AN ALTERNATIVE PERSPECTIVE ON ECONOMIC CONVERGENCE OVER THE LONG-RUN

Steven Cook

Department of Economics, University of Wales Swansea

ABSTRACT

Economic convergence over the long-run is examined for 18 OECD economies for the period 1870 to 2001. Using existing and newly proposed rank-based statistics, significant intra-distributional mobility is detected in years associated with the two World Wars and the period from the mid-1970s onwards. The detection of intra-distributional mobility is therefore found to relate closely the periods of structural change noted by Maddison (1991). The results add to earlier findings in the literature which failed to find evidence of intra-distributional mobility using a much shorter sample period.

Keywords: Rank concordance; β-convergence; Income convergence.

JEL codes: C12, C15, E00, O40.

INTRODUCTION

A central feature of the literature on economic growth is the analysis of economic convergence. This follows the prediction of convergence in per-capita incomes by the neo-classical growth model (Solow, 1956). In recent years, a range of methods has been suggested to examine a number of alternative definitions of convergence. One notion which has received much attention is that of β-convergence whereby poorer economies experience faster growth in per-capita income than richer economies. A simple method of testing for the presence of β-convergence is provided by Barro-Baumol regressions (see Barro 1991; Baumol 1986), which involve the regression of the growth rates of per-capita income upon the initial levels of per-capita income for a cross-section of economies. A significant, negative coefficient on the initial level regressor is then taken as evidence of the presence of β-convergence. However, despite its popularity (see, *inter alia*, Barro and Sala-i-Martin 1991, 1992; Mankiw *et al*. 1992), use of the Barro-Baumol regression has proved highly controversial with questions raised concerning the validity of any resulting inferences drawn (see, *inter alia*, Friedman 1992; Quah 1993, 1996; Evans 1996; Sala-i-Martin 1996; Bliss 1999, 2000; Cannon and Duck 2000). In response to the difficulties associated with Barro-Baumol regressions, Friedman (1992) has proposed the coefficient of variation as a means of examining possible convergence, with an observed reduction in its value through time

denoting convergence in the form of a reduction in the cross-sectional dispersion of per-capita incomes. This is referred to as σ-convergence. Intuitively, it can be seen that σ-convergence ensures β-convergence, as the growth rates of poorer economies must be greater than those of richer economies for the spread of the distribution of per-capita incomes to decrease. However, β-convergence does not ensure σ-convergence, as the faster growth of poorer economies may result in leapfrogging to such an extent that the distribution of per-capita incomes increases. The asymmetry between these alternative forms of convergence reflects the failure of σ-convergence to provide information concerning the intra-distributional mobility. For example, σ-convergence may occur in the presence or absence of changes in the ranking of economies with respect to their levels of per-capita income. In response to this, Boyle and McCarthy (1997) have proposed two indices to examine β-convergence in the absence of σ-convergence. Drawing upon Kendall's index of rank concordance, Boyle and McCarthy's multi-annual and binary indices permit the detection significant changes in the ranking of economies over time with respect to per-capita income.

In the present paper, economic convergence is examined for 18 OECD economies over the period 1870-2001. Following an analysis of σ-convergence, Boyle and McCarthy's (1997) rank concordance indices are applied to examine the intra-distributional properties of per-capita incomes. The issue of intra-distributional mobility warrants consideration in the present context as differences in growth rates and structural change over the long-run have previously been noted in the literature (see Maddison 1991; Mills and Craft 2000). Indeed, in an analysis of data up to 1994, Mills and Craft (2000, p.70) refer to 'substantial changes in the rank order of income levels', although this is not formally examined by the authors or elsewhere in the literature. The use of ranks in the present analysis is extended further to develop two new indices. It is found that application of these alternative indices reveals substantial changes in rankings which are not apparent when considering σ-convergence. The results obtained contrast with those of Boyle and McCarthy (1997) for a much shorter span of data (1950-1988), where intra-distributional mobility is not detected. Interestingly, it is found that the significant changes in rankings detected in the present analysis coincide with major economic and political events. In addition to the years of the two World Wars, significant mobility is found in the period after 1973, a year identified by Maddison (1991) as a point of structural change in OECD economies.

MEASURING INTRA-DISTRIBUTIONAL MOBILITY USING RANKS

Rank concordance indices

To examine the intra-distributional mobility of per-capita incomes across a range of economies, Boyle and McCarthy (1997) suggest the use of non-parametric, rank-based testing procedures to assess whether significant changes in ranking are observed over time. Drawing upon Kendall's coefficient of concordance (see Siegel 1956), calculation

of the indices requires the economies under investigation to be ranked in each year according to the observed level of per-capita income. Therefore, given N economies, the ranks in year i run from 1 for the economy with the highest per-capita income, to N for the economy with the lowest per-capita income. A series of ranks is then generated as $r_{j,i}$ where $j = 1,\ldots, N$ denotes the cross-sectional or 'economy' index and $i = 1,\ldots, T$ denotes the temporal index. Both of the indices proposed by Boyle and McCarthy (1997) draw upon the variances of the ranking distributions in each year, $r_{j,i}^d = \{r_{j,i}\}_{j=1}^N$ relative to the variance of the ranking distribution in the initial year of the sample, $r_{j,1}^d = \{r_{j,1}\}_{j=1}^N$. This allows examination of any change in ranking between a given year and the initial year. Adopting the above notation, the multi-annual index (rm_t) is given as:

$$rm_t = \frac{\mathrm{var} \sum_{i=1}^t r_i^d}{\mathrm{var}\left(t \times r_1^d\right)} \tag{1}$$

and considers changes in the distributions of ranks between years 1 and t using the information provided by these and all intervening years. In contrast, the binary index (rb_t) compares the years 1 and t using the information in these years only:

$$rm_t = \frac{\mathrm{var}\left(r_t^d + r_1^d\right)}{\mathrm{var}\left(2 \times r_1^d\right)} \tag{2}$$

Both indices employ a null hypothesis of no association between rankings in different years. In the context of economic convergence, Boyle and McCarthy (1997) interpret this null as relating to an absence of intra-distributional mobility, with no evidence provided of economies switching positions in the ranking distribution between periods 1 and t. Test statistics for the indices are given as the index multiplied by $T(N-1)$, and are distributed as χ_{N-1}^2. In the case of the rb_t, the use of just two years leads to a fixed value of $T = 2$.

Alternative Rank Statistics

In addition to the above rank concordance indices, alternative simple indices can be employed to examine changes in ranking. The two measures proposed here are based upon summations of the changes in ranking across economies in a given time period. The first index, rs_t, is defined as follows:

$$rs_t = \sum_{j=1}^{N} \left(r_{j,t} - r_{j,t-1} \right)^2 \qquad t = 2,\ldots,T \tag{3}$$

The above statistic therefore considers the one-period change in rank for all of the economies examined. Obviously, greater intra-distributional mobility results in larger values of rs_t. It should be noted that the change in rank is squared as $\sum_{i=1}^{N} r_{j,t} = 0$ by definition. A second proposed statistic, ra_t, uses the absolute value of the change in ranks as below:

$$ra_t = \sum_{j=1}^{N} \left| r_{j,t} - r_{j,t-1} \right| \qquad t = 2,\ldots,T \tag{3}$$

EMPIRICAL RESULTS

The data considered in this paper are annual observations on real per-capita income measured in millions of 1990 International Geary-Khamis dollars over the period 1870 to 2001 for the following 18 OECD economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom and United States. Before presenting results for the various rank indices discussed above, the presence of ó-convergence is examined. Considering the properties of the coefficient of variation presented in Figure One, the most striking feature is that an overall downward trend reflecting ó-convergence is punctuated by a dramatic increase corresponding to the Second World War (WWII). Between 1939 and 1945, the coefficient of variation more than doubled, increasing from 0.27 in 1939 to 0.56 in 1945. From 1945 onwards, substantial σ-convergence is apparent with the coefficient of variation falling to 0.13 in 2001. An episode of divergence on a smaller scale relates to the First World War, with the coefficient of variation increasing from 0.33 to 0.38 between 1914 and 1918. Again, this is followed by a period of convergence until the onset of WWII.

The above results provide a clear picture on the nature of σ-convergence. However, as noted above, analysis of σ-convergence alone does not provide a full analysis of convergence. Additionally, neither the presence nor absence of σ-convergence provides information concerning intra-distributional mobility. To overcome this, the rank concordance indices of Boyle and McCarthy (1997) are considered. The first index examined, the multi-annual rank concordance rm_t index, was found to return exceptionally small p-values for the null hypothesis of no association. These ranged from a maximum of 0.008 for the index in 1871 to a minimum of zero, with an average of 0.00007. It is therefore apparent that the null of no association between rankings is overwhelmingly rejected, implying little evidence

Figure 1
The Coefficient of Variation, 1870-2001
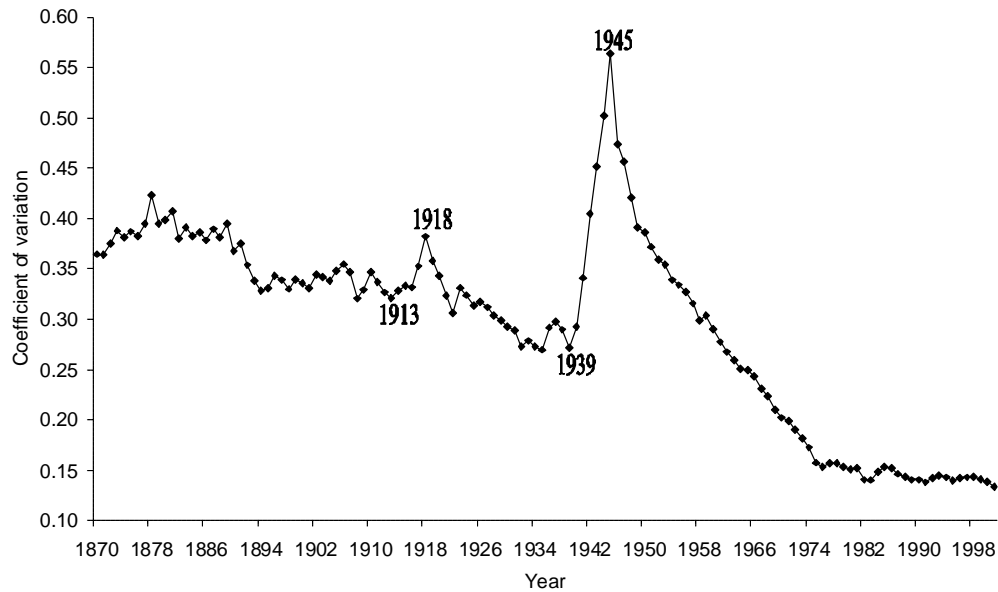
of intra-distributional mobility. However, as rm_t employs an increasing number of years through the sample period, it is possible that differing behaviour during certain phases is masked by aggregation. The binary index, rb_t, avoids this problem. From inspection of the p-values associated with rb_t in Figure Two, it can be seen that differing behaviour is present at different points in the sample. If the conventional 5% level of significance is employed, the null is rejected for every year until 1944 when a p-value of 7.1% is observed. The null is also not rejected for 1945 with a p-value of 6.7% obtained. Although, these non-rejections are marginal, they suggest the presence of intra-distributional mobility in 1944 and 1945. For subsequent years, rb_t is at the margins of significance until the mid-1970s when a rapid increase in p-values is observed. This increase is illustrated by the p-values of 8.2% and 36.1% in 1973 and 1983, respectively, and the maximum p-value of 50.4% in 1989. As with previously discussed changes in the coefficient of variation, the change in rb_t can be related to economic events, with 1973 being a breakpoint noted by Maddison (1991) and the early to mid-1970s in general being recognised as a time of great economic turbulence. To illustrate the change in rankings, Table One lists the 18 OECD economies according to their levels of per-capita income at the start of the sample (1870), in 1973 and at the point where rb_t is most significant (1989). The differences in the three ranking distributions illustrate the intra-distributional mobility which has caused the noted changes in significance of rb_t. Considering changes in rank between 1870 and 1973, the biggest improvements are noted for Canada and Sweden which both move eight places higher in the ranking, while Australia and the United Kingdom fare worst,

falling seven and nine places respectively. For the period from 1973 to 1989, the greatest improvements are seen for Norway and Japan, their rankings improving by 9 and 7 places respectively, while New Zealand is the worst performing economy, experiencing a slid of 8 places from ninth to seventeenth in the rankings.

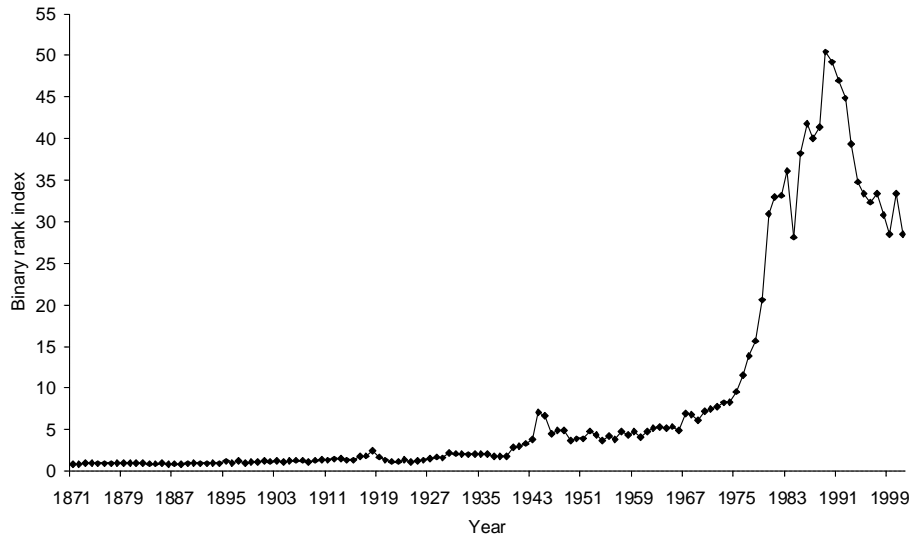**Figure 2**
The Binary Rank Concordance Index (rb_t), 1871-2001

Table 1
Per-capita Income Rankings of OECD Economies

1870	1973	1989
Australia	Switzerland	United States of America
United Kingdom	United States of America	Switzerland
New Zealand	Denmark	Canada
Netherlands	Canada	Denmark
Belgium	Sweden	Norway
United States of America	France	Japan
Switzerland	Netherlands	France
Denmark	Australia	Sweden
France	New Zealand	Australia
Austria	Belgium	Finland
Germany	United Kingdom	Belgium
Canada	Germany	Netherlands
Sweden	Japan	Germany
Italy	Norway	United Kingdom
Norway	Austria	Austria
Spain	Finland	Italy
Finland	Italy	New Zealand
Japan	Spain	Spain

Notes: Economies are ranked in descending order with respect to the level of per-capita income.

The results for the alternative rs_t and ra_t indices are presented in Figures Three and Four. The results relate closely to the behaviour of the coefficient of variation depicted in Figure One. In particular, the noted increases in the coefficient of variation around WWII corresponds to substantial changes in ranking, with 1945 being the year achieving the maximum values for both rs_t and ra_t. The second and third highest values of these indices are observed in 1919 and 1940, and have a similar explanation.

Figure 3
The Squared Rank Index (rs_t), 1871-2001
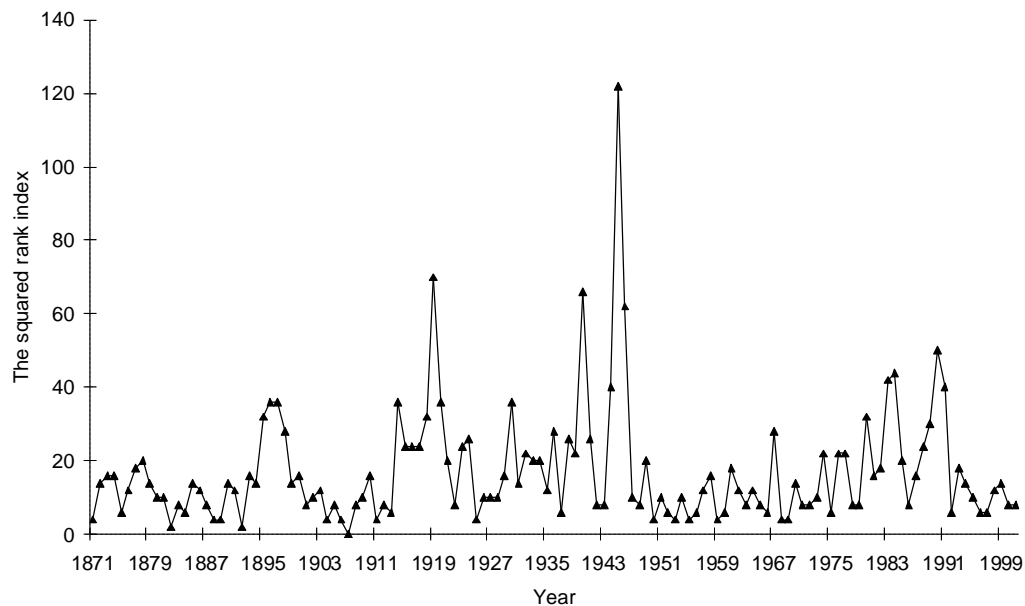
CONCLUSION

In this paper, economic convergence over the long-run has been examined using data on per-capita income for 18 OECD economies over the period 1870-2001. It was shown that a general tendency of σ-convergence throughout the sample was punctuated by divergence in the periods around the two World Wars. The analysis was then extended to consider intra-distributional mobility using rank-based statistics. It was found that the present analysis of long-run data resulted in the detected of significance intra-distributional mobility from the mid-1970s onwards using Boyle and McCarthy's (1997) binary rank concordance index. It was also found that application of two newly proposed rank-based statistics detected substantial changes in the distribution of economies in the periods associated with the two World Wars. Combined with the results from the analysis of σ-convergence, these results indicate that the years of the World Wars saw substantial changes in the relative standings of OECD economies

which widened the distribution of incomes, while changes in ranking in the post-1973 period were accompanied by a narrowing of the distribution of per-capita incomes.

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