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Trade, Convergence and Globalisation: the dynamics of change in the international income distribution, 1950-1998

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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 (e.g. 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 '60s. Likewise, income convergence may have been limited to the richer economies and it may only have been a phenomenon of the Golden Age of 1950-73.

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, Romer and Weil, 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 (Maddison, 1995; Broadberry, 1996; Mills and Crafts, 2000; Temin, 1997, 2002; Toniolo, 1998; Epstein, Howlett and Schulze, 2003). 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 (e.g. 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 (Grossman and Helpman, 1991; Abramovitz and David, 1996). Another strand in the literature went a step further and linked openness to income convergence (Sachs and Warner, 1995; Ventura, 1997; Fisher and Serra, 1996; Proudman, Redding and Bianchi, 1997). However, openness is not directly observable and there is no theoretical agreement about how to measure trade openness, or rather no one accepted standard.[1] Pritchett (1996), for example, has shown that there is

[1] Drawing on Baldwin (1989) and Pritchett (1996), Proudman, Redding and Bianchi (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'.

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.

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, 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, Howlett and Schulze 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 characterized by separation, divergence and polarization in the distribution where the rich got richer and the poor were losing out in relative terms. In the present paper we extend this research in two major ways. First, conditioning is used to examine the importance of potential causal factors in the 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.

In this context, it is important to distinguish between the *empirically observed dynamics* of the international cross-sectional income distribution and its steady state solution (*long-run equilibrium*). Although the two are obviously related, the long-run equilibrium is not always apparent from the distributional characteristics demonstrated by the empirically observed dynamics during a given period. When discussing the latter, therefore, the focus is on *mobility* (the movement of economies between different income levels), *persistence* (where economies remain at given income levels), and tendencies such as *clustering* (where groups of economies cluster around a certain income level) and *stratification* (where economies move into distinct income-level strata). *Convergence* (or *divergence*), on the other hand, is viewed as the outcome of a long-run process and is captured in the shape of the steady state distribution.

2. A description of the data

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. The current price PPP-adjusted GDP estimates by Prados de la Escosura (2000) offer no alternative since they are only available for certain benchmark years and not on a continuous basis. Moreover, they cover only a comparatively small sample of largely developed economies. Data on international trade are taken from the International Monetary Fund's *Direction of Trade Statistics*.

Format. The following 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 normalized 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 of the 115 economies in the given year. This is as a means of removing trend from the data and of allowing the measurement of relative frequencies – a key factor in the analysis of distribution dynamics (see Section 3 below). In contrast, the case of 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 per cent 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.[2] The rationale here is to capture the interaction between economies that trade most intensively with each other, since – as has been hypothesized 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

[2] As a means of some initial sensitivity analysis, we are currently exploring the effects of alternative weights from the beginning and the middle of the periods investigated.

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 (e.g. 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.

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.

(a) Rwanda, unconditioned GDP per capita (normalized, %):

0.2500	0.2496	0.2447	0.2422
0.2477	0.2397	0.2364	0.2352
0.2335	0.2354	0.2285	0.2127
0.2304	0.1979	0.1619	0.1639
0.1654	0.1692	0.1699	0.1775
0.1852	0.1784	0.1693	**0.1627**

The range is 0.1627 to 0.2500 times the cross-sectional average.

(b) Rwanda, trade-conditioned GDP per capita, 1973 weights (normalized, %):

0.0715	0.0709	0.0710	0.0703
0.0728	0.0703	0.0707	0.0712
0.0728	0.0722	0.0707	0.0659
0.0710	0.0603	0.0495	0.0498
0.0501	0.0510	0.0511	0.0536
0.0567	0.0545	0.0509	**0.0485**

giving a range from 0.0485 to 0.0728 times the weighted average of its principal trading partners.

(c) USA, unconditioned GDP per capita (normalized, %):

4.3905	**4.4489**	4.4013	4.4079
4.2367	4.2688	4.1602	4.0941
3.9380	4.0494	3.9361	3.8805
3.9369	3.9748	3.9395	4.0187
4.0798	4.0748	4.0856	4.0307
3.8856	**3.8736**	3.9304	3.9426

giving a narrower range at a high relative level compared to the Rwandan case.

(d) USA, trade-conditioned GDP per capita, 1973 weights (normalized, %)

1.8425	1.8620	1.8164	1.8219
1.7836	1.7594	1.6772	1.6580
1.6045	1.6406	1.5914	1.5586
1.5557	1.5484	1.5258	1.5404
1.5447	1.5262	1.5028	1.4577
1.3988	1.3910	1.3844	**1.3719**

which shows a compression of the range in absolute terms, and a general lowering of values compared to (c).

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.

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. This provides some empirical background for the discussion of distribution dynamics in the following sections. Figure 1 (a) presents box-plots of the unconditioned, normalized GDP per capita observations (measured on the vertical scale) for 1950, 1973, 1988 and 1998 (horizontal scale). The box represents the inter-quartile range (IQ), i.e. it covers the space between the 25th and 75th percentiles and thus contains the middle 50 per cent of the distribution. The thin line in the box shows the median income. The whiskers represent upper and lower adjacent values, where the upper (lower) value is the largest (smallest) income value less (greater) than or equal to the 75th (25th) percentile value plus 1.5*IQ. The asterisks indicate upper and lower outside values, i.e. observations that lie outside the upper and lower adjacent values. These denote those economies that have performed exceptionally well or exceptionally poorly relative to most other economies and could be labelled ‘outliers’ as short-hand.

Figure 1 (a) reveals several striking features of the international income distribution that offer little support for notions of global catch-up and convergence. First, the inter-quartile range has widened over time in both directions. Hence the middle 50 per cent 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’ was lower in 1998, i.e. 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 fifty 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 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 lower in 1998 than in the immediate post-war period.

[Figure 1 (a) here]

Figure 1 (b) shows box-plots for the trade-conditioned data. Here, as expected, the income range is far more compressed than in Figure 1 (a), 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 only 2.0 as compared to nearly 5.0 for the unconditioned data. In addition, there are fewer ‘outliers’ (though these are more extreme in 1998 than in 1950) 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 times the weighted sum of their main trading partners.

[Figure 1 (b) here]

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

The main 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.

The intuition here is the histogram. For each year, the GDP per capita data are normalized to the average level of GDP per capita among the 115 economies (see Section 2) and then divided into discrete class intervals. The next step involves measuring the dynamic transitions of economies in the cross section from one class interval to another from time t to time $t + s$, for $s \geq 1$. These transitions are expressed as relative frequencies, and can be interpreted as transition probabilities. The class intervals in this case are income states, and so the model gives information on the likelihood of an economy in state k in year t moving up or down within the distribution into state l in year $t + s$. Through iteration, the resulting transition matrix permits finding the steady (or ‘ergodic’) state of the system. However, the number of states chosen by the researcher is arbitrary, and, as in the histogram, is possibly too coarse to capture important details of the dynamics.

There is a refinement of the discrete state-space approach, known as the ‘kernel’, or ‘kernel density’ estimator. It is an extension of the histogram: instead of disjoint states, the frequency distribution is estimated for a large number of overlapping class intervals (or ‘windows’), which gives a much smoother appearance, resembling a probability density function. Here, the height of the kernel is calculated as a weighted sum of the observations within the window, the weights being heaviest for those observations closest to the centre point of the window. A dynamic extension, known as the stochastic kernel, measures transition probabilities on a much finer grid (rather than across discrete states) and is an analogue of the transition matrix. The representation is as a surface in three dimensions which is interpreted as the likelihood of economies moving up and down the rankings of the distribution over a time-horizon t to $t + s$. Additionally, because the grid is much finer, the overall shape of the distribution of transition probabilities, single or twin peaks, is clearly defined.

The emergence of coalitions or clubs of economies, represented by peaks in the stochastic kernels, can thus be described but not explained directly. However, by an extension of the stochastic kernel it is possible to 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. It may be, for example, that a coalition forms 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 the conditioning, e.g. 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: representation

Like the transition probability matrix, the stochastic kernel can be generated for any length of transition period. We have chosen 5-year transitions throughout on practical grounds.[3]

Figure 2 considers the *dynamic* stochastic kernels and the related contour plots for 5-year transitions in (a) unconditioned relative income data and (b) trade-conditioned relative income data for the 115 economies during the Golden Age, averaging over the 'regime' period (1950-73). [The contour plot in all cases is simply a plan view of the three-dimensional kernel. It is easier to see the distributional features in plan than in perspective view.] Figure 3 does the same for the post-Golden Age period (1973-98). Thus in each case, the relative income of

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[3] Over a shorter, one-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 kernel.

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.

[Figure 2 here]

How do we interpret the stochastic kernel? The stochastic kernel provides evidence about mobility and persistence in the empirically observed distribution. Figures 2 and 3 show how the cross-sectional distribution at time t evolves into that at time t + 5. The horizontal axes (for Period t and Period t + 5) give relative income, with 1.0 representing the standardised average level of income.[4] The interpretation of the graphs is the same for the unconditioned and the trade-conditioned case. Thus, a movement from right to left along the Period t horizontal axis, or from left to right along the Period t + 5 horizontal axis, represent increasing relative income. Slicing vertically through the kernel from any point on the Period t axis extending parallel to the Period t+5 axis gives a probability density function that describes transitions over 5 years from a given relative income in period t.[5] This is captured on the vertical axis whose scale, however, is unbounded. Thus two characteristics of the stochastic kernel help to reveal patterns of distributional mobility: its location and the shape of its surface.

[Figure 3 here]

Mobility and persistence can first be assessed by asking how the stochastic kernel lies relative to the 45-degree diagonal. This is more

[4] Note that the standardization 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.

conveniently captured in a contour plot, a view from above on the stochastic kernel where contours have been drawn at the indicated relative income levels and projected onto the base of the graph. If most of the stochastic kernel were concentrated along this diagonal then mobility is low and there is little change in the cross-section distribution: 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) – an example of persistence.[6] If, on the other hand, most of the mass of the stochastic kernel had rotated around the 45-degree diagonal then this would indicate substantial changes in the distribution and a high degree of mobility.[7] 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 equalization. At the extreme, this might take the form of over-taking with rich countries becoming poor and poor countries becoming rich. 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 surface shape of the stochastic kernel (or contours in the corresponding contour plot) tells us about probabilities of transition from given relative incomes in t to different relative incomes in t+5. In other words, a peak reflects a (comparatively) large number of observed transitions from one particular part of the distribution to another. It thus provides evidence on clustering over a 5-year horizon. There may be

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[5] The profile traced out by this slice is non-negative and integrates to unity and is analogous to a row of a transition probability matrix. It can be interpreted as a marginal probability density function.

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

more than one peak if different economies' transitions cluster in different parts of the distribution (or around different income poles). 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.[8] Furthermore, 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.

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 Figure 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.

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[7] Given the time horizon the kernel has been estimated for, we would not expect there to be major rotations.

[8] Polarisation is a complex concept but Esteban and Ray (1994) explain those complexities clearly and methodically.

5. Distribution dynamics and trade: empirical findings

What do Figures 2 (a) and 3 (a) reveal about the dynamics of the unconditioned cross-country income distribution during the Golden Age and post-Golden Age periods? For the Golden Age, the pattern of distributional change is characterized by polarization and emerging twin peaks behaviour, suggesting the formation of distinctive clubs of economies . Note, though, that initial income levels in the moderately rich (i.e. 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 anti-clockwise 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-degree 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 3 times the cross-sectional average. Figure 3 (a) shows the unconditioned dynamics for the later period 1973-98. Here the evidence indicates also polarization into two clubs[9]: there is a peak for a group of rich economies, clustered initially around 2.6 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, Howlett and Schulze, 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)

[9] Bianchi (1997) and Paap and van Dijk (1998), drawing on a similar approach, also found evidence of bimodality for the period 1970-1989 and 1960-1989, respectively.

income group was becoming poorer. Only in the extreme ends of the distribution is there some movement commensurate with catching-up, convergence with the very poor slightly improving their relative income position and the very rich losing out in relative terms.

Both contour plots in Figure 4 (a) for 1950-73 and (b) for 1973-98 show a counter-clockwise twist in the kernel towards the vertical, or clustering at the high end of the original scale and low end of the trade-conditioned scale. This graph should be interpreted in the same manner as Figures 2 and 3 except that the axes are now Original and Trade-Conditioned rather than Period t and Period t+5. Comparing these graphs with Figures 2 (a) and 3 (a) (i.e. unconditional dynamics), the most significant change is this counter-clockwise shift in probability mass parallel to the Original axis. 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.[10]

[Figure 4 here]

The question that now arises is *how* these trade patterns impacted on the dynamics of the international income distribution. Figures 2 (b) and 3 (b) provide 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 equalization in the middle ground of the distribution during the Golden Age (Figure 2 (b)). The initial bi-modality reflected in

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[10] This results matches with Quah's (1997) finding for 105 economies over the period 1960-88.

the original unconditioned data makes way for a single peak. The anti-clockwise 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 polarization 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), Figure 3 (b) shows no significant big change in the distribution dynamics compared to the unconditioned kernel (Figure 3 (a)) and polarization remains a feature. This finding lends some credence to 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?

So far, the focus has been on distributional mobility and persistence over 5-year horizons during the two periods under review. However, if we have reason to believe that the Golden Age and the post-Golden Age periods may indeed represent different epochs or historical regimes, then it is also important to establish the long-run equilibrium of each regime so as to be able to address the issues of convergence and divergence more explicitly. These equilibrium positions, or steady states, are not immediately apparent from the distributional characteristics reflected in the empirically observed dynamics (or short-run transitions) during a given period.

To find the steady state solutions for the Golden Age and post-Golden Age we turn to the discrete state analysis of the transition probabilities matrix, i.e. the discrete analogue of the stochastic kernel. First, for each of the two periods under consideration we estimate 1-year transition probability matrices, using five income states.[11] These matrices give the probabilities of economies to move from one income state to another, on average in any one year across the period. Second, the *ergodic distribution* is derived drawing on the well-known feature of any transition probability matrix to yield a *unique* long-run steady state condition (through continuous iteration).[12] This is a central concept in the analysis since it permits gauging the 'convergence' properties of historical periods or regimes. By addressing the question of what the outcome would be if the dynamic system represented by the transition probability matrix were allowed to evolve unrestrictedly (i.e. beyond the length of the actual historical period whose empirical data it is incorporating), it allows us to estimate the extent to which the Golden Age and post-Golden Age periods were conducive to long-run convergence processes.[13] The ergodic distribution suggests what the shape of the long run equilibrium distribution would look like.[14]

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[11] The choice of the number of income states is arbitrary but the usual number of states, known collectively as the 'state space', is five in current work. We adhere to this practice.The income ranges representing the five states are not imposed by the researchers but are derived on purely empirical grounds. First, all the annual standardised income observations are treated effectively as a single cross-section. The observations in this 'cross-section' are then ranked from the lowest to the highest observation and split into five equal states: each state contains the same number of observations. This gives us the values for the partition for each state. It also means that the size and values of the states is different for each of the two sub-periods, since the population is different for each sub-period. Alternative definitions of the income states are also possible and will be investigated in future research. We use Quah's TSRF (Time Series Random Field) which is an econometric shell that permits the calculation of transition probability matrices and ergodic distributions.

[12] Technically, the ergodic distribution is obtained by multiplying the matrix by itself *n* times until all its rows are identical. The theory of probability matrices guarantees that this will always happen.

[13] A more detailed explanation of the calculation and use of transition probability matrices and ergodic distributions is provided in the appendices of Epstein, Howlett and Schulze (1999).

[14] As indicated in the discussion above, the imposition of discrete states involves some loss of responsiveness to changes in the underlying data. For example, using the

Table 1 shows the ergodic distributions for the 115 economies for both the Golden Age and the post-Golden Age, distinguishing, again, between the unconditioned and the trade-conditioned income observations. The numbers in the table report the equilibrium (or steady state) 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 1950-73 and heavily skewed with a single peak in the *lowest* income state for 1973-98. On this preliminary 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.

The discussion in Section 5 above has shown that international trade in the post-World War II period was dominated by the rich economies: rich economies traded primarily with rich economies and poor economies, too, traded largely with rich economies rather than with other poor or middle income economies. What, then, are the effects of such trade patterns on the long-run equilibrium – do 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 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-

stochastic kernel allows tracing transitions within the distribution over shorter distances. Movements that fall within the boundaries of discrete income states cannot be captured by the transition matrices, but such movements could be traced in the stochastic kernel estimates. Thus tendencies such as clustering, separation, and polarization are more readily picked up in the stochastic kernel. In other words, transition matrices offer a less detailed and precise depiction of the period dynamics than stochastic kernels and, therefore, the ergodic distributions are affected by the coarser underlying state grid.

modality in the original (i.e. 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 (i.e. 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. The effects of trade on the distribution are not significant for the post-Golden Age period after 1973: 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 [Figure 3 (a) and (b)].

Table 1: 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

7. Some implications

The preliminary findings presented here raise several issues that require further detailed investigation. First, the age of post-war 'globalization' appears to have been associated with a widening in the income gaps between the poorest and the richest economies – this is what the snapshots of income dispersion (box-plots) for selected years would suggest. By that very 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) seem to offer little in terms of explaining their perpetuation in the post-Golden Age? In other words, if foreign trade is one significant aspect of globalization, why does it matter in accounting, at least partly, 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? Finally, does the evidence from the ergodic distributions suggest that in the very long the established trade patterns favoured the growth of the rich at the expense of the poor?

<u>References</u>

Abramovitz, M. and David, P. (1996), 'Convergence and deferred catch-up: productivity leadership and the waning of American exceptionalism', in R. Landau, T. Taylor and G. Wright (eds.), *The Mosaic of Economic Growth*.

Balassa, B. (1985), 'Exports, policy choices and economic growth in developing economies after the 1973 oil shock', *Journal of Development Economics*, 23-35.

Baldwin, R. (1989), "Measuring Non-Tariff Trade Policies", *National Bureau of Economic Research Working Paper,* No.2,978.

Barro, R. J. and Sala-I-Martin, X. (1991), 'Convergence across states and regions'*, Brookings Papers* (1991), 107-82.

Barro, R. J. and Sala-I-Martin, X., 'Convergence', *Journal of Political Economy* (1992), 223-51.

Bianchi, M. (1997), 'Testing for Convergence: Evidence From Non-Parametric Tests.' *Journal of Applied Econometrics* 12, 393-411.

Broadberry, S. N. (1996), 'Convergence: What the Historical Record Shows.' In B. van Ark and N. F. R. Crafts (Eds.), *Quantitative Aspects of Post-War European Growth*. Cambridge: Cambridge University Press.

Durlauf, S. N. and Johnson, P.A. (1995), 'Multiple regimes and cross-country growth behaviour', *Journal of Applied Econometrics*, 365-84.

Durlauf, S. N. and Quah, D. (1998), 'The new empirics of economic growth.' Centre for Economic Performance, London School of Economics and Political Science, Discussion Paper No. 384.

Edwards, S. (1998), 'Openness, productivity and growth: what do we really know?' *Economic Journal*, 383-398

Epstein, P., Howlett, P. and Schulze, M.-S. (1999), 'Income distribution and convergence: the European experience, 1870-1992', London

School of Economics, *LSE Working Papers in Economic History* 52/99.

Epstein, P., Howlett, P. and Schulze, M.-S. (2003), 'Distribution Dynamics: Stratification, Polarization and Convergence Among OECD Economies, 1870-1992.' *Explorations in Economic History* 40, 78-97 .

Esteban, J.-M. and Ray, D. (1994), 'On the Measurement of Polarization..' *Econometrica* 62, 819-51.

Fisher, R.D. and Serra, P.J. (1996), 'Income convergence within and between countries', International Economic Review, 531-51.

Grossman, G. and Helpman, E. (1991), *Innovation and Growth in the Global Economy*. Cambridge, Mass.: MIT Press.

International Monetary Fund, *Direction of Trade Statistics* (various issues).

Maddison, A. (1995), *Monitoring the World Economy, 1820-1990*. Paris: OECD.

Maddison, A. (2001), *The World Economy: A Millenial Perspective*, Paris: OECD.

Mankiw, N. G., Romer, D., and Weil, D. (1992), 'A contribution to the empirics of economic growth.' *Quarterly Journal of Economics* 107, 407-38.

Mills, T. C. and Crafts, N. F. R. (2000), 'After the Golden Age: a long run perspective on growth rates that speeded up, slowed down and still differ.' *Manchester School* 68, 68-91.

O'Rourke, K. H. and Williamson, J. G. (1999), *Globalization and History*. Cambridge, Mass., and London: MIT Press.

Paap, R. and van Dijk, H. K. (1998), 'Distribution and mobility of wealth of nations." *European Economic Review* 42, 1269-93.

Prados de la Escosura, L. (2000), ‘International comparisions of real product, 1820-1990: An alternative data set.” *Explorations in Economic History* 37, 1-41.

Pritchett, L. (1996), ‘Measuring outward orientation of LDCs: Can it be done?’, *Journal of Development Economics* 49, 307-35.

Proudman, J., Redding, S. and Bianchi, M. (1997), ‘Is international openness associated with faster economic growth’, Working Paper Series No. 63, Bank of England.

Quah, D. T. (1996), ‘Twin peaks: growth and convergence in models of distribution dynamics.’ *Economic Journal* 102, 1045-55.

Quah, D. T. (1997), ‘Empirics for growth and distribution: stratification, polarization, and convergence clubs.’ *Journal of Economic Growth* 2, 27-59.

Sachs, J. and Warner, A. (1995), ‘Economic reform and the process of global integration’, *Brookings Papers on Economic Activity*, 1-118.

Temin, P. (1997), ‘The Golden Age of European growth: a review essay’, *European Review of Economic History* 1, 127-49.

Temin, P. (2002), ‘The Golden Age of European growth reconsidered’, *European Review of Economic History* 6, 3-22.

Temple, J. (1999), ‘The new growth evidence.’ *Journal of Economic Literature* 37, 112-56.

Toniolo, G. (1998), ‘Europe’s Golden Age, 1950-1973: speculations from a long-run perspective.’ *Economic History Review* 51, 252-67.

Ventura, J. (1997), ‘Growth and interdependence’, *The Quarterly Journal of Economics*, 57-84.

Figure 1 (a): Box-plots, unconditioned per capita income data (normalized), 1950, 1973, 1988,1998

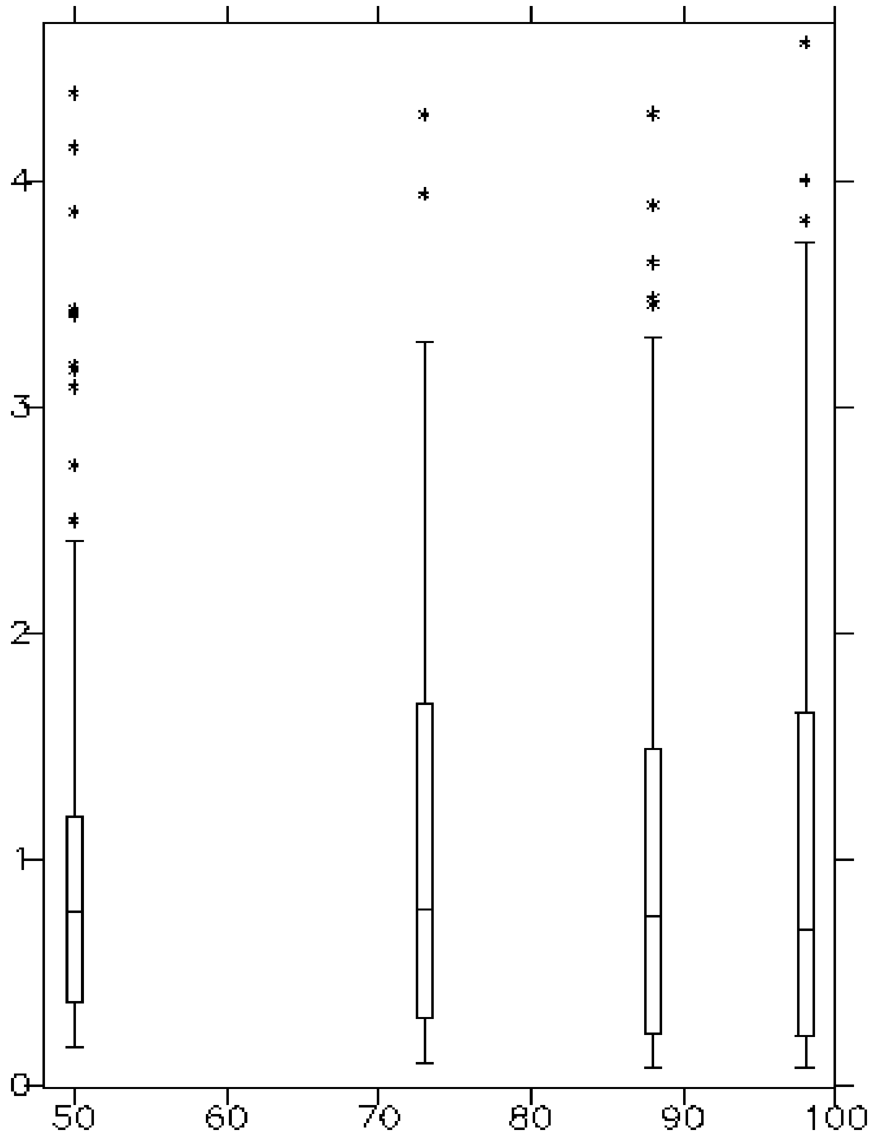


Figure 1 (b): Box-plots, trade-conditioned per capita income data, 1950, 1973, 1988, 1998

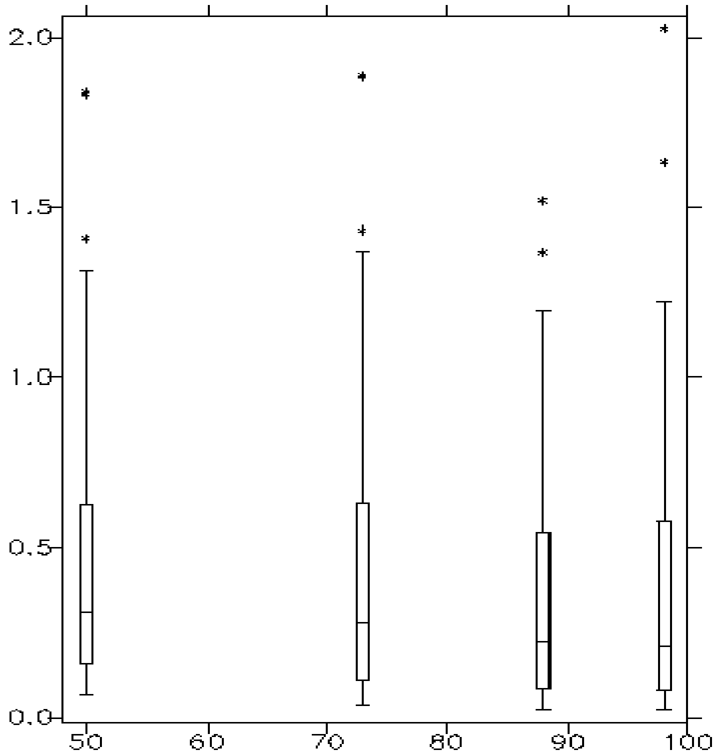


Figure 2 (a): Unconditioned, Golden Age, 1950–1973

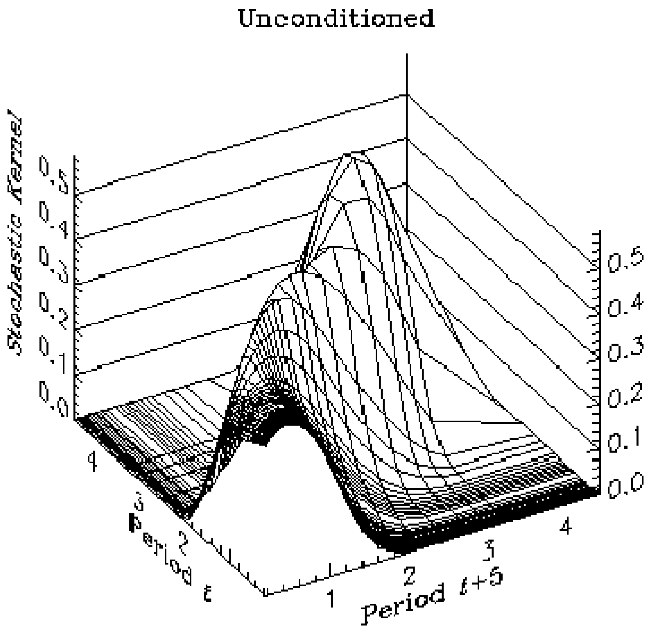


Figure 2 (a): Unconditioned, Golden Age, 1950–1973 – Contour Plot

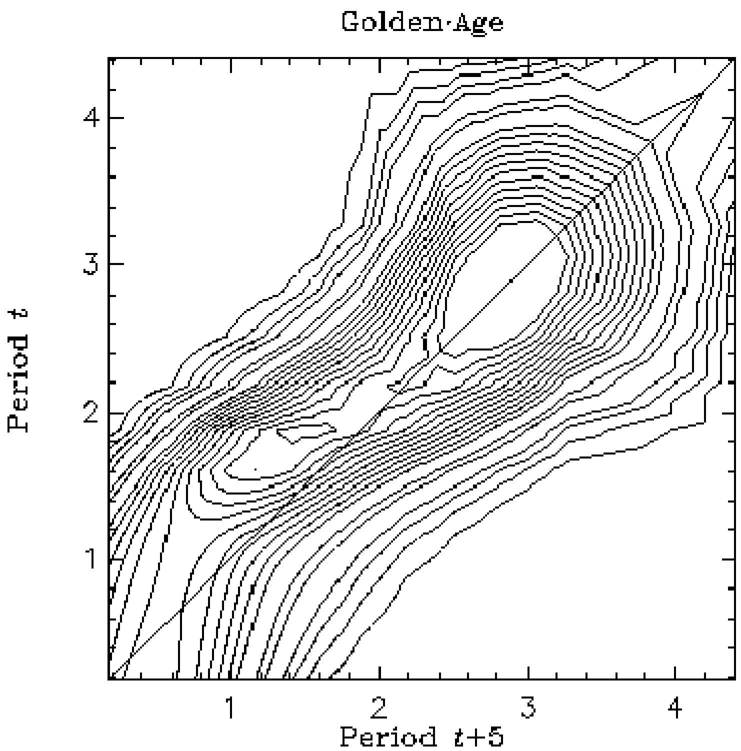
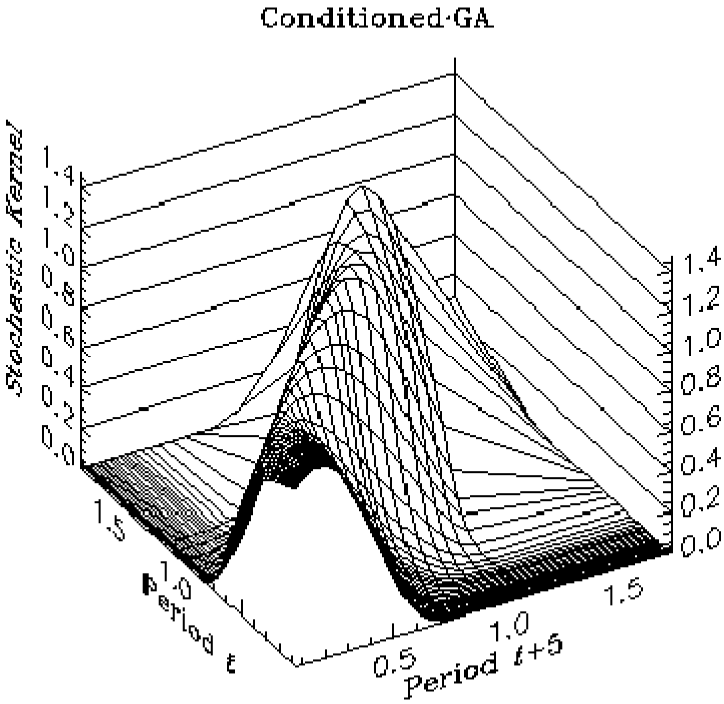


Figure 2 (b): Trade-Conditioned, Golden Age, 1950-1973



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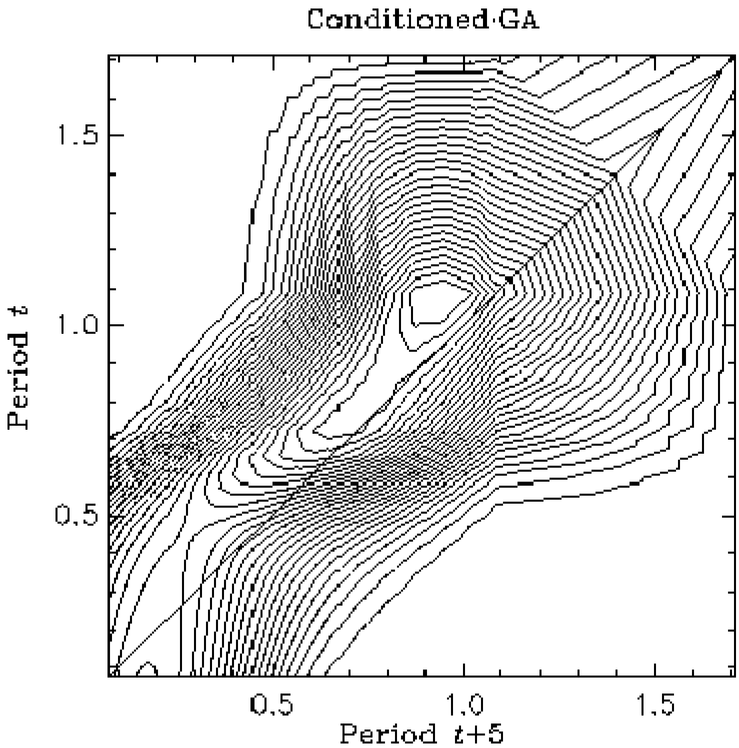


Figure 3 (a): Unconditioned, Post-Golden Age, 1973-1998

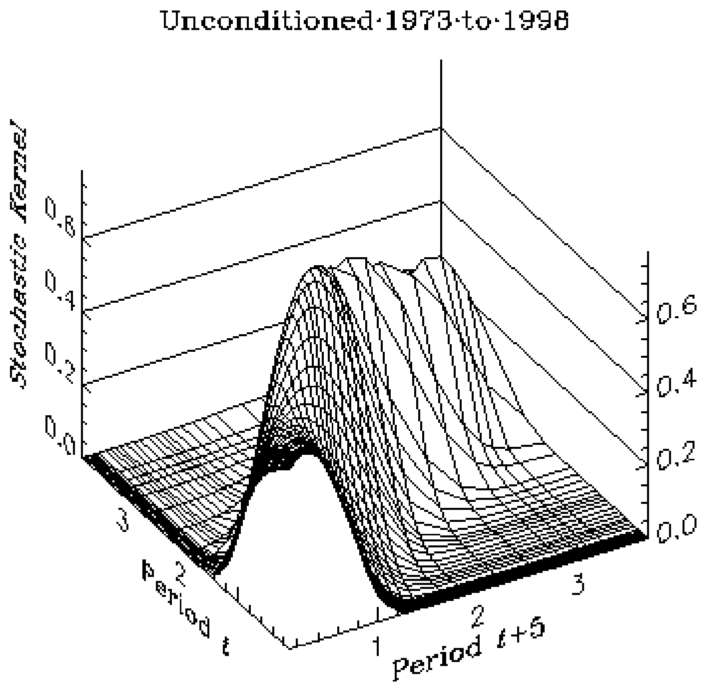


Figure 3 (a): Unconditioned, Post-Golden Age, 1973-1998 – Contour Plot

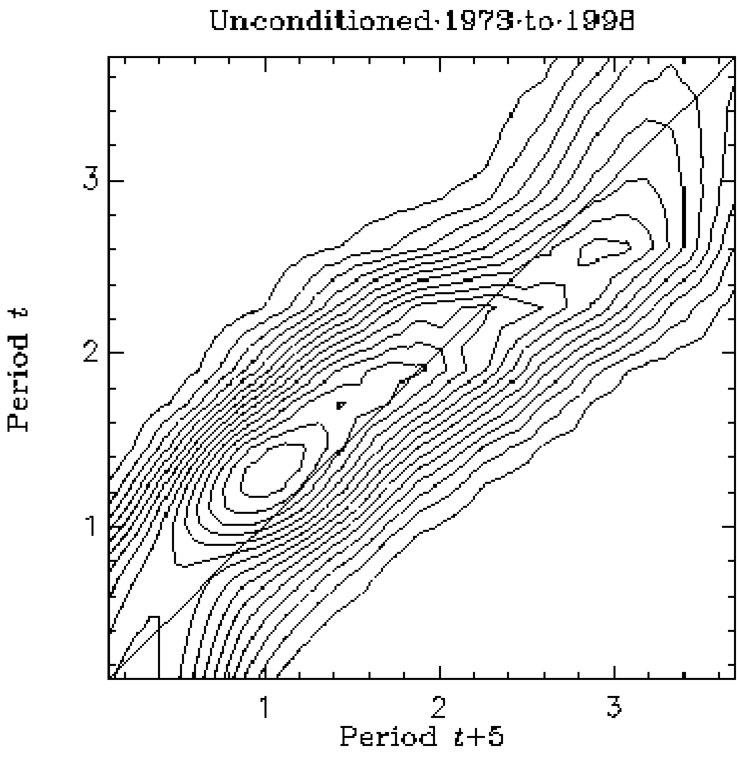


Figure 3 (b): Trade-Conditioned, Post-Golden Age, 1973-1998

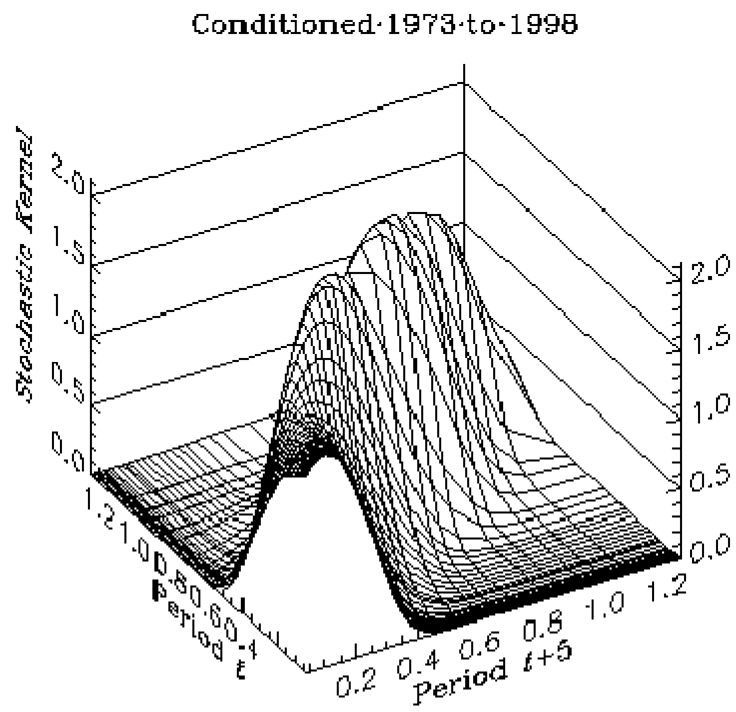


Figure 3 (b): Trade-Conditioned, Post-Golden Age, 1973-1998 - Contour Plot

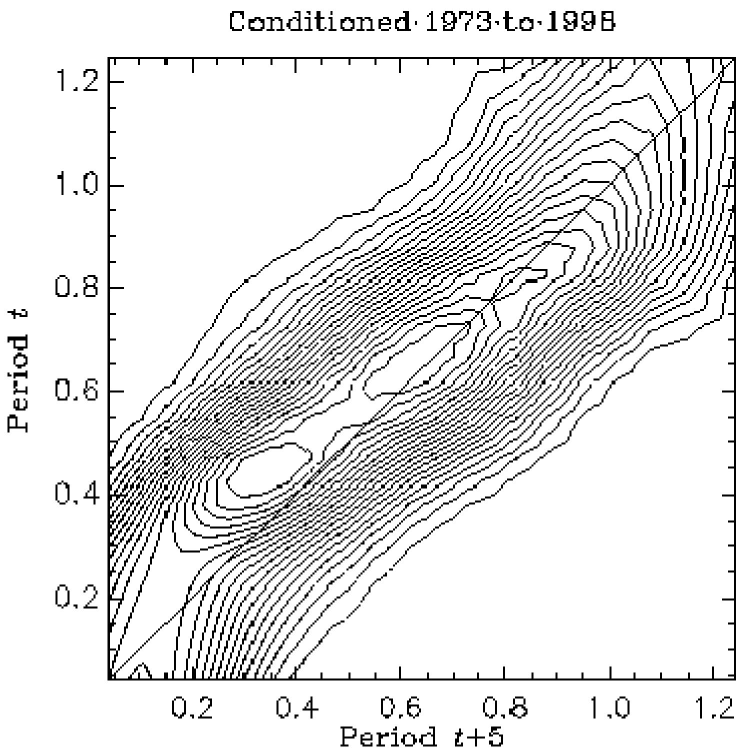


Figure 4 (a): Transitions, Original-Conditioned Data, Golden Age, 1950-1973

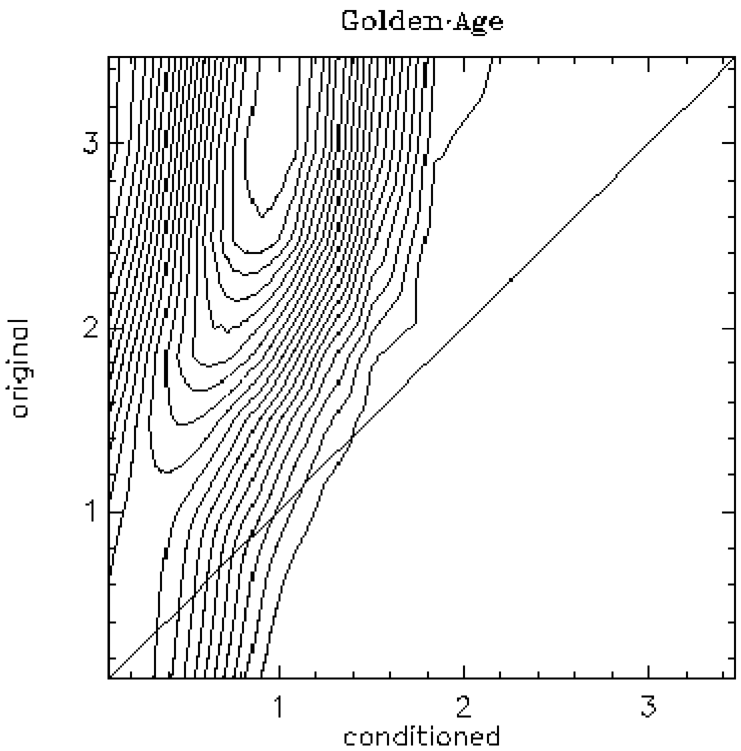
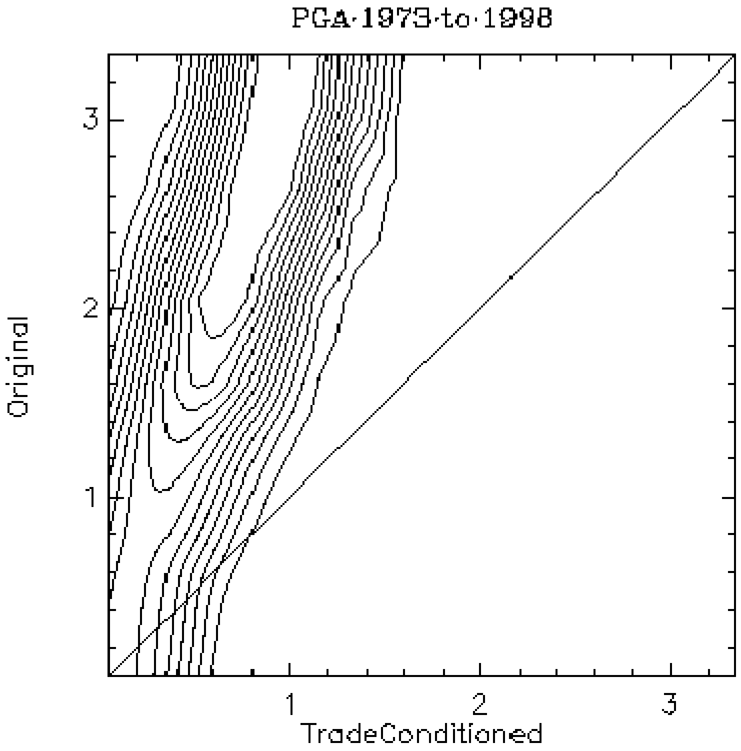


Figure 4 (b): Transitions, Original-Conditioned Data, Post-Golden Age, 1973-1998



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