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Trade, convergence, and globalisation: The dynamics of the international income distribution, 1950–1998 ☆

Philip Epstein, Peter Howlett, Max-Stephan Schulze *

London School of Economics, UK

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Abstract

This paper investigates the evidence for convergence in per capita incomes across 115 economies during the period 1950–1998 and examines the impact that international trade had on this process. Drawing on trade-conditioning within a distribution dynamics framework, that explicitly models frequency distributions of the cross sections of economies over time, this study suggests that trade patterns in the Golden Age were conducive to the formation of middle and high income groups or clubs of economies, but similar trade patterns (dominated by the rich economies) do not seem to explain the perpetuation of these group formations in the post-Golden Age period. If foreign trade is a key aspect of globalisation, why does it matter in accounting for the observed dynamics of the international income distribution during the Golden Age, but not during the decades since the first oil-shock? Further, the evidence from the ergodic (long-run equilibrium) distribution suggests that in

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* Corresponding author. Fax: +44 0 20 7955 7730.
E-mail address: m.s.schulze@lse.ac.uk (M.-S. Schulze).

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the long term the established trade patterns favoured the growth of the rich at the expense of the poor economies across the world.

Keywords: Distribution dynamics; Economic growth; Convergence; Foreign trade; International income distribution; Globalisation

1. Introduction

Much of the literature on economic change in the post-1945 world is permeated by two ideas: the temporal convergence of per capita incomes across economies and the spatial advance of free trade. For many economists and historians the two are linked: the reduction of trade barriers in the post-war world ushered in a new era of globalisation and that globalisation in turn helped, indeed may have been the major engine of, convergence (for example, O'Rourke and Williamson, 1999). If this were true then it would represent one of the most important transitions of the twentieth century. Free trade was championed by the liberal market democracies and the inducement held out to other economies was that by embracing free trade they too might reach the levels of income enjoyed by the richest nations.

This broad characterisation of the literature, of course, hides important nuances and controversies. For example, the most significant growth in trade tended to be between industrialised nations trading finished and semi-finished goods with each other, as evidenced by the dramatic rise in intra-European trade during the 1950s and 1960s. Likewise, income convergence may have been limited to the richer economies and it may only have been a phenomenon of the Golden Age of 1950–1973.

Initially the literature on convergence tended to characterise it as a uni-modal process whereby the steady-state equilibrium growth path would be similar for all (Barro and Sala-I-Martin, 1991, 1992; Mankiw et al., 1992). However, especially in the empirical literature, this view has been largely displaced by one that characterises convergence as a multi-modal process where there are two or more convergence clubs (Durlauf and Johnson, 1995; Quah, 1996; Temple, 1999). The problem becomes even more complex if one also accepts the view, prevalent in the economic history literature, that the post-war era can be divided into two distinct chronological periods, with possibly distinct economic characteristics: 1950–1973, known as the Golden Age, and the period after 1973, unsurprisingly, if unimaginatively, termed the post-Golden Age (Broadberry, 1996; Epstein et al., 2003; Maddison, 1995; Mills and Crafts, 2000; Temin, 1997; Temin, 2002; Toniolo, 1998). This paper examines the evidence for convergence, and whether it was uni-modal or multi-modal, in both these periods to see if they are distinct.

Turning to trade, there has been a consistent strand in the literature arguing that more open economies experienced faster productivity growth (for example, Balassa, 1985; Edwards, 1998). One explanation is that openness aided technological transfer which, in turn, raised productivity levels, although it has been argued that this would only happen if the less technologically advanced economies possessed the necessary social capabilities (Abramovitz and David, 1996; Grossman and Helpman, 1991). Another strand in the literature went a step further and linked openness to income convergence (Fisher and Serra, 1996; Proudman et al., 1997; Sachs and Warner, 1995; Ventura, 1997). However, openness is not directly observable and there is no theoretical

Table 1
Foreign trade as a proportion of nominal GDP (percent)

	1965			1995		
	Average	Minimum	Maximum	Average	Minimum	Maximum
OECD	22.7	8.8	80.0	40.4	17.2	162.7
Latin America, Caribbean	25.6	10.7	136.3	34.2	23.8	159.0
Africa	38.4	15.6	163.5	42.3	30.4	180.0
Asia	17.6	10.3	205.0	41.4	17.2	239.8

Source: World Bank, *World Development Indicators*; IMF, *Direction of Trade Statistics*.

agreement about how to measure trade openness, or rather no one accepted standard.[1] Pritchett (1996), for example, has shown that there is only weak pair-wise correlation between different openness measures and this would suggest that they indeed capture different features rather than the same underlying orientation of trade policy. Either way, the summary data presented in Table 1 show that, over the last 30–40 years of the twentieth century, foreign trade accounted for a large and increasing proportion of national product across the globe.

Here we approach the problem of the relationship between trade, growth and convergence from a different perspective and examine the impact of trading patterns, using information on who trades with whom, rather than trade openness. For it could be argued that in terms of convergence *clubs* or *coalitions* the key issue may not be openness per se but rather the relationship between the economies in the club. Hence if one believes that trade is an important factor in influencing growth and convergence, through for example technological transfer, then it is the trading relationship between members of the club that is the key factor. These problems are explored within a distribution dynamics framework that is used to investigate the evidence for convergence in per capita incomes across 115 economies during the period 1950–1998 and to assess the impact that international trade patterns had on this process. In contrast to traditional, regression-based analyses of income convergence that tended to focus on growth and to leave issues of distribution largely aside, the distribution dynamics approach adopted here allows assessing the dynamics of both growth and distribution simultaneously (Quah, 1996; Quah, 1997). The paper thus builds on our earlier work where we have used distribution dynamics analysis to examine income convergence in a relatively small sample of OECD economies for 1870–1992 (Epstein et al., 2003). One of the main results there was that distributional convergence was a temporary phenomenon, largely confined to the Golden Age. The post-Golden Age period, by contrast, was characterised by separation, divergence and polarisation in the distribution where the rich got richer and the poor were losing out in relative terms. Here we extend this

[1] Drawing on Baldwin (1989) and Pritchett (1996), Proudman et al. (1997) identify three main approaches in the literature and point to problems of endogeneity. The first relates growth to ex post measures of openness such as export shares. The second strand is *outcome-based* and asks what the outcome would have been without trade barriers, using trade intensity or price distortion measures. Finally, they distinguish an *incidence-based* approach that relies on the direct observation of trade restrictions such as average tariff rates, non-tariff barriers, black market exchange rates, central planning or state monoplies in major exports to classify economies as 'open' or 'closed.'

research in two major ways. First, conditioning is used to examine the importance of potential causal factors in processes of distributional convergence. This paper asks whether the interaction among economies trading with each other affected the dynamics of the international income distribution. Second, we look at a much larger sample of economies, which allows us to investigate per capita income convergence as a world phenomenon, and not one driven primarily by the rich OECD nations.

2. A description of the data

2.1. Sources

Annual real GDP per capita observations for 115 economies have been taken from the much used and recently up-dated data set of Maddison (2001). Its main strength compared to the other obvious post-war source, the most recent edition of the Penn World Tables, is its more complete coverage of economies over the longer period from 1950 rather than 1960 onwards. It is thus particularly helpful for any study that seeks to include the decade and a half or so after the end of the Second World War. Data on international trade are taken from the International Monetary Fund's *Direction of Trade Statistics*.

2.2. Format

The analysis builds on two types of data: (1) unconditioned GDP per capita observations and (2) trade-conditioned GDP per capita. In the first case, the per capita income observations for each year and each economy are normalised to the average level of GDP per capita among the 115 economies. That is, each observation is expressed as a proportion of the average per capita income of the cross-section in the given year. This is as a means of removing trend from the data and of allowing for the measurement of relative frequencies—a key factor in the analysis of distribution dynamics (see Section 3 below). In contrast, trade-conditioning involves expressing each GDP per capita observation as a proportion of the weighted sum of the per capita GDPs of the respective economy's principal trading partners, rather than equal weights for all as in the unconditioned case. *Principal trading partners* are taken to be those who make up 50 percent of a given economy's imports plus exports. The trade weights are from 1973 for the period 1950–1973 and from 1998 for 1973–1998. The rationale here is to capture the interaction between economies that trade most intensively with each other, since—as has been hypothesised in the introduction—it may be not be openness to trade per se that is the key issue in terms of emerging convergence clubs or coalitions, but rather the trading relationship between the members of such groupings. Unsurprisingly, there are marked differences between unconditioned and trade-conditioned GDP per capita observations for each economy and for the respective cross-section distributions as a whole. These differences are determined by who trades with whom. Here it is important to note that throughout the post-Second World War period, international trade was heavily dominated by the rich, developed economies (for example, Maddison, 1995). The geographical breakdown of the trade statistics shows, moreover, that both the poor and the rich countries traded primarily with rich economies (IMF, *Direction of Trade Statistics)*. For the trade-conditioned case this means, crudely put, that the denominator rises compared with the unconditioned case.

2.3. Examples

The effects of the above operations can be seen from the following examples for 1950–1973: Rwanda, an extremely poor economy; and the USA, one of the richest. Table 2 reports (a) unconditioned GDP per capita (normalised as percentage of cross-section average) and (b) trade-conditioned GDP per capita (normalised as percentage of weighted average of principal trading partners).

The lowering of relative income values when moving from unconditioned to trade-conditioned data is a consequence of the trading partners' income rankings. In the Rwandan case, in 1973 the principal partners were the USA, Belgium and the UK—all very rich relative to Rwanda. For the USA, the principal partners in 1973 were Canada, Japan, Germany, the UK and Mexico. Canadian and UK incomes were about three times the cross-section average in that period, Japanese and German per capita GDPs about twice. Mexico has a small weight, so the USA data reflect the predominance of rich trading partners (relative to the whole cross section) by a decrease in value to between 1.3 and 1.8 times the average of its trade partners. In other words, even though the US trading partners were poorer than the USA, they were much richer than the cross-section average and, therefore, US per capita income relative to her (fairly rich) main trading partners is significantly lower than US per capita income relative to the cross-section average.

Table 2
Effect of trade-conditioning—normalised GDP per capita

	Rwanda		USA	
	Unconditioned	Trade-conditioned	Unconditioned	Trade-conditioned
1950	**0.2500**	0.0715	4.3905	**1.8425**
1951	0.2496	0.0719	**4.4489**	1.8620
1952	0.2447	0.0710	4.4013	1.8164
1953	0.2422	0.0703	4.4079	1.8219
1954	0.2477	**0.0728**	4.2367	1.7836
1955	0.2397	0.0703	4.2688	1.7594
1956	0.2364	0.0707	4.1602	1.6772
1957	0.2352	0.0712	4.0941	1.6580
1958	0.2355	0.0728	3.9380	1.6045
1959	0.2354	0.0722	4.0494	1.6406
1960	0.2285	0.0707	3.9361	1.5914
1961	0.2127	0.0659	3.8805	1.5586
1962	0.2304	0.0710	3.9369	1.5557
1963	0.1979	0.0603	3.9748	1.5484
1964	0.1619	0.0495	3.9395	1.5258
1965	0.1639	0.0498	4.0187	1.5404
1966	0.1654	0.0501	4.0798	1.5447
1967	0.1692	0.0510	4.0748	1.5262
1968	0.1699	0.0511	4.0856	1.5208
1969	0.1775	0.0536	4.0307	1.4577
1970	0.1852	0.0567	3.8856	1.3988
1971	0.1784	0.0545	**3.8736**	1.3910
1972	0.1693	0.0509	3.9304	1.3844
1973	**0.1627**	**0.0485**	3.9426	**1.3719**

Note. Minima and maxima set in bold. Sources: see text.

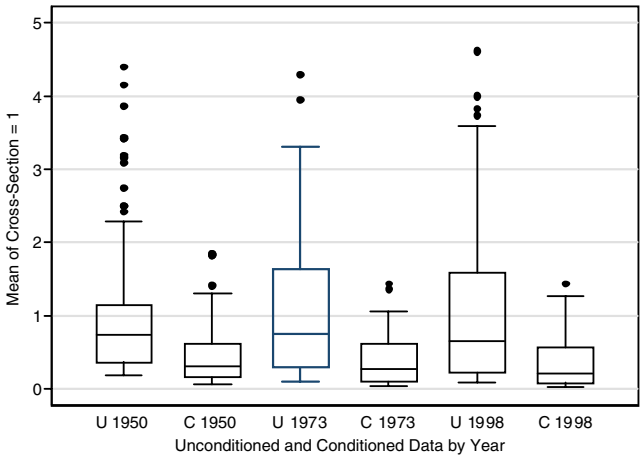

Fig. 1. Box-plots, unconditioned (U), and trade-conditioned (C) GDP per capita (normalised), 1950–1998.

2.4. Income dispersion

Some of the salient features of the data set can be captured by looking at the dispersion of per capita incomes across the 115 economies at various points in time. Fig. 1 presents box-plots of the normalised unconditioned (U) as well as trade-conditioned (C) GDP per capita observations for 1950, 1973, and 1998. These reveal several striking features of the international income distribution that offer little support for notions of global catch-up and convergence. Turning to the unconditioned case first, the inter-quartile range (indicated by box) has widened over time in both directions. Hence the middle 50 percent of the cross-section distribution was covered by a larger part of the income space in 1998 (and 1973) than in 1950. In other words, capturing the middle-income ground in 1998 required a much wider range of incomes than half a century earlier. Second, while the number of very rich 'outliers' (indicated by asterisks) was lower in 1998, that is, parts of the world were catching-up with the initially richest economies, the income range had increased at the top end (excluding the 'outliers') from about 2.4 times the average income in 1950 to about 3.7 times in 1998 (top whiskers). Or: the top and bottom ends of the international income distribution were much further apart at the end of the century than 50 years earlier. Third, most of the world's economies remained (relatively) poor throughout the period 1950–1998. Unlike the upper parts, the lower portion of the box never rose and, in fact, had dropped by 1998. Even though there were no 'outliers' at the bottom end, this can be seen as merely an indication that those who did extremely poorly in international comparison were not alone—they were numerous. The median income (indicated by thin bar in the box) in 1950 was well below the world average in 1950 and continued to be so by 1998. In fact, relative to the cross-section average, the median income was even lower in 1998 than in the immediate post-war period.

For the trade-conditioned data, as expected, the income range is far more compressed than for the unconditioned observations, with upper adjacent values below 1.5 times the trade-weighted income of economies' trading partners. Even the 'outliers' are at a maximum value of less than 2.0 as compared to circa 4.7 for the unconditioned data. In addition, there are fewer 'outliers' and, overall, less pronounced changes in the extant of the

boxes and the whiskers over the period 1950–1998. However, both the drop in the vertical position of the box and the fall in the median by 1998 are indicative of a move towards the bottom in terms of per capita incomes relative to the principal trading partners. Note that throughout the second half of the twentieth century the bulk of the economies achieved per capita incomes of only about half the weighted sum of their main trading partners.

3. Distribution dynamics and conditioning: a brief non-technical summary

The key question in the modelling of convergence is whether all economies in the distribution converge to the same level, shown by a single peak in the distribution, or whether clubs of economies within the overall distribution converge, shown by twin peaks (or more). The traditional approach using regression models, in particular panel-data estimators, fits a conditional mean to the data, rather than measuring the shape of the distribution. The alternative, the distribution dynamics approach, explicitly models frequency distributions of the cross sections of economies over time.[2]

The intuition here is the *histogram*. For each year, the normalised GDP per capita observations can be divided into discrete class intervals (or income states). The next step involves measuring the transitions of economies in the cross section from one class interval to another from time t to time $t + s$. These transitions are expressed as relative frequencies and can be interpreted as transition probabilities. Hence the model gives information on the likelihood of an economy in income state k in year t moving up or down within the distribution into state l in year $t + s$. This is formalised in a *transition probability matrix.* Through iteration, this matrix permits finding the steady (or 'ergodic') state of the system.

Here, however, we use *kernel density estimators* (or kernels) to map the frequency distribution. Like a histogram, its discrete analogue, the kernel divides the data into classes to represent distributions at given points in time. Instead of disjoint class intervals as in an histogram, though, the frequency distribution is estimated for a large number of *overlapping* class intervals. The height of the kernel is calculated as the weighted sum of the observations within the interval (or 'window') as the latter slides along the data range. The weights are the heaviest for those observations closest to the centre point of the window. The procedure yields a smooth, quasi-continuous estimate of the frequency distribution and so avoids potential problems of the results being sensitive to the fixed number of discrete income states chosen. Yet like a histogram, the kernel is a static device offering only a snapshot of the distribution in a given year. To capture patterns of distributional mobility over time, we estimate *stochastic kernels.* They are the continuous analogue of the discrete transition probability matrix and can be seen as dynamic extensions of the kernel density estimator. A stochastic kernel is the transition function of a stochastic process, represented either as a surface in three dimensions or a two-dimensional contour plot. All points of the surface are interpreted as probabilities—in the present case, the probabilities of economies' transitions from one part of the international income distribution to another periodically over a time-horizon t to $t + s$.[3]

The emergence of coalitions or clubs of economies, represented by peaks in the stochastic kernels, can thus be described but not explained directly. However, it is possible to

[2] We use Quah's TSRF (Time Series Random Field) econometric shell to compute transition probability matrices, ergodic distributions, kernel densities, and stochastic kernels.

[3] See Quah (1997) and Durlauf and Quah (1998) for applications of stochastic kernels.

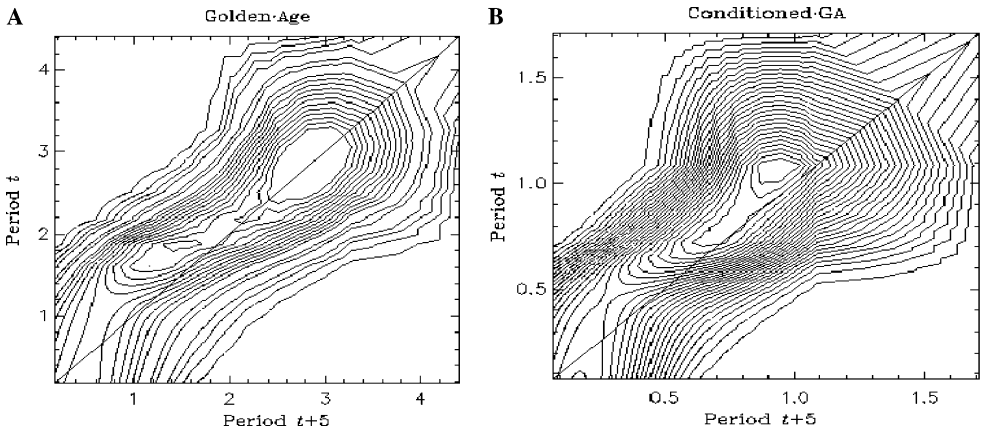

Fig. 2. (A) Contour plot—Unconditioned, Golden Age, 1950–1973. (B) Contour plot—Trade-conditioned, Golden Age, 1950–1973.

identify the factors which may induce the formation of these coalitions, in a manner analogous to the conditioning of regression lines on explanatory, right-hand-side variables. Coalitions are thought to form among groups of economies that interact in some well-defined way. For example, a coalition may form among economies that are geographically contiguous; or among a group of economies that trade mainly with other members of the group. This approach is known as 'conditioning' (Quah, 1997). The effects of conditioning are identified by changes in the shape of the stochastic kernel brought about by trade-weighting, or by weighting by geographical proximity. For example, the unconditioned stochastic kernel may show twin peaks. If conditioning, for example, by trade-weighting, removes this feature, then it can be inferred that the conditioning factor is significant in explaining the convergence clubs. The procedure used here to trade-condition the income observations has been set out above (see Section 2). There are, then, three types of kernels:

(1) the dynamic unconditioned kernel that measures transitions from t to $t + s$;
(2) a kernel that measures transitions from the original unconditioned income data to trade-conditioned data; and
(3) the dynamic conditioned kernel capturing transitions from t to $t + s$.

4. Distribution dynamics: a graphic exposition

The stochastic kernel can be generated for any length of transition period. We have chosen 5-year transitions throughout on practical grounds.[4] Figs. 2 and 3 consider the contour plots of *dynamic* stochastic kernels for 5-year transitions in (a) unconditioned

[4] Over a shorter, 1-year transition period, for example, mobility can be expected to be very limited and emerging patterns would be more difficult to trace. A significantly longer horizon, say 10 or 15 years, would reduce the number of observations available for the estimation of the stochastic kernel.

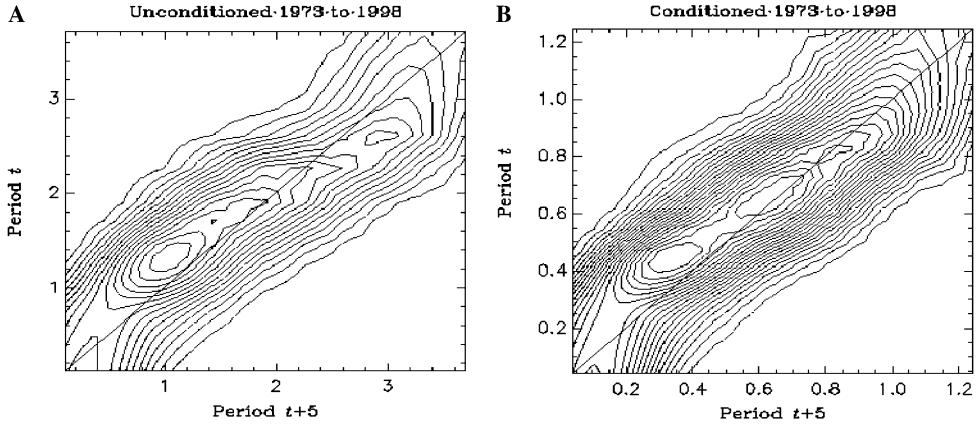

Fig. 3. (A) Contour plot—Unconditioned, post-Golden Age, 1973–1998. (B) Contour plot—Trade-conditioned, post-Golden Age, 1973–1998.

relative incomes and (b) trade-conditioned relative incomes across 115 economies during the Golden Age and post-Golden Age, averaging over the 'regime' periods 1950–1973 and 1973–1998, respectively. The contour plot in all cases is simply a plan view of the three-dimensional stochastic kernel where contours have been drawn at the indicated relative income levels and projected onto the base. It is easier to see the distributional features in plan than in perspective view. In each case, the relative income of each economy in any given year t is periodically compared to its relative income in year $t + 5$ over each year in the sample period under review. The interpretation of the graphs is the same for the unconditioned and the trade-conditioned case.[5]

Two characteristics of the stochastic kernel help reveal patterns of mobility and persistence in the empirically observed distribution: its location and the shape of its surface.[6] In terms of location, we can distinguish three basic cases. First, if most of the mass of the stochastic kernel were concentrated along the 45° diagonal then mobility is low and there is little change in the cross-section distribution (persistence): economies' relative income in Period $t + 5$ has not changed significantly since Period t (the relatively rich remain rich and the relatively poor remain poor).[7] Second, a counter-clockwise movement around the diagonal would represent a situation in which, relatively speaking, the rich were becoming poorer and the poor were becoming richer, periodically over 5-year horizons, thus indicating a tendency towards income equalisation. Third, a clockwise movement would indicate the reverse: that the rich were becoming richer and the poor were becoming poorer, thus suggesting that forces of divergence were potentially more powerful.

The contours (or surface shapes) inform us on probabilities of transition from given relative incomes in t to different relative incomes in $t + 5$. A peak reflects a comparatively large number of observed transitions from one particular part of the distribution to

[5] Note that the standardisation in the conditioned case is based on the trade-weighted GDP per capita of the given economy's principal trading partners, rather than the equal weights for all as in the unconditioned case.

[6] For a more detailed treatment see Epstein et al. (2003).

[7] Obviously, given the long 'memory' of most GDP series and with relative short transition periods, one would expect to find that most of the stochastic kernel would be concentrated along the 45° diagonal.

another (clustering). There may be more than one peak if different economies' transitions cluster in different parts of the distribution (polarisation).[8]

What, then, is the relationship between the *dynamic* unconditioned and trade-conditioned stochastic kernels? If the original features of the unconditioned kernel, which quantifies the evolution of the cross-sectional income distribution over time, are altered or removed once the data have been trade-conditioned, the inference is that the conditioning factor trade is significant in explaining the original pattern in the unconditioned data. In other words, we ask whether the conditioning factor trade affects the cross-sectional income distribution (and how it evolves through time). A comparative glance at Fig. 2, for example, shows that there are indeed marked differences between the (a) unconditioned and (b) trade-conditioned kernels, most notably the disappearance of bi-modality and, instead, a single peak in the conditioned kernel. In addition, the relative income range the stochastic kernel expands over is more compressed in the trade-conditioned case (see Section 2). The next section looks at these issues in empirical detail.

5. Distribution dynamics and trade: empirical findings

For the Golden Age, the dynamics of the unconditioned cross-country income distribution are characterised by polarisation and emerging twin peaks behaviour, suggesting the formation of distinctive clubs of economies (Fig. 2A). Note, though, that initial income levels in the moderately rich (that is above average income) club are almost twice the cross-section average. Moreover, there is significant mobility in the lower income parts of the distribution. The anticlockwise movement in the lower tail points to some catching-up of the poorest economies with the richer ones. Yet there is evidence of divergent tendencies between the two clubs. As indicated by the clockwise movement around the 45° diagonal, the group of above-average income economies is becoming marginally poorer with the peak moving from about 1.8 to about 1.6 times average income. In contrast, the position of the group of very rich economies remains unchanged over the 5-year horizon: they remain relatively rich with per capita incomes about three times the cross-section average. Fig. 3A shows the unconditioned dynamics for the later period 1973–1998. Here the evidence indicates also polarisation into two clubs:[9] there is a peak for a group of rich economies, clustered initially around 2.5 times average income, and another representing a group of economies that clustered around 1.3 times average cross-section income. However, mirroring the experience of a small sample of OECD economies (Epstein et al., 2003), clustering around the lower and upper income poles in the post-Golden Age was associated with a slight clockwise rotation of the peaks. Thus over a 5-year transition period, the group of the rich was getting richer, whilst the lower (about average) income group was becoming poorer. Only in the extreme ends of the distribution is there some movement commensurate with catching-up, with the very poor slightly improving their relative income position and the very rich losing out in relative terms.

[8] For example, in the classic twin peaks story, polarisation would be expressed as clustering of transitions around a low-income pole and a high-income pole. If this were also associated with a dip in the middle of the stochastic kernel this would suggest that separation was an important underlying characteristic: middle-income economies move into either high or low-income parts of the distribution. See Esteban and Ray (1994).

[9] Bianchi (1997) and Paap and van Dijk (1998), drawing on a similar approach, also found evidence of bi-modality, or twin peaks in the distribution, for the periods 1970–1989 and 1960–1989, respectively.

The stochastic kernels that measure transitions from the original unconditioned to the trade-conditioned data (not reproduced here) show a counterclockwise shift in probability mass parallel to the vertical axis with the original unconditioned income observations.[10] In other words, trade patterns may account for a significant part of the original cross-section income distribution and its main feature twin peaks. Specifically, in both periods rich economies traded primarily with other rich economies and, notably, poor economies, too, were mainly interacting through trade with rich countries.[11]

How did these trade patterns impact on the *dynamics* of the international income distribution? Figs. 2B and 3B provide stochastic kernel representations of 5-year transitions in trade-conditioned incomes. This means, effectively, controlling for trade. When measuring the dynamics relative to trading partners' income, the evidence suggests that, periodically over 5-year horizons, there was a tendency towards income equalisation in the middle ground of the distribution during the Golden Age (Fig. 2B). The initial bi-modality reflected in the original unconditioned data makes way for a single peak The broadly anticlockwise movement around the diagonal at the lower end of the trade-weighted income range is indicative of a tendency of the poor to catch up with the rich economies. Overall, there is a strong trade effect observable for the Golden Age. The implication is that trade patterns were a significant factor in polarisation and the emergence of distinctive middle-income (above average) and high-income clubs. The same cannot be said for the three decades or so since the first oil shock of 1973/4. Apart from the compression in the relative income range over which the stochastic kernel extends (owing to trade-weighting), Fig. 3B shows no significant big change in the distribution dynamics compared to the unconditioned kernel (Fig. 3A) and polarisation remains a feature. This finding supports the notion that the dynamics of the two periods studied here were indeed different and that different factors may have governed in each.

6. The very long run: convergence or divergence?

The differences in the short-run dynamics of the Golden Age and post-Golden Age, traced out in the preceding section, raise the question of whether in *long-term* perspective the two periods represent different epochs or historical regimes characterised by different convergence or divergence properties. One way of addressing this issue is to derive the long-run equilibrium (or steady state) of each regime.

Here we turn to the discrete state analysis of the transition probabilities matrix, i.e., the discrete analogue of the stochastic kernel (see Section 3). For each of the two periods under consideration we estimate 1-year transition matrices (five income states)[12] that give the probabilities of economies of moving from one income state to another, on average in any one year across the period. In a second step, the *ergodic distribution* is derived through continuous iteration of the transition matrix to yield a *unique* long-run steady state. In effect, the dynamic system represented by the transition probability matrix is allowed to evolve beyond the length of the actual historical period whose empirical data it is

[10] These graphs, which are available from the authors upon request, should be interpreted in the same manner as Figs. 2 and 3 except that the axes are now Original and Trade-Conditioned rather than Period t and Period $t + 5$.
[11] This results matches with Quah's (1997) finding for 105 economies over the perbd 1960–1988.
[12] A more detailed explanation of the calculation and use of transition probability matrices and ergodic distributions is provided in Epstein et al. (1999, 2003).

Table 3
Ergodic distributions, 115 economies

	Income states				
	1	2	3	4	5
Unconditioned					
1950–1973	.247	.141	.123	.153	.335
1973–1998	.333	.192	.179	.153	.142
Trade-conditioned					
1950–1973	.664	.162	.065	.056	.053
1973–1998	.412	.227	.133	.118	.110

incorporating and so informs on the extent to which the two periods were conducive to long-run convergence.

Table 3 shows the ergodic distributions for the 115 economies for both the Golden Age and the post-Golden Age, distinguishing between the unconditioned and trade-conditioned income observations. The numbers in the table report the equilibrium proportion of economies falling in either of the five relative income states. According to this evidence, there are significant differences in the distributional convergence properties of the two periods under review. The equilibrium distribution across the 115 economies is decidedly bi-modal for 1950–1973 and heavily skewed with a single peak in the *lowest* income state for 1973–1998. On this basis, there is little to be said in favour of strong factors working towards unconditional income convergence across the globe since the end of the Second World War.

International trade in the post-World War II period was dominated by the rich economies: they traded primarily with other rich economies and poor economies, too, traded largely with rich economies rather than with other poor or middle income economies (Section 5). What were the effects of such trade patterns on the long-run equilibrium—did they make for long-run distributional convergence or divergence? The data for the Golden Age suggest that foreign trade did indeed matter: accounting for economies' trade relationships removes the bi-modality apparent in the unconditioned data and leaves an ergodic distribution with a pronounced single peak in the lowest income state. In other words, the majority of the economies are becoming poorer relative to their trading partners in the long run. Thus, controlling for trade suggests that a good deal of the bi-modality in the original (unconditioned) equilibrium distribution can be linked to the effects of foreign trade patterns: growth was faster among the developed economies and these were the main trading partners for all. Hence, trade with the rich does not appear to improve the relative income position of the numerous poor over the very long run. At first sight, this finding appears to sit somewhat uneasily alongside the results of the trade-conditioned dynamic kernel analysis. However, here it is important to consider the distinction between short-run transitions (as represented in the stochastic kernels) within the distribution and the very long-run process leading to an equilibrium distribution. This latter process is based on ceteris paribus assumptions (that is, the dynamic system represented by the transition matrix evolves unrestrictedly) and its result, the ergodic distribution of relative income levels and its shape, can be understood as the outcome of cumulative, unrestricted transitions over the long-run. As mentioned above, the steady states are not readily apparent in the transition patterns traced over comparatively short periods such as 5 or even, say,

10 years. For the post-Golden Age period after 1973 the effects of trade on the distribution are not significant: the long-run equilibrium shows a peak in the lowest income state (and rising densities associated with movements down the income scale) in both the unconditioned and the trade-conditioned cases. This finding corresponds fairly well with the dynamic stochastic kernels which indicated that trade over the 5-year horizon did not entail an increase in catch-up opportunities (Figs. 3A and B).

7. Some implications

The new results presented here raise several important issues that require further investigation. First, the age of post-war 'globalisation' appears to have been associated with widening income gaps between the poorest and the richest economies—this is what the snapshots of income dispersion for selected years would suggest. By that basic measure, there is little to be said in favour of global, unconditional σ-convergence. Second, why were trade patterns in the Golden Age apparently conducive to the formation of middle and high income groups of economies, but similar trade patterns (dominated by the rich economies) do not seem to explain their perpetuation in the post-Golden Age? In other words, if foreign trade is one significant aspect of globalisation, why does it matter in accounting for the observed dynamics of the international income distribution during the Golden Age but not during the decades since the first oil-shock? Were existing catch-up and convergence opportunities more readily exploitable in a world of broadly declining barriers to trade as during the Golden Age? Further, were limitations of social capabilities among the poorer economies less of a constraint to catch-up growth during the Golden Age than thereafter—for instance, because of changes in the nature, direction and rate of technological advance that placed a higher premium on societal and institutional adaptability in the later period? Finally, if, as the evidence from the ergodic distributions seems to suggest, the established trade patterns favoured the growth of the rich at the expense of the poor in the very long run, what are the implications for the conduct of international trade policies?

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