richer countries could afford. Thus in searching for data sources from which one can draw a sample, one is faced with a preponderance of countries that are relatively rich⁷.

Carrying on, it can be argued that even the ex ante criterion which typically looks to the relative income levels of sample countries at the start date (DeLong), or the mid-point date (Baumol and Wolff), may be an inadequate representation of the likelihood of a country to converge. As Abramovitz points out, the path to convergence depends on many things; in particular, social compatability (i.e. similar political, social, and economic institutions, as well as technical competence) and technological congruence (i.e. a country's raw materials, capital, and labour skills)⁸. It is clearly not enough that a country exhibit a high enough income level to make it a candidate for catching-up, (indeed, this point is supported by the data for countries such as Argentina, Chile and Portugal)⁹. Therefore maybe a better ex ante criterion would look more closely at 'social compatability' or 'technological congruence', rather than income levels. Some possible proxies might be literacy levels, the existence of democratic political institutions, or a country's labour skills or natural resource base. It is interesting to note that DeLong (1988), while using 1870 per capita income levels as his ex ante criterion, did check the significance of dummies for both democracy and religion, in that perhaps they would best represent social compatability. He found

that Democracy was not a significant determinant of growth and convergence, but that Protestantism was; "...the main message is that, for the...sample of 22, a country's religious establishment has been a surprisingly good proxy for the social capability to assimilate modern technology"¹⁰.

iii. Sample Size

In addition to the issue of sample selection bias, there is the related issue of sample size. Some studies, such as Baumol's (1986) which uses Maddison's sample of sixteen countries, and DeLong's (1988) which uses twenty-two countries, use a relatively small sample of countries, whereas others - mainly those who incorporate the Summers and Heston data (1984; 1988) - have a much larger sample size (such as Dowrick and Nguyen [1989], or the 1950-80 results of Baumol and Wolff[1988]). Those using the larger samples typically have found no convergence for the broader sample, and thus have looked for convergence by whittling the sample down, (Baumol and Wolff find no convergence for seventy-two countries, but mild convergence for roughly thirty-six countries, and strong convergence for fifteen; Dowrick and Nguyen find only marginal convergence for twenty-seven countries, and none for any samples above twenty-seven; results of both papers will be discussed later). Those using the smaller samples have in some cases found convergence (Baumol[1986], Abramovitz[1989]), and in other cases have not (DeLong[1988]). My concern, besides the lack of consistency in results, is that any study that does not seek to incorporate as broad a sample as possible, will be missing the big picture. The benefits of using a large sample is that one can check for convergence for the whole sample, as well as different sub-groups, and report on each, thereby reducing the likelihood of bias due to too small a sample as well as bias due to sample selection problems.

iv. Period Considered

A further concern is the range of periods covered in different studies. Obviously convergence studies will be limited by the availability of data. Those using the Summers and Heston (1984;1988) data are confined to 1950-80, with some supplementing it via the OECD estimates for the 1980's (Dowrick and Nguyen). Those using the Maddison data are 'limited' to 1870-1979. And of course there are other sets of data, such as Bairoch (1976) which covers 1830-1913. The lack of consistent methodology across these sources makes it impossible to seriously consider pooling them all for one massive period ¹¹(I will briefly go into this in my discussion of DeLong[1988]). However, it is equally clear that studies which are looking at different start and end dates cannot successfully refute one another. Even if one massive source were available for all the years in question, the determination of start and end dates will in turn determine the sample selection (whether it be ex poste or ex ante) since the countries to be included in the samples will almost certainly differ with each other from year to year in terms of their income levels or social compatability. (Indeed, any sample that covers an exceptionally long period will be faced with the problem of the very *existence* of certain countries, such as Yugoslavia, Germany, or Italy).

v. Purchasing Power Parity Estimates

In recent years, more use has been made of purchasing power parity estimates of international income levels, growth rates, and so on, (where PPP is defined as the number of units of currency A required to buy the same amount of goods that a unit of numeraire currency B can buy). OECD results (for the eighties) (M.Ward[1985]), and Summers and Heston (1984 or 1988) (for 1950-80) are two sources in particular. These comparisons are preferable to those using market exchange rates as the basis for international comparisons (such as Maddison [1982]¹², and also Bairoch [1976]¹³).

Since market exchange rates tend to be volatile, international estimates may vary drastically from year to year, and in doing so are not always reflective of reality. Yet still, as Irving Kravis and Robert Lipsey point out,

The predominant method...is to convert own-currency value aggregates to a numeraire currency, usually the (U.S.) dollar, via exchange rates...Exchange rate conversion is still the common practice, despite clear evidence that exchange rates fail to reflect the relative purchasing power of currencies, sometimes being off by a factor of three.¹⁴

Further, "A persistent finding...is that the purchasing power of the currency of low-income countries is much greater than indicated by the exchange rates."¹⁵ They point to the examples of South American and Asian countries, whose real per capita income was more than twice as much as suggested by exchange rate conversions.¹⁶

It is important to remember this, especially in view of those studies which have used non-PPP estimates and have found a lack of convergence when the sample size includes poorer countries, (such as DeLong[1988]).

To further emphasise the importance of using PPP estimates, I look to Helliwell and Chung's "Macroeconomic Convergence: International Transmission of Growth and Technical Progress" where they find that their results for convergence are greatly affected by the use of PPP's instead of market exchange rates; the use of PPP's decreases the international variation in income, thus increasing the tendency for the data to converge. They also point to the fact that when they use two different sets of data based on exchange rates for different base years (1980 and 1985), there are significant differences in results with respect to convergence, (this makes sense because exchange rates vary from year to year). They consistently find, however, that the use of PPP's, while it not only is theoretically preferable, also increases the tendency for per

capita income convergence to occur, in their sample of nineteen industrialised countries from 1960-85.¹⁷

A final point regarding PPP estimates is that some may be concerned as to the methodology employed, and if using different sources of PPP results will alter the outcome of a test of convergence. Suffice it to say that not only did Dowrick and Nguyen find almost zero change when going from one source to another, but also found a correlation of about .95 between different sets of PPP estimates (Summers and Heston[1984], Blades and Roberts [1987], and the OECD estimates (M.Ward[1985]).¹⁸

vi. Measurement Error

Systematic errors in estimating early income levels from a common base year may also lead to bias. As Abramovitz (1989) and also DeLong (1988) point out, initial-year income levels in most long-period data are obtained by backward extrapolation of later levels, via growth rates. Therefore, errors in the growth rates produce an inverse correlation between initial income levels and subsequent growth rates, thus biasing the results in favour of convergence.¹⁹ (More precisely, if the cumulative errors in the backward extrapolation are significant compared to the actual differences in levels of income then results may be biased in favour of convergence). For example, if the data for growth rates tends to be less than the true values, then the initial income level (which has been estimated via the growth rates) will appear higher than *its* true value; thus there will be an inverse correlation between the estimated initial income level and the subsequent growth rates, thus tending to confirm the convergence hypothesis. A solution to this problem is shown by DeLong [1988] in his use of the Maximum Likelihood Estimation technique, (rather than Ordinary Least Squares). DeLong shows that, since OLS assumes measurement error in the dependent variable is non-existent, MLE can be used instead, and thus allow for *any* degree of measurement error; on page 14, I show how DeLong's dependent variable reflects income growth rate

from 1870-1979, and is regressed on initial 1870 income level. He estimates the equation several times via MLE, each time assuming a different level of error in the dependent variable (i.e. growth rate). I will go into his specific results later.

vii. Trended Data

It is surprising to me that more studies do not make use of trended data in their experiments. It is clearly an important aid to determining whether convergence has occurred. For example, if two countries are being tested, and the first country in the initial year is in the trough of a business cycle but the other country is not, and the first country in the end year is on the crest of a cycle but the other country is not, then there is a strong bias in favour of convergence; but of course it is only an illusion, due to the nature of the cyclical distortion.²⁰ Also, the distortion may be different than my above example, in which case there could be bias against convergence. Thus the use of trended data would rid the data of these cycles. There are different methods for purging the data of cyclical components; in particular, the method of moving averages can be used, in which a series of averages is taken from the data, each representing the mean of a fixed interval, where the size of the interval depends on the frequency of the distortion. The result is a set of values for which the variation due to the cyclical component has been reduced. The point is made by Dowrick and Nguyen (1989) that the use of nontrended data has led to masking of convergence among the OECD since 1973. Indeed, they find that the results of Abramovitz (1986) as well as Baumol and Wolff (1988) that since 1973 convergence among the richer countries has either stopped or reversed, are significantly different in the light of trended data.²¹ Using trend income levels, Dowrick and Nguyen show that some convergence within the OECD has in fact occurred since 1973.

viii. Stability of Results Over Time

As a final note, it is clear that one must ensure that any results regarding convergence are stable over time. In order to show, for example, that convergence between 1950 and 1980 is not simply the result of, say, post-WWII reconstruction, it is necessary to divide the data into subperiods such as 1950-60, 1960-73, and 1973-80, and see if the convergence trend has continued past the immediate post-war years. Further, if the convergence hypothesis is to make sense, then one expects growth rates to be decreasing over time as incomes increase. Thus in order to show this tendency, one must divide into subperiods to see if this is truly what is happening. To support the convergence hypothesis, growth rates must be decreasing as their corresponding income levels get closer to the leader. If this is not shown then one cannot accept a convergence hypothesis necessarily since the increase in income levels may not be due to catch-up.

II. Results of Five Important Convergence Studies

i. Results of:

William J. Baumol "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show"

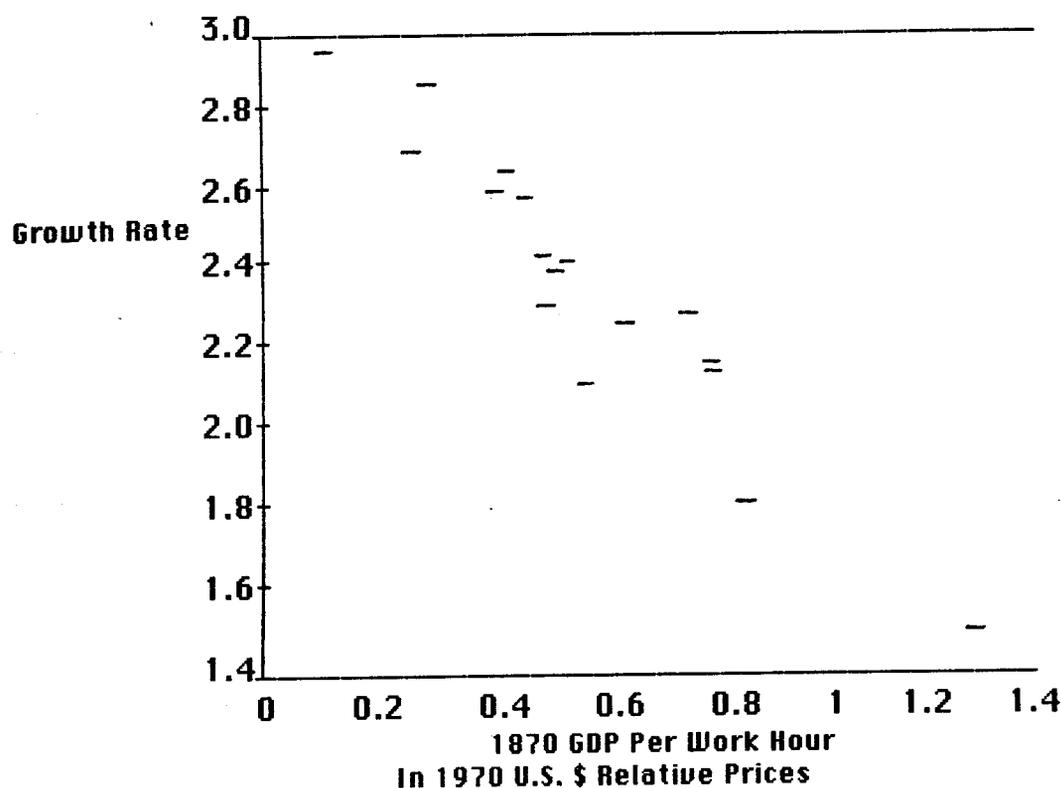


Figure 1
Productivity Growth Rate, 1870-1979 vs. 1870 level

As indicated in Figure 1, Baumol finds a strong inverse correlation between initial productivity levels and subsequent growth rates. His regression equation is:

$$\text{Growth Rate}(1870-1979) = 5.25 - .75\ln(\text{GDP per work hour, 1870})$$

$$R^2 = .88$$

Baumol concludes that there has been significant convergence amongst the "Maddison's sixteen" country sample.

His sample consists of the following sixteen countries: Australia, United Kingdom, Switzerland, Belgium, Netherlands, Canada, Italy, Denmark, United States, Austria, Germany, Norway, France, Finland, Sweden, Japan.

Source: Maddison (1982)

ii. **Results of:**

J. Bradford DeLong, "Productivity Growth, Convergence, and Welfare: Comment"

First, he reproduces the results of Baumol (1986):

Table 1 - Regressions Using Maddison's Sixteen Countries

Independent Variable	Dependent Variable	Constant	Slope Coefficient	Standard Error of Estimate	R ²
LN of 1870 Productivity	Ann. % Productivity Growth	5.251	-0.749 0.075	0.14	.87
LN of 1870 Income	Log Diff. of 1979 and 1870 Income	8.457	-0.995 0.094	0.15	.88

Source: data from Maddison (1982)

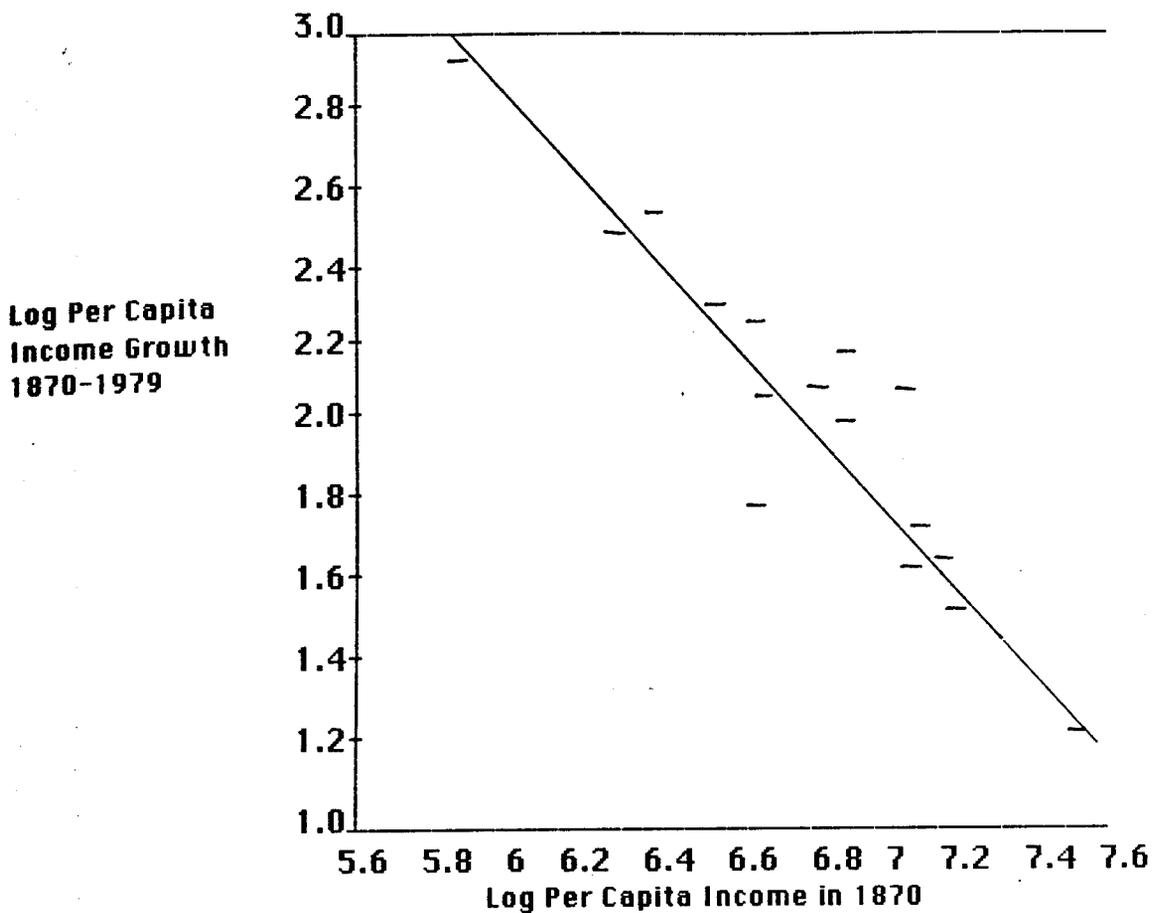


Figure 2
Per Capita GNP Regression For Maddison's Sixteen

Then, he alters the sample to become the "Once-Rich Twenty-two" countries, which are: Sweden, Finland, Norway, Germany, Austria, Canada, Denmark, United States, Italy, Switzerland, Belgium, Netherlands, France, United Kingdom, Australia, East Germany, Spain, Ireland, Chile, Portugal, Argentina, New Zealand:

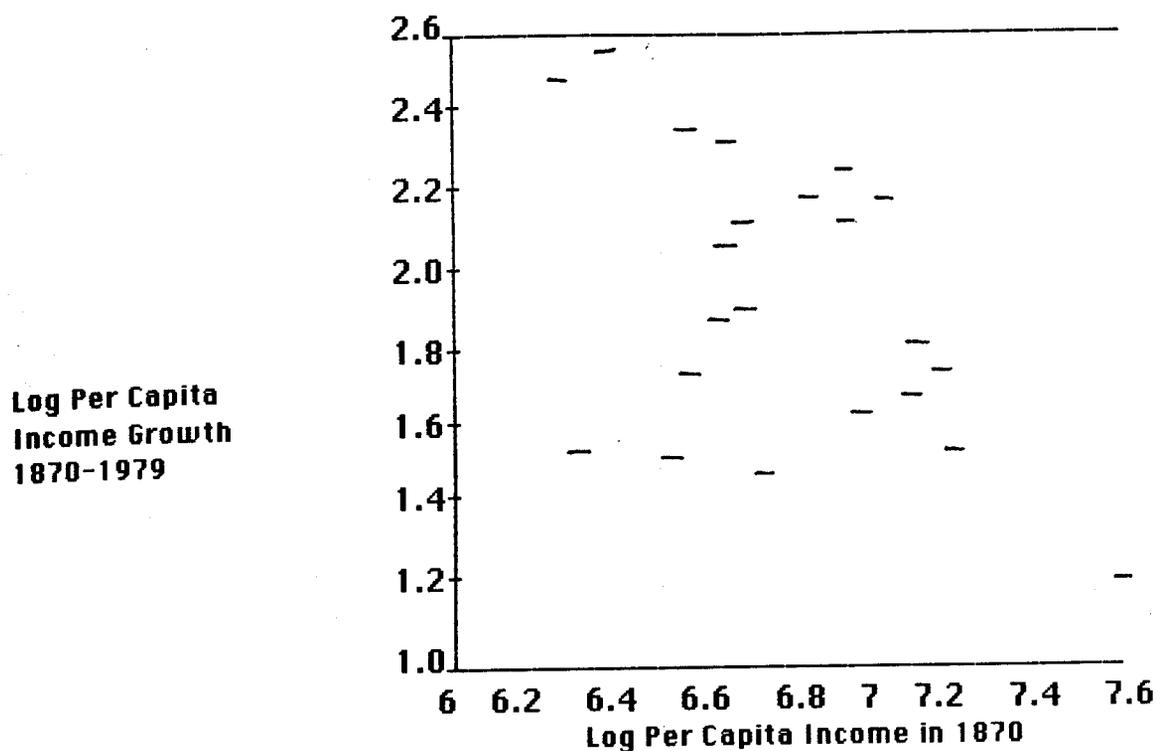


Figure 3
1870 Per Capita Income And Subsequent Growth
For The Once-Rich Twenty-two

DeLong estimates the following system via Maximum Likelihood Estimation:

$$(1979 \text{ Income}) - (\text{True } 1870 \text{ Income}) = a + b(\text{True } 1870 \text{ Income}) + e_i$$

where $(\text{Estimated } 1870 \text{ Income}) = (\text{True } 1870 \text{ Income}) + n_i$
 $(e_i \text{ and } n_i \text{ are random error terms, and are assumed uncorrelated})$
 $(\text{True } 1870 \text{ Income is not observed})$

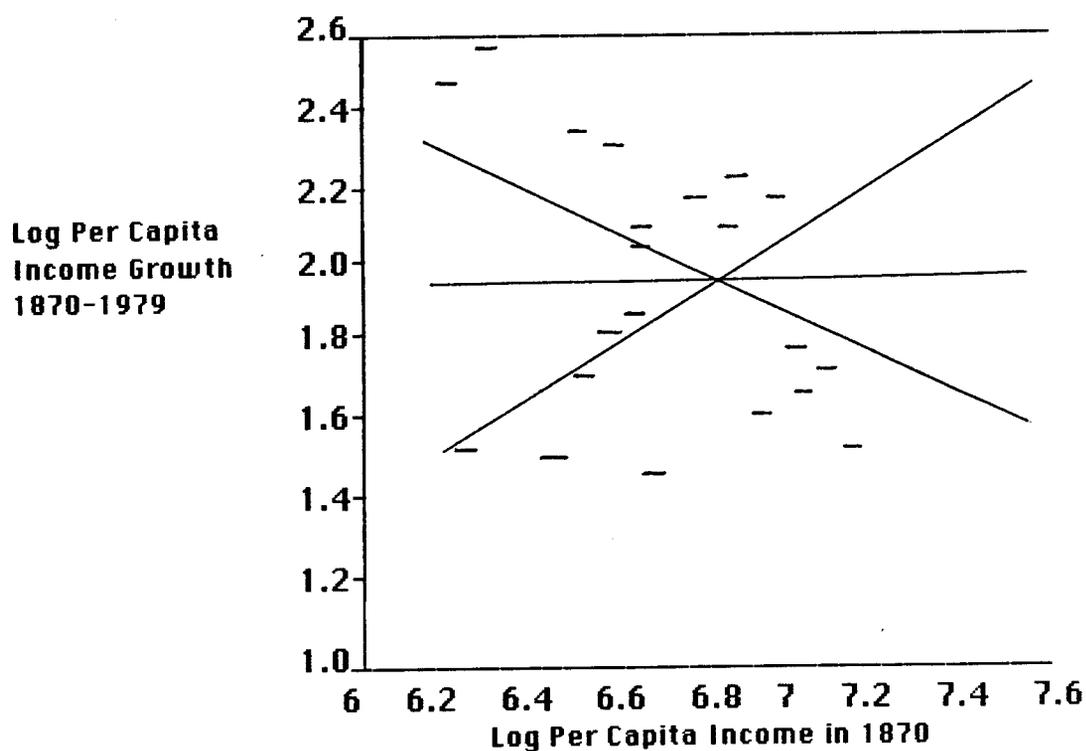
This system is identified if one assumes e_i and n_i are uncorrelated, and that the ratio of their variances can be defined as $\rho = \text{var}, n_i / \text{var}, e_i$.

Rho is meant to represent the size of the measurement error relative to the size of the regression disturbance e_i . The results are as follows:

**Table 2- Maximum Likelihood Estimation
For The Once-Rich Twenty-Two, 1870-1979**

ρ	Slope Coefficient β	Standard Error of Slope	Standard Error of Regression	Standard Error in 1870 PCI
0.0	-0.566	0.144	0.207	0.0
0.5	-0.292	0.192	0.192	0.136
1.0	0.110	0.283	0.170	0.170
2.0	0.669	0.463	0.134	0.190
∞	1.381	0.760	0.0	0.196

Source: data from Maddison (1982)



**Figure 4
Maximum Likelihood Estimation
For The Once-Rich Twenty-Two, 1870-1979**

DeLong also tries using 1913 as a start date, in order to further be sure that measurement error has not altered his fundamental results:

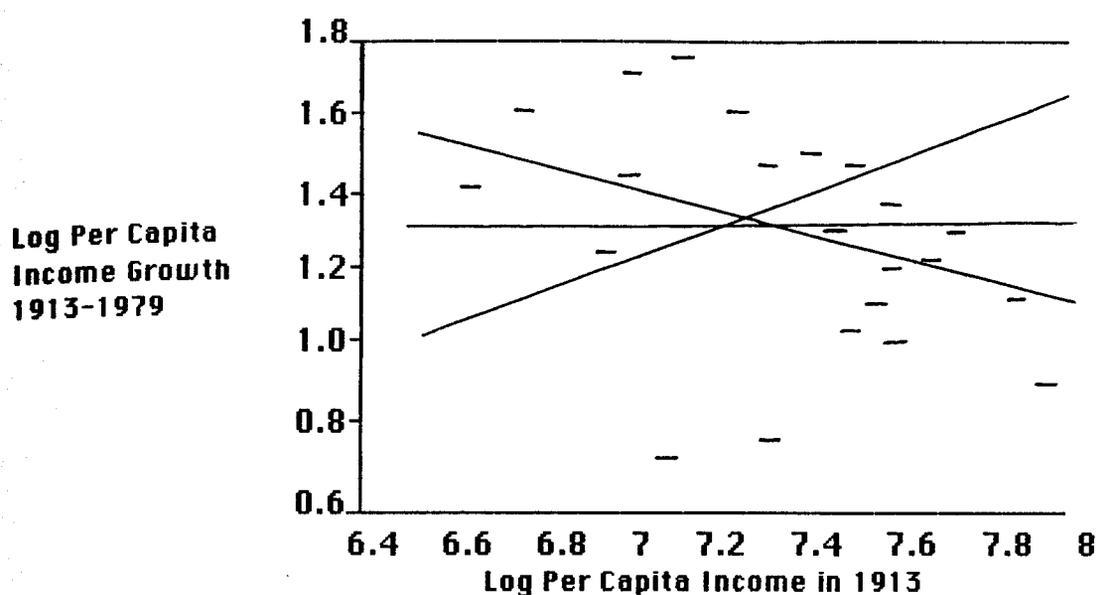


Figure 5
Maximum Likelihood Estimation For The
Once-Rich Twenty-Two, 1913-1979

Table 3- Maximum Likelihood Estimation For The
Once-Rich Twenty-two, 1913-1979

ρ	Slope Coefficient β	Standard Error of Slope	Standard Error of Regression	Standard Error in 1870 PCI
0.0	-0.333	0.116	0.171	0.0
0.5	-0.140	0.136	0.151	0.107
1.0	0.021	0.158	0.133	0.133
2.0	0.206	0.191	0.106	0.150
∞	0.444	0.238	0.0	0.167

Source: Maddison (1982)

DeLong concludes that for neither 1870-1979 nor 1913-1979 is there any significant convergence.

As a further indication of how drastic can be the effects of sample selection bias, DeLong presents the following comparison of his "once-rich twenty-two" sample and Baumol's "Maddison's sixteen"

sample, where Baumol's sample indicates convergence, but DeLong's does not:

Table 4- Standard Deviations Of Log Output For Maddison's Sixteen And The Once-Rich Twenty-Two

Sample	1870	1913	1979
Maddison's 16	.411	.355	.145
Once-Rich 22	.315	.324	.329

Source: data Maddison (1982)

iii. Results of:

William J. Baumol and Edward N. Wolff, "Productivity Growth, Convergence, and Welfare :Reply"

Using Paul Bairoch's (1976) data for eleven European countries from 1830 -1913, they find evidence of convergence for the top ten countries since 1880, but not for all eleven:

Coefficient of Variation

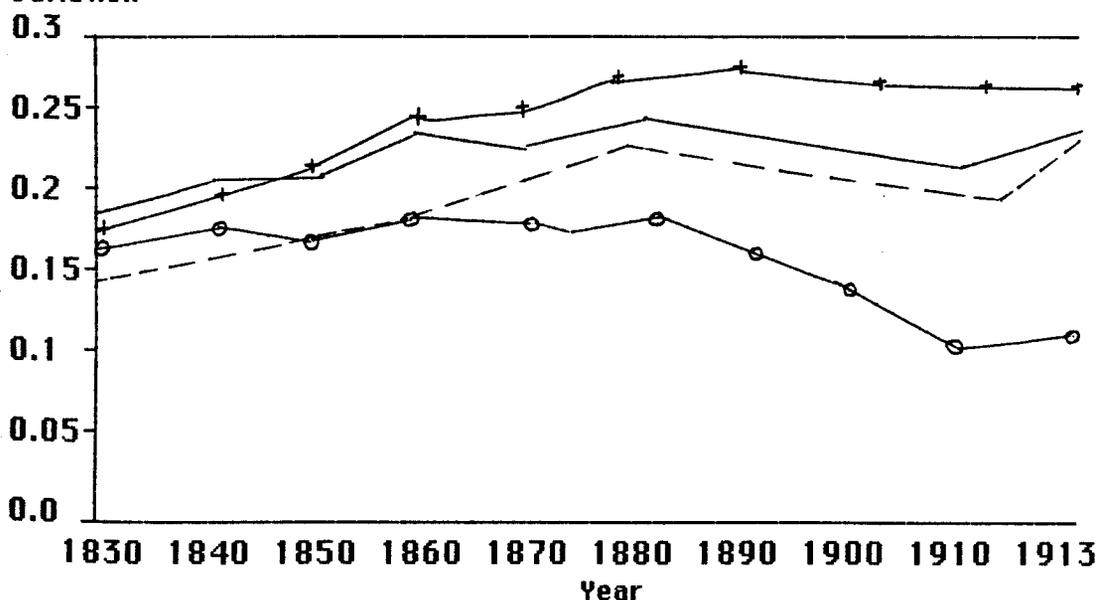


Figure 6

Coefficient of Variation GNP Per Capita, 1830-1913.

Bairoch Countries, 1870 Ranking. ○ Top 8 Countries;

--- Top 9 Countries; — Top 10 Countries; +++ Top 11 Countries

Now they expand the sample to seventy-two countries, using Summers and Heston data (1984), and alter the period to 1950 - 1980. Apparently to obtain a more readable pattern, they construct ten-country moving averages, (the first set made up of the ten poorest countries in the sample in 1950, the second set adding the eleventh lowest and removing the first lowest, and so on). They get the following:

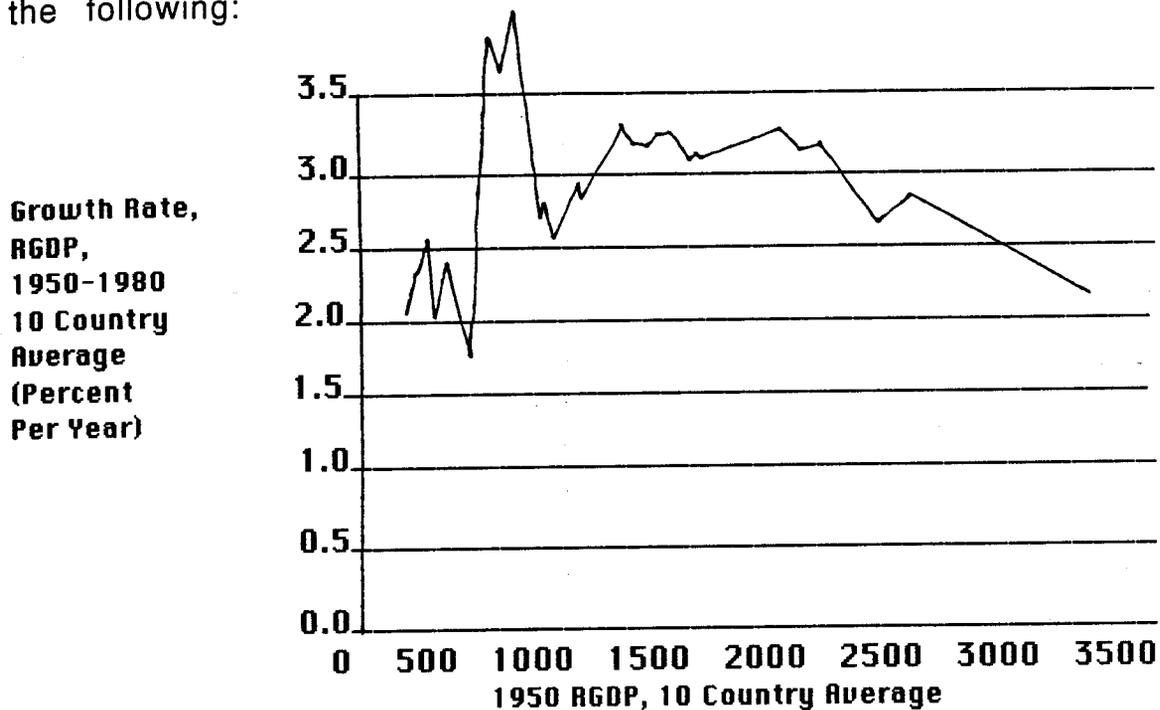


Figure 7
Growth Rate, RGDP (1950-80) vs. 1950
RGDP 10-Country Moving Average, 72
Countries Ranked BY 1950 RGDP
(Summers and Heston Data)

In the above figure, it is shown that the poorer countries have tended to diverge, while the richer countries have tended to converge. Roughly half the sample of seventy-two falls into the rich (convergence) category, and half into the poor (divergence) category.

A further indication of convergence among the rich countries is indicated in the following:

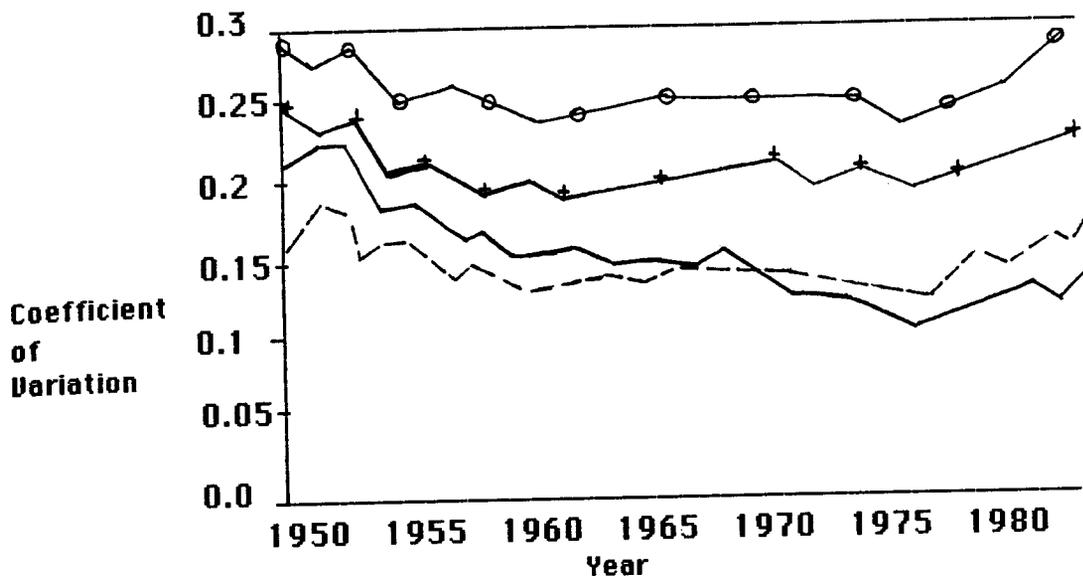


Figure 8
Coefficient of Variation, RGDP, 1950-1981, For
Sets Of Countries By 1950 RGDP Rank
 --- Top 10 Countries; — Top 14 Countries;
 +++ Top 20 Countries; o Top 24 Countries

Baumol and Wolff report regressions for the seventy-two country sample as follows:

$$\ln \text{Ratio} = .586 + .00038 \text{RGDP50} - (9.9/10^7) \text{RGDP50}$$

(4.2) (2.1) (2.2)

$$R^2 = .07 \quad N = 72$$

where Ratio = (1980RGDP/1950RGDP) and RGDP50 = per capita GDP in 1950.

They also try the following regression:

$$\ln \text{Ratio} = .658 + .00019 \text{RGDP50} - .00044 \text{D1900}$$

(5.8) (1.9) (2.2)

$$R^2 = .07 \quad N = 72$$

where D1900 = RGDP if RGDP ≥ \$1900
 = 0 if RGDP50 < \$1900

They also look at the seventeen richest countries independently:

$$\text{Ratio} = 3.3 - .00038\text{RGDP50}$$

$$(7.7) \quad (12.5)$$

$R^2 = .30$ $N = 17$ (thus, strong evidence of convergence in this group)

And the fifty-five poorest countries independently:

$$\text{Ratio} = 2.1 + .0005\text{RGDP}$$

$$(5.5) \quad (1.3)$$

$R^2 = .03$ $N = 55$ (thus, weak evidence of divergence in this group)

iv. **Results of:**

Moses Abramovitz, "The Catch-Up Factor In Postwar Economic Growth"

Abramovitz looks at the sample of Maddison's sixteen countries (i.e. same as those used by Baumol [1986]) from 1870-1979, and supplements this by also looking at the same sample, but from 1913-1986.

Source: Maddison (1982) and Maddison (1989)

Table 5
Comparative Levels of Productivity, 1870-1986
Means and Relative Variance of the Relatives of 15
Countries Compared with the United States
(U.S. GDP per hour = 100)

	Means		Coefficients of Variation	
	A	B	A	B
1870	77	-	.51	-
1890	68	-	.48	-
1900	-	52	-	.39
1913	61	52	.33	.35
1929	57	-	.29	-
1938	61	-	.22	-
1950	46	43	.36	.37
1960	52	-	.29	-
1973	69	65	.14	.16
1979	75	-	.15	-
1986	-	76	-	.14

Sources: A Columns Maddison (1982) B Columns Maddison (1989)

Abramovitz points out that the cross-country variation in productivity levels fell from 50% of the mean in 1870 to 15% in 1986. This is supportive of the convergence hypothesis.

Table 6
The Association (Rank Correlation) Between Initial Levels and Subsequent Growth Rates of Labour Productivity (GDP per hour in 16 Countries), 1870-1986

Discrete Periods		Lengthening Periods	
Based on Maddison (1982)			
1870-1890	-.32	1870-1890	-.32
1890-1913	-.56	1870-1913	-.59
1913-1929	-.35	1870-1929	-.72
1929-1938	-.57	1870-1938	-.83
1938-1950	+.48	1870-1950	-.16
1950-1960	-.81	1870-1960	-.66
1960-1973	-.90	1870-1973	-.95
1973-1979	-.13	1870-1979	-.97
Based on Maddison (1989)			
1900-1913	-.51	1900-1986	-.96
1913-1950	-.18		
1950-1973	-.96		
1973-1986	-.53		

Sources: Maddison (1982) and Maddison (1989)

Abramovitz looks at the above table, and notices that the inverse correlation between initial labour productivity levels and subsequent labour productivity growth rates is $-.97$ across 109 years. That is, the less productive a country was, the faster were its ensuing growth rates. He says this also supports the convergence hypothesis.

Abramovitz concludes that convergence has indeed occurred, across both periods observed, for Maddison's sample of sixteen countries.

v. **Results of:****Steve Dowrick and Duc-Tho Nguyen, "OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence"**

Dowrick and Nguyen use the Summers and Heston (1984) data for 1950-80, and supplement it with the OECD data for 1981-85. They initially only look at the OECD countries, but later expand the set to include all seventy-two countries.

**Table 7- The Dispersion Of Per Capita GDP Levels
Among 24 OECD Countries**

	1950	1960	1973	1985
A. Summers and Heston Data				
Weighted Mean	2508	3360	5567	6760
Unweighted Mean	2274	3034	5035	6078
Standard Deviation	1034	1108	1405	1674
Coefficient of Variation	0.45	0.37	0.28	0.28
Standard Deviation of Log	0.51	0.44	0.35	0.33
B. OECD Data				
Coefficient of Variation	0.46	0.39	0.30	0.29
Standard Deviation of Log	0.56	0.50	0.40	0.37
C. Summers and Heston Data, Trend Estimates				
Coefficient of Variation	0.45	0.36	0.28	0.27
Standard Deviation of Log	0.52	0.44	0.35	0.32

Sources: Summers and Heston (1984), OECD Ward(1985)

By looking at the above table (in particular the coefficients of variation) Dowrick and Nguyen find evidence of convergence for all three sets of data for the 24 OECD countries.

Table 8-Comparisons of Trend Growth Rates of the Richer and Poorer halves of the OECD Annual Average Percentage Rates of Change of Per Capita GDP

	1950-60	1960-73	1973-85	1950-85
Richer Countries				
Average Growth	2.3	3.1	1.5	2.3
Standard Deviation	0.8	0.6	0.7	0.5
Poorer Countries				
Average Growth	4.2	5.1	1.9	3.7
Standard Deviation	1.5	1.6	0.8	0.9
T-Statistic	3.7	4.1	1.3	4.6

Source: As for table 1

Notes: All Calculations based on trend estimates. The rich and poor halves are defined by their trend income levels at the beginning of each period. The t-statistic tests the null hypothesis that the average growth rates of the two subsamples are the same.

The above table also shows evidence of convergence, in that the poorer half of the OECD grew faster than the richer half over the same period, as the convergence hypothesis predicts.

Table 9-Regression Analysis of Relative Growth 1950-85

t=	1950	1950
Y_t	-1.57 (5.67)	-2.01 (9.67)
E		0.58 (3.74)
I		0.064 (2.54)

Notes: The dependent variable is the trend growth rate (percent per annum) of real GDP. Explanatory variables: Y_t is the logarithm of trend per capita gdp, relative to the U.S.A. in year t. E is the rate of growth of employment (percent per annum). I is the average ratio of gross investment to GDP (percent). Estimation is by OLS. Absolute t-statistics are shown in brackets ().

Sources: Summers and Heston (1984), OECD Labour Force Statistics and ILO.

The regression equation is:

$$q_i = c + a_i + bE_i - \partial \ln Y_t + e_i$$

In the first regression, (just using Y_t [i.e. initial income level as the explanatory]), the negative coefficient indicates a tendency for convergence.

In the second regression, adding employment growth and investment as explanatories to proxy for capital deepening and employment deepening, we find that their addition actually increases the significance of the coefficient for Y_t . Had capital and employment deepening been the sole explanations of convergence, the coefficient on Y_t would have gone to zero. But the opposite occurred. And, since TFP is derived as the residual growth once account has been taken of growth in employment and capital, Dowrick and Nguyen interpret the coefficient on Y_t in the second regression as a measure of the rate of TFP catch-up. Thus they find TFP growth to be a much more significant cause of growth than capital or employment deepening.

Table 10-Regression Analysis Of Growth Rates 1950-81: Samples Selected On 1950 Income Rankings Of GDP Per Capita

y	N	Dependent Variable	Y_{1950}	P	I	R2
0.25	27	Q/P	-0.98(-2.05)			.1438
		Q	-1.72(-5.70)	0.47(3.94)	0.125(5.90)	.7899
0.20	32	Q/P	-0.29(-0.77)			.0195
		Q	-1.52(-5.28)	0.46(3.89)	0.128(5.93)	.7662
0.10	55	Q/P	-0.04(-0.15)			.0004
		Q	-1.48(-6.18)	0.45(3.47)	0.139(6.50)	.6195
0.01	63	Q/P	0.22(1.01)			.0164
		Q	-0.78(-3.08)	0.57(3.53)	0.114(4.28)	.3762

Notes: The dependent variable is the annualized trend growth rate of real GDP (Q) or of real per capita GDP (Q/P). y is the minimum per capita income level of the sample (as proportion of U.S.) in 1950; all market economies in the data set with 1950 per capita income above this level are included in the sample. Y_{1950} , P, and I report the OLS coefficients (and t-statistics) on the logarithm of 1950 per capita GDP, the annualized growth rate of population 1950-81, and the average percentage share of gross investment in GDP.

Source: Summers and Heston (1984, data tape)

In the above table, Dowrick and Nguyen proceed in a similar manner to table 9, but this time they incrementally alter the sample. When trend growth of per capita GDP is regressed on initial income only, only the richest twenty-seven countries show a tendency to converge. And, for the largest sample, it appears that perhaps divergence has occurred. But, when population growth (which proxies labour growth) and investment are included as explanatories, the coefficient on initial income (now interpreted as the rate of TFP catch-up) is significant for all samples. In fact, the rate of TFP catch-up appears to be similar for all countries (except the very poorest group of sixty-three). Dowrick and Nguyen say that the reason why income levels have not converged in the larger samples (in spite of the fact that TFP has) is due to low investment relative to population growth in the poorest countries.

III. Reviewing the Studies in Light of the Empirical Issues Raised

Although Baumol's "Productivity Growth, Convergence, and Welfare" has been criticised before, (see DeLong), there are some further criticisms which have not been mentioned. Baumol uses Maddison's (1982) sample of sixteen rich countries in examining labour productivity from 1870 to 1979. This sample of course suffers from the ex post sample selection bias we talked of earlier, in that any country that has failed to converge has been excluded from the sample, thereby guaranteeing that Baumol would find convergence. In addition, Maddison's figures for growth rates were calculated using backward extrapolation which as we have mentioned leads to a bias in favour of the convergence hypothesis, (Baumol in fact acknowledges this); DeLong has since largely discredited this paper, and one of the means whereby he does this is to show that had Baumol taken into account this systematic error bias, he would have found significantly less (if any) tendency for the

data to converge.²² Maddison's data is also based on market exchange rates, and not on the PPP estimates, thus perhaps influencing the data to appear to converge less than it really does. Also, the data is not trended, which leads Baumol to the erroneous conclusion that convergence has virtually stopped since 1973, (Dowrick and Nguyen have found that convergence has continued past 1973 when trended data is used).

Baumol tried to rectify these errors, in his and Wolff's "Productivity Growth, Convergence, and Welfare: Reply". Using Bairoch's (1976) data, they select an ex ante sample of eleven countries, chosen on the basis of their relative incomes at the half-way point (1870) in their period 1830-1913.

They use the mid-point rather than the beginning of the period because they suggest that using 1830 may also have sample selection bias, but in the opposite direction.²³ I do not see this. In fact, when one looks at their results, they find that for the eight richest countries, incomes had begun to converge by 1860; so if they use 1870 as the year for choosing their ex ante sample, it is not clear that ex poste sample selection bias is not the case, (albeit in a lesser form than if they had used 1913).

For 1830-60, they find divergence of per capita incomes for the full sample; and for 1880-1913 they get convergence of the top ten income countries, but not for all eleven. One criticism is that Bairoch's data is not based on PPP estimates; (however, this is perhaps quibbling, due to the nonexistence of a PPP estimated set of data which goes back to 1830). In addition, the data is non-trended, and thus will result in bias; whether the bias is in favour of the convergence of incomes or not depends on the relative cyclical distortion levels of the eleven countries. Bairoch's data also suffers from error bias due to the backward extrapolation problem, and thus any results based on his data which do not take this error into account, (via MLE or some alternate means), will have a significant bias in favour of convergence (especially considering the period is so long : eighty-four years).

Baumol and Wolff also look at the period 1950-80 using Summers and Heston's (1984) data, which is based on PPP estimates. They look at seventy-two countries and find that the real per capita incomes of roughly the top half of the sample (in terms of income levels) have shown convergence, but that the whole sample when taken together does not show convergence. In particular, the top fifteen have shown strong convergence. My criticism again is that they do not make use of trended data, and thus their results are flawed; Dowrick and Nguyen show that using trended data for the same period and virtually the same sample (they exclude some LDC's which Baumol and Wolff leave in; [had Dowrick and Nguyen not excluded them, their results would have shown even less convergence]) that convergence is only marginally significant for the top twenty-seven income countries, and that for the top thirty-two, fifty-five, and sixty-three, no significant convergence has occurred.²⁴

DeLong, in his "Productivity Growth, Convergence, and Welfare: Comment", criticises Baumol's (1986) use of an ex poste sample, citing bias. In his sample, DeLong uses an ex ante selection criterion to rectify the problem. Using 1870 relative income levels for selecting those countries which looked like promising convergence candidates, DeLong attempts to remove the sample selection bias of Baumol's study. Yet it is interesting that Baumol and Wolff criticise DeLong's criterion, suggesting that making a choice based on 1870 income levels may just have the opposite direction of sample selection bias (this is why Baumol and Wolff chose their sample based on mid-period levels). However, I do not agree with this criticism. DeLong's criterion does not inherently contain bias as far as I can tell; indeed, it would seem to me that Baumol and Wolff's criterion would contain some left-over ex poste sample selection bias since they are using 1870 income levels, as I mentioned earlier.

Since DeLong's sample of twenty-two "once-rich" countries goes beyond the sixteen covered by Maddison (1982), DeLong is forced to mix data from different sources. Not only does he use some of Maddison's sample, but also data from Summers and Heston

(1984), as well as Bairoch (1976) and several other sources. Some, (such as Summers and Heston) use PPP estimates, whereas others (such as Bairoch and also Maddison) do not. This makes DeLong's results rather suspicious; one must question the compatibility of these various measures, and how likely they are when combined to produce accurate results.²⁵ Further, as is the case with Baumol and Wolff, DeLong fails to make use of trended data, which poses further questions regarding a bias toward or away from convergence (depending on relative levels of cyclical distortions in the sample).

Of note, DeLong does try to rectify the problem of backward extrapolation bias by using Maximum Likelihood Estimation instead of Least Squares, (thus allowing for measurement error in the dependent variable). His results are intriguing. He finds that when measurement error is assumed zero (as in OLS) there is a strong tendency toward convergence across the whole sample; however, when measurement error is assumed, no tendency toward convergence is present. This is an additional blow to Baumol's (1986) paper, in that even though the samples are slightly different, the extreme nature of DeLong's result makes us question the validity of Baumol's result which does not take into account measurement error.

Abramovitz (1989) has virtually the same empirical results as does Baumol(1986) with respect to the Maddison (1982) sample. But, although the same sixteen countries are covered, Abramovitz uses Maddison's (1989) data as well as the 1982 data, (the 1989 data covers 1913- 1986). So, in essence Abramovitz is not only reproducing Baumol's (1986) results, but also comparing them to a different period (1913-1986) in order to see if the convergence result is stable over time. As one would predict given the sample, Abramovitz comes to the conclusion that there has been convergence of labour productivity levels within the sample of sixteen rich countries. Due to the similarity of his data to Baumol's, his paper is subject to the same criticisms, such as sample selection bias (his sample of sixteen rich countries virtually guaranteed he would get convergence), use of non-trended data, use of non-PPP, and

systematic errors in estimation (which, as we have pointed out, is a significant problem). I will not go into further detail with respect to Abramovitz since my coverage of Baumol (1986) and also DeLong (1989) has made the consequences of the above criticisms clear.

Of the convergence-related papers I have read, Dowrick and Nguyen's "OECD Comparative Economic Growth, 1950-85: Catch-up and Convergence" does take into account several of the empirical issues raised. However I still have some misgivings regarding their results. They focus on the role of Total Factor Productivity in the catch-up hypothesis, and show that TFP catch-up has been occurring steadily from 1950 to 1985, (using Summers and Heston [1984] for 1950-80, and OECD estimates for 1981-85; both of which are PPP estimates), among not only the OECD, but also for roughly the top sixty income level countries, (and at a relatively homogeneous rate). Their results are robust in that PPP estimates are used, and tested for correlation with other PPP estimates for the same period to ensure that their particular data source is not biased (they get correlations of about .95)²⁶; they use trended data; they show that their results are consistent across sub-periods; they show that their result is not affected by sample selection bias, and so on. Their main result is to show that where income convergence has occurred, it has been due to TFP catch-up, and not increases in the growth of Factor Inputs. This explains the failure of many mid-income and poorer countries to catch-up in income levels, since although they have experienced strong TFP catch-up, they have had low investment levels relative to population growth, which has partially offset the catch-up in TFP.

My first concern is that, although Dowrick and Nguyen point to the fact that proportional TFP catch-up has been steady over sub-periods from 1950-85, and that it is the driving force behind the convergence of income levels, this conflicts with what one would expect. The rate of TFP catch-up should be decreasing over time as countries move toward convergence; and yet, Dowrick and Nguyen show that there is no significant slowdown in the rate of TFP catch-up.²⁷ This is inconsistent with the convergence hypothesis.

My second concern is related. As pointed out earlier, a study which fails to take into account changes in the quality of capital and labour input over time will seriously overestimate the importance of TFP. Dowrick and Nguyen's paper has this problem. Had they accounted for changes in quality, it is a distinct possibility that their results would be much different, in that TFP would be shown to be much less important to income growth than is made out. It is also possible that my first concern regarding TFP catch-up's failure to slow down is in some way a byproduct of this misreading of the importance of TFP.

Undoubtedly there are some empirical issues which will emerge from the literature which have not been covered here. Hopefully however, those that have been looked at will contribute to a better understanding of the many and varied convergence studies which have come out and no doubt will continue to. I have looked at the above papers in moderate detail, not only to provide an outline of some of the most important empirical work that has been done, but also in the hope that a critique of such studies will serve as a basis for looking at other papers done on the subject.

NOTES

- 1) DeLong, J. Bradford, "Productivity Growth, Convergence, and Welfare: Comment" pg.1140, American Economic Review, September, 1988
- 2) Dowrick, S. and D.T. Nguyen, "OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence" pg.1011, American Economic Review, December, 1989
- 3) Ibid., pg.1024
- 4) Dowrick and Nguyen, op.cit., pg.1011
- 5) Kendrick, J. and B. Vaccara (ed.'s). New Developments In Productivity Measurement And Analysis. Chicago: pg.641 University of Chicago Press, 1980
- 6) DeLong, op.cit., pg.1139
- 7) Ibid., pg.1141
- 8) Abramovitz, Moses, "The Catch-Up Factor In Postwar Economic Growth" pg. 3, Economic Inquiry, January, 1990
- 9) DeLong, op.cit., pg.1141
- 10) Ibid., pg.1148
- 11) Baumol, W. and E. Wolff, "Productivity Growth, Convergence, and Welfare: Reply" pg.1155, American Economic Review, September, 1988
- 12) Maddison, Angus, Phases of Capitalist Development. Oxford: Oxford University Press, 1982
- 13) Bairoch, Paul, "Europe's Gross National Product, 1800-1973" Journal of Economic History, Fall 1976

NOTES (Continued)

- 14) Hooper P. and J. Richardson (ed.'s). International Economic Transactions: Issues in Measurement and Empirical Research. pg.437, Chicago, University of Chicago Press, 1991
- 15) loc.cit.
- 16) loc.cit.
- 17) Helliwell, J. and A. Chung, "Macroeconomic Convergence: International Transmission of Growth and Technical Progress", in Hooper and Richardson
- 18) Dowrick and Nguyen, op.cit., pg. 1014
- 19) Abramovitz, op.cit., pg.13
- 20) Dowrick and Nguyen, op.cit., pg.1014
- 21) Ibid., pg.1028
- 22) DeLong, op.cit., pg.1144-5
- 23) Baumol and Wolff, op.cit., pg.1155
- 24) Dowrick and Nguyen, op.cit., pg.1021
- 25) Baumol and Wolff, op.cit., pg. 1155
- 26) Dowrick and Nguyen, op.cit., pg.1014
- 27) Ibid., pg.1028

BIBLIOGRAPHY

- Abramovitz, Moses. "The Catch-Up Factor in Postwar Economic Growth." Economic Inquiry, January, 1990
- Bairoch, P. "Europe's Gross National Product, 1800-1973." Journal of Economic History, Fall 1976
- Baumol, W. "Productivity Growth, Convergence, and Welfare: What the Long-Term Data Show." American Economic Review, December 1986
- Baumol, W. and E.N. Wolff. "Productivity Growth, Convergence, and Welfare: Reply." American Economic Review, September, 1988
- Christensen, L., and D. Cummings, and D. Jorgensen. "Economic Growth, 1947-73: An International Comparison," in Kendrick and Vaccara (1980)
- DeLong, J. "Productivity Growth, Convergence, and Welfare: Comment." American Economic Review, September, 1988
- Dowrick, S. and D.T. Nguyen. "OECD Comparative Economic Growth, 1950-85: Catch-up and Convergence." American Economic Review, December, 1989
- Helliwell, J. and A. Chung. "Macroeconomic Convergence: International Transmission of Growth and Technical Progress", in Hooper and Richardson (1991)
- Hooper, P. and J. Richardson (ed.'s). International Economic Transactions - Issues in Measurement and Empirical Research. Chicago: University of Chicago press, 1991

BIBLIOGRAPHY (Continued)

Kendrick, J. and B.Vaccara (ed.'s). New Developments in Productivity Measurement and Analysis. Chicago: University of Chicago press, 1980

Kravis, Irving and Robert Lipsey. "The International Comparison Program: Current Status and Problems", in Hooper and Richardson (1991)

Maddison, A. Phases of Capitalist Development. Oxford: Oxford University Press, 1982
The World Economy in the Twentieth Century. Paris: OECD, 1989

Summers, R. and A. Heston. "Improved International Comparisons of Real Product and its Composition, 1950-80." Review of Income and Wealth, June, 1984

_____. "A New Set of International Comparisons of Real Product and Price Levels: Estimates for 130 Countries, 1950-85." Review of Income and Wealth, March, 1988

Ward, Michael. Purchasing Power Parities and Real Expenditure in the OECD. Paris: OECD, 1985