The First Global Recession in Decades

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Abstract

I use monthly data on industrial production to estimate the distribution of international business cycle correlations since the 1980's, with focus on the current turmoil. The degree of international correlation in national business cycles since the end of 2008 is unprecedented in three decades. From 2008M12, an upward shift in the cross-sectional distribution of cycles synchronization is sizeable and significant, especially between advanced economies. It is less evident amongst developing countries. The change in correlations is associated with receding financial openness in the rich world, but falling goods trade in developing economies.
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1 Introduction

The current turmoil is often argued to have had unprecedented global consequences. According to virtually any definition, most countries have entered recession since late 2008. Perhaps more than the severity of the recession, it is the universal consequences of a US-based shock that has drawn comparisons with the Great Depression. In this paper, I investigate rigorously the global nature of the sub-prime crisis. I estimate the cross-sectional distribution of bilateral cycle correlations for a large sample of countries, including both rich and developing economies. I consider how the distribution has evolved over time, with focus on sub-periods characterized by "global" shocks. In particular, I contrast the months surrounding the LTCM debacle around the summer 1998, to what has happened since the late 2000's.

As the sub-prime crisis unraveled, both goods and assets trade retreated, or at least relocated. It is an open question whether the change was a consequence of the crisis, or did actively contribute to its diffusion. World trade can fall as a result of the collapse in economic activity, and international capital be withdrawn because recessions are a bad time to invest. Still, international financial linkages are often accused of having channeled the international diffusion of the shock. Capital is repatriated as financial intermediaries "de-leverage" their balance sheets, and, perhaps, export the crisis to borrowing, developing economies.

The paper proposes to examine the joint dynamics of bilateral cycle correlations, and the observed changes in goods and financial trade. Crucially, no causal inference is sought, as both types of trade have presumably responded to the onset of the crisis. Time varying instruments for goods and assets trade are simply not available, especially for the type of country and time coverage proposed in this paper. Rather, the approach is akin to an analysis of variance: What fraction of the change in cycle correlation observed around the sub-prime crisis can be explained by changes in goods and assets trade? And is one channel more important for developed or developing economies?

The main results are as follows. There is overwhelming evidence world cycles have become significantly more synchronized with the sub-prime crisis, relative to their level since the 1980's. The distribution of bilateral correlations has observably shifted upwards for data ranges that include the last few months of 2008, and thereafter. In fact, a significant shift in the distribution occurs when 2008M12 and the months that follow are included in the computation of correlations. In contrast, no observable shift is observed in 1998 around the date of the LTCM debacle, arguably the previous instance of a global shock. In fact, there is no other period in the data available since the 1980's that displays a similarly significant shift in the distribution of cycles synchronization. In that sense, the current turmoil is indeed the first global recession in decades.

The increase in cycles correlation is particularly pronounced for rich OECD countries. But it is at best weakly significant for cycle correlations between developing economies. The data point to a shock that has diffused first and foremost between developed economies, while the developing world has so far remained relatively insulated. Including data until the end of 2008, the mode of the distribution of bilateral correlations is weakly significantly positive for developing economies. In the rich world, it stands above 0.8. Yet there were no observable differences across the two samples prior to 2008. There seems to be a specificity to the diffusion mechanism that exists between rich countries. At the very least, the shock has diffused slowly to the developing world, where cycles correlations have remained sizably lower. They continue to do so, even with data running until May 2009.

The last section of the paper seeks to account for this difference across samples. I consider two conventional determinants of business cycle correlations, or particular relevance in the current context. I compute the intensity of bilateral trade, and a measure of mutual openness to financial flows. Both measures vary over time, and the paper relates these dynamics with the changes in the cross-sectional distribution of cycle synchronization. I use two variants for both measures. The first is scale dependent and normalizes goods or assets trade by the size of the economy. Thus, it may increase if the fall in trade happens to have been less than proportional to the fall in economic activity. This is in fact what happens between 2000 and 2009 in the data. The second is scale independent and captures the reallocation of trade across partner countries. Goods or assets trades are normalized by their total value across countries. The variable captures reallocation effects, as changes in goods or financial trade that happen to an unequal extent across partner countries affect its cross-section. The distinction is potentially important, as international linkages may matter either because of their absolute or their relative size.

Both before and after the sub-prime crisis, the determinants of business cycle correlations are conventional. Countries where goods trade represents a large proportion of GDP tend to be more correlated in cross-section. So do those that happen to be financially open, although not as a proportion of GDP, but rather in relative terms. The cross-sectional results are roughly in line with the literature. This happens both in rich countries, and (albeit more weakly) in developing economies.

Business cycles correlations increased around the sub-prime crisis, and so did goods trade and financial openness *relative to GDP*. In contrast, the change in the *allocation* of goods and financial trade correlates negatively with the shift in cycle synchronization. Both kinds of trade retreated between countries where cycle synchronization rose with the crisis. Interestingly, the response was drastically different in rich or developing economies. In rich countries, financial linkages fell as cycles synchronized; goods trade did not change. In the developing world, the opposite prevailed. The allocation of goods trade altered, and

fell where cycles synchronized. But financial openness did not rebalance in a significant way.

These correlations should not be interpreted causally, for both kinds of trade are eminently endogenous to the cycle, and cannot be instrumented in this panel framework. But the results suggest a fundamentally different margin of adjustment in response to the sub-prime shock across the two regions. The discrepancy can reflect a more advanced stage of financial integration amongst rich economies. In developing countries, it is goods trade that is relatively unhampered, and it is therefore the dominant response to the shock. In the rich world, the global recession is associated with falling asset trade. Perhaps because the role for multinational banks is more advanced there to start with, and de-leveraging is more prevalent.

The rest of the paper is structured as follows. Section 2 introduces the variables of interest, i.e. the cross-section of cycles correlation, bilateral trade and openness to capital flows. The Section also describes the data used in computing all variables. Section 3 discusses the time pattern in bilateral cycle correlations. Section 4 investigates its trade and financial determinants in a panel framework. Section 5 concludes.

2 Measurement and Data

I first discuss the procedure used to track the distribution of cycle correlations over time, and the choices imposed by the necessity to have data on recent developments. I then describe the measures of bilateral trade intensity and financial openness.

2.1 The Time Pattern of Bilateral Correlations

The approach is directly inspired from the seminal contribution in Frankel and Rose (1998), and the extensive literature that followed to investigate the determinants of the international synchronization of business cycles. I estimate the lower triangular matrix of the Pearson correlation coefficients between all pairs of countries in a given sample. Each estimation is performed on a window of arbitrary length. I save the cross-sectional matrix of estimates, then roll the window forward in time, and repeat the procedure. The outcome is a panel formed by repeated cross-sections of cycle synchronization. This panel is the result of several choices of a relatively arbitrary nature, which I now discuss.

The length of each window determines the significance of the coefficients that form each cross-section. For an estimation of conventional Pearson correlation coefficients ρ computed on N observations, we know

$$t = \frac{\rho}{\sqrt{(1-\rho^2)(N-2)}}$$

approximately follows a t-distribution with $N-2$ degrees of freedom. This provides a convenient rule of thumb to evaluate the significance of bilateral correlation coefficients. In most of the monthly data used here, correlation coefficients are computed on 60 months. For results based on monthly industrial production, correlations above 0.22 are therefore significant at the 10% confidence level. Some results are also presented using quarterly data, for which a minimum of 30 quarters are used, and coefficients above 0.31 can be considered significant at 10% confidence level.

The availability of recent data is of the essence in this paper. The onset of the subprime crisis is typically dated to September 2008, with the bankruptcy of Lehman Brothers, or barely one year ago at time of writing. It is crucial to have a sufficient number of observations posterior to the beginning of the crisis. The constraint conditions the type of data frequency that can be used here. With quarterly data, at best 3 observations are available since 2008Q3. With monthly data, up to 10 may be available. The paper makes use of monthly industrial production series, which are available from the IMF's International Financial Statistics. Industrial production is of course an imperfect measure of overall economic activity. But the implied mis-measurement is presumably moving slowly over time, and is unlikely to have altered substantially since the onset of the current crisis. It is therefore unlikely to be at the source of a putative high frequency change in the distribution of international cycle synchronization, happening around the late 2000's.

Industrial production data exist for up to 39 countries, with uninterrupted coverage from 1980M1 until 2009M5. For simplicity and convenience, I focus on up to six sub-periods, namely 1980M1-1983M12, 1984M1-1988M12, 1989M1-1993M12, 1994M1-1998M12, 1999M1-2003M12 and 2004M1-2009M5. The first period runs 48 months, while the last is 65 months long. All others last precisely 5 years. Country coverage varies across periods. The first two periods have 24 countries, the third has 29, the fourth, 34, the fifth has 38 and the final period has 39 countries.[1] For each available cross-section of countries, the paper presents results for whichever of the six considered periods that have data. For instance, the distribution estimates are presented for the 24 countries with data over all six sub-samples. But estimates based on 38 countries are only presented for the last two sub-periods.

In order to date with precision the shift in the cross-sectional distribution of business cycles correlations, I focus on the 2000's. I first consider five-year overlapping windows

[1]The 24 initial countries are: Austria, Barbados, Belgium, Denmark, Finland, France, Germany, Hungary, India, Ireland, Italy, Japan, Jordan, Korea, Luxembourg, Malaysia , Mexico, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom and United States. The five additional countries from 1989 are Cyprus, Poland, Romania, the Slovak Republic and Turkey. From 1994, Croatia, the Czech Republic, Nicaragua, the Republic of Serbia and Tunisia become available. From 1999, Armenia, Canada, Greece and Lithuania have data. Finally, Bulgaria is included in the final period.

between 2000 and 2009, starting with 2000M1-2004M12 and separated by increments of 12 months. Only the latest of the five thus generated samples, ranging from 2004 to 2009, contains the start of the sub-prime crisis. I then refine the analysis further, and consider one-month increments of five-year windows, between 2003M6-2008M6 and 2004M5-2009M5. The fourth thus generated sub-sample starts including September 2008. This helps dating the month when the crisis starts affecting observably the international correlation in business cycles.

Ten years ago, the LTCM debacle was considered by many as the closest instance of a shock with global consequences. It is natural to compare the dynamics of international cycle synchronization around the summer of 1998, with the recent months. With that in mind, I estimate once again one-month increments of five-year windows, this time between 1993M5-1998M5 and 1994M4-1999M4. These ranges imply 12 distribution estimates. The LTCM crisis is customarily dated between May 1998, when returns entered negative territories, and September 1998, when the Russian government defaulted on their government bonds. If the LTCM crisis was indeed a crisis of a global nature on equal footing with the current turmoil, we should observe an upward shift in the distribution estimated on data inclusive of the summer of 1998.

The same exercises are performed on a sample of up to 44 countries with quarterly data on industrial production. Quarterly data from IFS are available from 1980Q1, and make it possible to estimate the distribution of cross-correlations over four non-overlapping periods of 30 quarters, namely 1980Q1-1987Q2, 1987Q3-1994Q4, 1995Q1-2002Q2, and 2002Q3-2009Q2. Thirty one countries are available from 1980Q1, 35 from 1987Q3, and 44 from 1995Q1.[2]

Industrial production is measured both in local currency and in US dollars, and reported with or without seasonal adjustment. The results presented in the body of the paper correspond to unadjusted local currency numbers, simply because that choice maximizes coverage. The same conclusions do obtain with USD or seasonally adjusted data. By the same token, the correlation coefficients are computed between the (logarithm) year-on-year differences of production, simply because growth rates are the most widely used numbers in reference to the onset of or the exit from a recession. An alternative is to detrend the series using a conventional filter to isolate its business cycle component. The body of the paper consist of results based on yearly growth rates, but similar conclusions obtain when the filter introduced by Baxter and King (1999) is implemented on the data instead.

[2]The 31 initial countries are Australia, Austria, Barbados, Belgium, Cyprus, Denmark, Fiji, Finland, France, Germany, Hungary, India, Ireland, Italy, Japan, Jordan, Korea, Luxembourg, Malaysia, Mexico, Netherlands, Nigeria, Norway, Portugal, Spain, Sweden, Switzerland , Trinidad and Tobago, Turkey, United Kingdom, and United States. From 1987Q3, New Zealand, Poland, Romania and the Slovak Republic become available. From 1995Q1, Armenia, Canada, China, Croatia, the Czech Republic, Greece, Lithuania, Nicaragua and Tunisia become available.

2.2 Trade and Financial Linkages

The paper relates the cross-section of cycle correlations with two of its conventional determinants. Frankel and Rose (1998) forcefully established the relevance of trade intensity as a driver of the international business cycle. Cycles between trade partners are significantly more correlated, so much so that the estimated elasticity is in fact hard to reproduce in a general equilibrium model of the business cycle. This was labeled a "trade-comovement" puzzle by Kose and Yi (2006).

The conventional approach implements data from the IMF's Direction of Trade data to compute

$$T^1_{i,j} = \frac{X_{i,j} + X_{j,i}}{Y_i + Y_j}$$

where $X_{i,j}$ denotes total merchandise exports from country i to j and Y_i denotes nominal GDP in country i. Trade intensity is typically measured at the beginning of the period to assuage endogeneity concerns, and the same will be true here. Even so, external instruments are typically indispensable because trade patterns are persistent over time. Instruments for trade are based on gravity arguments, and include variables such as geographic proximity, the presence of a common border, or a common colonial history, languages or access to an open body of water. Most of these instruments are constant over time, and thus cannot be used in this paper, where the time dimension is of the essence. This conditions the interpretation of the results, which should not be taken in a causal sense, but rather in a purely descriptive one. I seek to evaluate whether the time pattern of international correlations correlates with changes in trade intensity, bearing in mind the sub-prime shock may have conjointly increased cycle correlations, and lowered goods or assets trade.

The measure $T^1_{i,j}$ focuses on trade intensity relative to output. If trade falls less than output in response to an exogenous shock, however, $T^1_{i,j}$ will actually increase. I construct an alternative measure that is robust to scale effects, and focuses on the allocation of trade across trade partners. It is defined as

$$T^2_{i,j} = \frac{X_{i,j} + X_{j,i}}{X_i + X_j}$$

where X_i denotes total exports from country i. $T^2_{i,j}$ will respond to relative changes in the allocation of goods trade between partners, rather than to an absolute shift in trade relative to production.

Financial linkages are an especially pertinent channel in the current context. Unfortunately, available bilateral data on financial flows do not yet cover the current crisis. The Country Portfolio Investment Survey (CPIS) supervised by the IMF, and released on a yearly basis stops in 2007 at time of writing. And the Bank of International Settlements

(BIS) "locational bank statistics" are only available bilaterally for a reduced cross-section of lending economies, limited to OECD countries. In this paper, I propose to approximate bilateral financial openness with country specific data. I consider conventional measures of bank lending, taking inspiration from Lane and Milesi-Ferretti (2001, 2007, 2008). I construct the share of external lending by banks relative to the size of the lending economy. The data are available from the BIS's "locational banking statistics", at least until 2008Q4.

The locational banking statistics gather quarterly data on international financial claims and liabilities of bank offices in the reporting countries. Both domestically owned and foreign-owned banking offices in the reporting countries record their positions on a gross (unconsolidated) basis, including those vis-à-vis own affiliates in other countries. This is consistent with the residency principle of national accounts, balance of payments and external debt statistics. The variable brings the focus on the role of banks' international linkages for the diffusion of the current crisis. A "retrenchment" argument is often heard to account for the global nature of the current crisis, and financial intermediaries are often accused of "deleveraging" their balance sheets, thus contributing to the international diffusion of an originally US-based shock. BIS data are therefore directly relevant to the question at hand. I have also verified that data on capital account from the IMF's International Financial Statistics imply similar conclusions.[3]

The BIS data used here are not bilateral. This is a serious shortcoming, especially relative to information on goods trade. I propose an approximating shortcut, and compute a bilateralized version of the BIS data, given by

$$\phi^1_{i,j} = \frac{(A_i + L_i) + (A_j + L_j)}{Y_i + Y_j}$$

where A_i and L_i are measures of banks claims and liabilities in country i. The contention implicit in the interpretation of $\phi^1_{i,j}$ as a measure of bilateral financial linkage is that countries that are both open to capital flows will tend to be open to each other.

As was the case for goods trade, $\phi^1_{i,j}$ will actually increase if financial retrenchment falls short of the collapse in GDP. It is informative to construct a measure of financial openness that is invariant to such scale effects. Analogously to the bilateral trade measure T^2, I construct

$$\phi^2_{i,j} = \frac{(A_i + L_i) + (A_j + L_j)}{\sum_i (A_i + L_i) + \sum_j (A_j + L_j)}$$

[3]One of the attractions of IMF data is they make it possible to decompose international positions into portfolio, direct investment, or financial derivatives. The importance of the latter in journalistic accounts of the current developments make IFS data an interesting alternative to those released by the BIS. On the other hand, IFS report flow data, as opposed to the stocks of assets and liabilities reported for banks in the locational banking statistics used here. Financial linkages are surely best captured by stock data.

ϕ^2 captures changes in the relative magnitude of financial openness across partner countries. It remains a proxy of actual bilateral financial linkages, one that rests on the premise that financially open countries are open to each other. In contrast with ϕ^1, however, it is invariant to changes in the size of the economy.

3 The First Global Recession in Decades

This Section discusses the patterns observed in the cross-section of bilateral cycle correlations. It presents the results that pertain to the whole sample of countries, then draws comparisons between the recent period and the LTCM debacle. The Section closes with sample splits and some robustness.

3.1 World Business Cycles

Throughout the paper, the reported distributions are based on Epanechnikov kernel estimates. Figure 1 reports the estimates for the six sub-periods considered in monthly data. There are 24 countries with monthly industrial production, so that each distribution is estimated on the basis of 276 bilateral correlations. Since they are estimated over 60 months, any correlation above 0.22 can be considered significantly different from zero at a 10% confidence level. Until the last 1990's, the cross-sectional distributions are centered around barely significant values. In the first four sub-periods, the distributions modes are positive, but below 0.4. Most bilateral correlations until the late 1990's are therefore close to zero, with low degrees of skewness. It is only between 1999M1 and 2003M12 that the distribution begins to appear to shift to the right and become skewed to the left. The mode shifts slightly upwards, above 0.5. This may reflect what happened in the wake of the Asian crisis, with more bilateral correlations taking significantly positive values.

But the striking result in Figure 1 pertains to the last, most recent, period. With data between 2004M1 and 2009M5, the distribution becomes heavily skewed to the left, with a mode now above 0.8. Most correlations have become significantly positive at any conventional confidence level, and only few country pairs display negative correlations. Comparing the most recent 5 years with any earlier period with available data, it is patent a significant upwards shift in cycle synchronization has happened. It is tempting to associate it with the sub-prime crisis.

This remarkable pattern is not an artefact of a sample focused on 24 countries only. Figures 2, 3 and 4 consider the 29, 34 and 38 countries with data since 1989, 1994 and 1999, respectively. The results are similar. Prior to the last period, distribution estimates are centered around zero. But all three figures point to a large and significant shift in the distribution over the recent period. In all the figures, the distribution mode is above 0.7 for correlations computed between 2004 and 2009. Interestingly, figures 2 and

3 suggest the shift upwards in the late 1990's apparent from figure 1 may have been an artefact of sampling. For instance, there is no clear difference between the distributions corresponding to 1994M1-1998M12 and 1999M1-2003M12 from Figure 3.

Figure 5 focuses on monthly industrial production since 2000, and considers the five overlapping 5-year windows since 2000M1, separated by one year increments. As the data stop in 2009M5, the last period starts from 2004M5. With the exception of the last estimate, all distributions have modes that are barely significant. The last period, once again, is characterized by a large and quite systematic increase in cycle correlations. The shift has to have happened after 2007.

In order to identify the timing of this shift with more precision, figure 6 presents estimates corresponding to the twelve overlapping 5-year windows between 2003M6-2008M6 and 2004M5-2009M4, separated by one month increments. The estimated distribution shifts upwards slightly in 2003M11-2008M11, with a mode now around 0.5, a significantly positive value. That stands in contrast with the previous periods, when distributions were centered around 0. From 2004M1-2009M1, the estimated distributions become skewed to the left, with fewer still negative correlations. The mode increases to 0.7. The skewness intensifies markedly thereafter, and the modes for the last four estimated distributions in figure 6 are all above 0.8. At face value, figure 6 is strongly suggestive that a shock occurred in the very last months of 2008, which started having strong synchronizing effects on the world business cycle from the first months of 2009. It is difficult not to think of the sub-prime crisis as the culprit for these developments.

Is the global increase in cycles correlations as unprecedented as the figures in this paper suggest? For instance from figure 1, the cross-sectional distribution of cycle correlation has not been centered at such high level as they are now since the 1980's, at least amongst the 29 countries considered there. An alternative experiment is to compare the current period and what happened around the time of an arguably similarly global shock. An immediate candidate is the LTCM debacle from the summer of 1998. For instance, in its interim report issued in December 1998, the IMF's World Economic Outlook dedicated a whole chapter to the consequences of the LTCM bankruptcy for the world economy, inclusive of both rich and developing countries.

Figure 7 considers the twelve overlapping 5-year periods between 1993M5-1998M5 and 1994M4-1999M4, separated by one month increments. It is difficult to notice any significant change across the twelve sub-periods. Across all estimates, the modes lie between 0 and 0.5, and there is no observable tendency for skewness to change. Nor do ranges for correlation estimates vary observably from one period to the next. It is perhaps possible the immediate months following the LTCM crisis have seen correlations increase for a sub-group of countries, as distribution estimates may become bimodal for periods including 1998M7, 1998M8, 1998M9 and 1998M10. But these modes are barely

significant, and they remain below 0.4. In any event, no changes in the estimated kernels is remotely comparable to what figure 6 illustrated. The current developments do appear to have triggered the first global recession in decades.

3.2 Comparisons

The current increase in average cycle correlations is unprecedented in recent history. It remains to be seen whether this evolution has affected indifferently rich and developing economies. A common view is the sub-prime shock has originated in the US, and its international impact turned out to be virtually universal. Few if any countries escaped the fallout. Figures 8 to 11 investigate the question, on the basis of a sample split according to income level. Year-by-year and month-by-month distribution estimates are presented for two sub-groups of countries. The first includes 19 rich economies in the sample of 39 countries that underpin figure 6.[4] The second includes the remaining 20 developing economies.[5]

Figures 8 and 9 provide a clear-cut illustration that the recent synchronization in business cycles is clearly at play within the rich world. Across all periods, rich countries tend to be more correlated unconditionally, perhaps because they trade more, or they are less volatile. As a result, the distributions in figure 8 have modes at or above 0.5, at levels slightly higher than what the broader sample implied in figures 5 and 6. But once again, when the recent period is included, the kernel estimates start implying a heavily skewed distribution, with a mode above 0.8. In fact, the extreme skewness estimated over 2004M5-2009M4 in the rich world is even higher than its counterpart in figure 5. The same pattern is apparent from figure 9. From the early months of 2009, the international correlation of business cycles between rich countries increases significantly. This is an unprecedented global recession for the rich world.

Figures 10 and 11 perform the same estimations, but on the basis of twenty developing economies. The shift in the distributions is much less apparent. Cycles are less correlated to start with amongst developing economies than in the OECD - with modes now between 0 and 0.5. But more importantly, it is less evident that correlations increase significantly when the current period is included. The last period in figure 10 is indeed slightly skewed to the left, with a mode above 0.5. But the shift is substantially smaller than what happened in rich economies as illustrated on figure 8. The same is true in figure 11. Correlations increase slightly on average with the first months of 2009, but the estimated distributions remain much less skewed than in the corresponding periods in figure 9. This

[4]They are: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom and United States.

[5]They are: Armenia, Barbados, Bulgaria, Croatia, Cyprus, the Czech Republic, Hungary, India, Jordan, Korea, Lithuania, Malaysia, Mexico, Nicaragua, Poland, Romania, the Republic of Serbia, the Slovak Republic, Tunisia and Turkey.

remains true up until the last period with available data, from 2004M5 to 2009M5. The developing world, as reflected by the 20 economies included in the sample on figures 10 and 11, has so far remained relatively insulated from the sub-prime crisis.

All the results detailed up to now rest on monthly industrial production that was not seasonally adjusted, in order to maximize country coverage. Even though growth rates were computed on a year-to-year basis, it is important to ascertain the large shifts we observe in the recent period are unrelated to seasonal developments. Figure 12 considers the 28 countries for which seasonally adjusted industrial production is available. The correlations continue to be estimated on the basis of yearly growth rates, and the figure reports the twelve 5-year overlapping periods between 2003M6-2008M6 and 2004M5-2009M4. A pronounced shift upwards in the distribution continues to be apparent when the first months of 2009 are included. Seasonality explains none of the results in this paper.

Finally, industrial production is available at the quarterly frequency. The country coverage is broader than for monthly production, which is interesting for comparison purposes. On the other hand, quarterly data have by construction few observations that are posterior to the onset of the sub-prime crisis. Figure 13 presents kernel estimates for the twelve 5-year overlapping periods between 2003M6-2008M6 and 2004M5-2009M4, on the basis of the sample of 44 countries for which quarterly industrial production is available. Even though the time pattern prevalent in monthly data is less clear cut here, it remains true that cycle correlations increase observably in periods that are inclusive of the first quarters of 2009. In other words, country coverage is probably not driving the results in this paper.

4 Trade and Financial Openness

This section presents conventional regressions of the determinants of business cycles synchronization, following the tradition pioneered by Frankel and Rose (1998). The focus is on the time changes in the cross-section of bilateral correlations, and in particular on the correlates of the difference in distribution dynamics between rich and developing countries. The section examines the determinants of cycles synchronization over the early 2000's (from 2000M1-2004M12), and contrasts them with the most recent period, inclusive of the current recession (from 2004M5 to 2009M4). Then it asks how both trade and financial linkages contribute to explaining changes in cycles synchronization in both regions.

The specification of the estimated regressions takes inspiration from Frankel and Rose (1998), Imbs (2004, 2006), or Kalemli-Ozcan, Papaioannou, and Peydro (2009). I regress a given cross-section of bilateral correlations, denoted $\rho_{i,j}$, on the corresponding measures of financial openness $\phi^1_{i,j}$ and $\phi^2_{i,j}$, and on both measures of trade intensity, $T^1_{i,j}$ or $T^2_{i,j}$.

The specification writes

$$\rho_{i,j} = \alpha_0 + \alpha_1 T^1_{i,j} + \alpha_2 T^2_{i,j} + \alpha_3 \phi^1_{i,j} + \alpha_4 \phi^2_{i,j} + \varepsilon_{i,j} \tag{1}$$

The residual $\varepsilon_{i,j}$ is liable to have a heteroskedastic structure reflective of measurement error specific to a given country i. This may contaminate all pairs country i is part of. I account for this possibility via clustering of the residual along the country dimension.

The coefficients α_1 and α_3 capture the hypothetical effects of the scale of trade and financial openness on cycle correlations. The coefficients α_2 and α_4 reflect the possibility that the relative magnitude of trade and financial linkages affects cycles correlations. The latter are especially interesting in a panel context. One would want to differentiate the crisis-induced changes in the scale of trade relative to the (shrinking) economy, from shifts in the relative magnitude of trade across partner countries.

Be that as it may, all coefficient estimates are to be understood as a check against standard results, rather than for causal interpretation. In particular, Frankel and Rose (1998) famously established α_1 and α_2 are positive and significant, for a wide range of country coverages and time periods. Imbs (2004, 2006) showed bilateral measures of financial integration taken from the IMF's Country Portfolio Investment Survey also correlate positively with $\rho_{i,j}$, even when instrumented with institutional variables capturing the depth of financial markets.

Table 1 reports summary statistics for the five variables of interest, over the 39 countries with monthly industrial production since 2000. The average bilateral correlation increased from 0.25 in the early 2000's to 0.55 over the last 5 years. The increase is prevalent in both rich and developing economies. As a proportion of GDP, both goods and assets trade increased between 2000 and 2009. T^1 rose from 0.70 to 0.88, an increase that affected disproportionately more the developing world, where T^1 went from 0.39 to 0.81. ϕ^1 also rose over the period, in both sub-samples. This suggests the decrease in trade observed over the last few months fell short of the collapse in GDP. In some sense, the increase in T^1 and ϕ^1 around the sub-prime crisis period is an artefact of the severity of the recession, and illustrates the eminent endogeneity of both variables. In contrast the average values for T^2 and ϕ^2 barely altered between 2000 and 2009. For instance, the representative bilateral trade relation accounts for around 1% of overall trade in the representative country. That proportion barely changed over the 2000's.

Table 2 presents the estimation results for equation (1), over the first and second halves of the 2000's. The first two specifications present the coefficients estimates corresponding to the whole sample of 39 countries. In line with Frankel and Rose (1998), α_1 is positive and significant. In line with the results in Imbs (2004, 2006), so is α_4. This suggests the *relative* degree of international exposure of banks correlates positively with

$\rho_{i,j}$. Country pairs where banks tend to be especially invested abroad tend to be highly correlated. Estimates of α_3, in contrast, are negative. Ceteris paribus, countries with large international banks *as a proportion of GDP* tend to be conditionally less correlated. These results continue to obtain across both time periods, and in both sub-samples - although perhaps slightly more weakly in the developing world.

Table 3 presents fixed effects estimates of equation (1). On the basis of the whole sample, both scale-dependent variables T^1 and ϕ^1 correlate positively with the time change in ρ. This simply reflects the dynamics of these variables apparent in Table 1. While cycle synchronization rose, so did goods and assets trade as a proportion of GDP. But both allocative measures T^2 and ϕ^2 correlate negatively with ρ. The increase in cycles correlations was associated with a re-location of goods and financial trade across partner countries: As both types of trade fell, cycle synchronization rose.

Splitting the sample into rich and developing economies is informative. The second specification focuses on all country pairs involving at least a rich country. There, T^2 ceases to be significantly negative, Only ϕ^2 remains significant and negative, while the scale-dependent variables T^1 and ϕ^1 continue to enter with a positive sign. In other words, in this sample, it is the reallocation of financial trade that falls as ρ increases. Changes in goods trade are innocuous.

In the developing world, the opposite is true. It is T^2 that enters the estimation with a negative sign - ϕ^2 is not different from zero. In other words, cycles correlation increased slightly in the developing world, and that seems to have been associated with a decrease in bilateral trade - not relative to the size of the economy, but relative to overall trade. A reallocation mechanism is also at play, but via goods rather than financial markets. In terms of explanatory power, the within-R^2 falls from 0.54 to 0.21 when the financial variables are omitted for rich countries, and from 0.40 to 0.23 when trade variables are omitted for developing economies.

Some caution is in order when it comes to interpreting these results. There is nothing causal in these correlations. Given the descriptive evidence presented earlier in this paper, negative estimates of α_2 and α_4 partly reflect the endogenous responses of goods and assets trade to the crisis. We saw $\rho_{i,j}$ increased in the more recent period, and goods or financial trade conjointly reallocated as exporters withdrew and financial intermediaries "deleveraged". Both phenomena likely happened in response to the same (omitted) shock. The evidence in this section is therefore not suggestive that financial linkages were the reason the sub-prime shock diffused in the rich world. Retrenchment undoubtedly also happened as a result of the shock. The difference in estimates across samples, however, is informative, for it suggests the response to the shock differed fundamentally in the rich and developing worlds. This may reflect the fact that developing economies are relatively less financially integrated than the developed world. Perhaps banks are less invested internationally there, and so the channel is less relevant empirically.

5 Conclusion

This paper presents some descriptive evidence of the changes in the patterns of international business cycles correlations over the past three decades, particularly in the current turmoil. I document a large and significant positive shift in the cross-sectional distribution of bilateral correlations since the early months of 2009. Including the past 6 months of data implies distribution estimates that are heavily skewed to the left, with modes above 0.8, significantly positive at any standard confidence levels. This shift is robust across various measures of the business cycle. The previous instance of a global shock, the LTCM debacle in the summer of 1998, did not come close to trigger a similarly significant response of distribution estimates. In fact, no other sub-period since the 1980's can be characterized by a similarly skewed distribution. In that sense, the current turmoil is effectively the first global recession in decades.

Its effects are however mostly felt in the developed world. Bilateral correlations changed much less in a sub-sample formed exclusively by developing economies, which appear to have so far "decoupled" from the global cycle. Accounting for this difference is difficult, because the conventional explanatory variables for international cycle correlations are eminently endogenous to the sub-prime crisis. A standard regression of bilateral correlations on goods and assets trade cannot be used for causal inference. But it is still informative from a descriptive standpoint. I find that in the developing world, goods trade fell markedly as cycles became more synchronized with the current global recession. In stark contrast, in rich countries it is assets trade that fell significantly as countries entered the global recession. This may be a reflection of different adjustment margins in the two regions. In particular, the difference may rest in the fact that banks contributed heavily to the diffusion of the sub-prime shock in the developed world, but not elsewhere.

6 References

Baxter, Marianne and Robert King, 1999. *Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series*, Review of Economics and Statistics, 81, 575-593.

Frankel, Jeffrey and Andrew Rose, 1998. *The Endogeneity of the Optimum Currency Area Criteria*, Economic Journal, 108, 1009-1025.

Imbs, Jean, 2004. *Trade, Finance, Specialization and Synchronization*, Review of Economics and Statistics, 86, 723-734.

Imbs, Jean, 2006, *The Real Effects of Financial Integration*, Journal of International Economics, March, Vol. 68(2).

Kose, Ayhan and Kei-Mu Yi, 2006, *Can the Standard International Business Cycle Model Explain the Relation between Trade and Comovement?,* Journal of International Economics, March, pp. 267-295.

Lane, Phil and Gian-Maria Milesi-Ferretti, 2001, *The External Wealth of Nations: Measures of Foreign Assets and Liabilities for Industrial and Developing Countries*, Journal of International Economics, 55, 263-294, December.

Lane, Phil and Gian-Maria Milesi-Ferretti, 2007, *The External Wealth of Nations Mark II*, Journal of International Economics 73, 223-250, November.

Lane, Phil and Gian-Maria Milesi-Ferretti, 2008, *International Investment Patterns*, Review of Economics and Statistics 90(3), 538-549, August.

Papaioannou, Elias, Peydro, Jose Luis and Sebnem Kalemli-Ozcan, 2009, *Financial Integration and Business Cycle Synchronization,* NBER working paper 14887.

Table 1: Summary Statistics

	Whole Sample		OECD		Non OECD	
	2000	2009	2000	2009	2000	2009
ρ	0.251	0.554	0.280	0.578	0.166	0.485
	(0.278)	(0.268)	(0.273)	(0.271)	(0.274)	(0.250)
$T_1(\times 1,000)$	0.702	0.882	0.800	0.905	0.395	0.807
	(1.604)	(1.964)	(1.679)	(1.864)	(1.297)	(2.257)
T_2	0.012	0.014	0.015	0.016	0.003	0.008
	(0.031)	(0.031)	(0.035)	(0.034)	(0.011)	(0.017)
ϕ_1	1.046	1.736	1.197	1.987	0.575	0.953
	(2.176)	(3.155)	(2.453)	(3.518)	(0.676)	(1.278)
ϕ_2	0.051	0.051	0.068	0.067	0.003	0.004
	(0.072)	(0.073)	(0.077)	(0.078)	(0.003)	(0.002)
Nobs	741	741	551	551	190	190

Notes: The table reports means and standard deviations. ρ is the Pearson coefficient, computed using monthly industrial production over 2000M1-2004M12 for the earlier period (2000), and over 2004M5-2009M4 for the latter (2009). The variables T_i and ϕ_i are defined in the text. OECD denotes all pairs of countries involving at least one rich economy. Non-OECD denotes all pairs of developing countries.

Table 2: Period by Period Determinants of Cycles Synchronization

	Whole Sample		OECD		Non OECD	
	2000	2009	2000	2009	2000	2009
T^1	0.057^{**} (0.025)	0.071^{***} (0.019)	0.079^{***} (0.027)	0.060^{**} (0.026)	-0.017 (0.046)	0.088^{***} (0.029)
T^2	-0.016 (0.022)	-0.027 (0.020)	-0.031 (0.025)	-0.017 (0.028)	0.025 (0.042)	-0.043 (0.027)
ϕ_1	-0.102^{***} (0.018)	-0.101^{***} (0.020)	-0.108^{***} (0.022)	-0.094^{***} (0.027)	-0.040 (0.041)	-0.106^{***} (0.031)
ϕ_2	0.056^{***} (0.010)	0.052^{***} (0.009)	0.065^{***} (0.011)	0.061^{***} (0.013)	0.061^{**} (0.029)	0.037 (0.036)
R^2	0.237	0.279	0.296	0.242	0.273	0.279
Obs.	678	687	529	530	149	157

Notes: The left-hand side is $\rho_{i,j}$ as defined in the text. The correlations are computed using monthly industrial production over 2000M1-2004M12 for the earlier period (2000), and over 2004M5-2009M4 for the latter (2009). The variables T_i and ϕ_i are defined in the text. OECD denotes all pairs of countries involving at least one rich economy. Non-OECD denotes all pairs of developing countries. Trade is in logarithms, and measured in 2000Q1 for the early period, and in 2008Q4 for the later one. ϕ is in logarithms, and measured in 2000Q1 for the early period, and in 2008Q4 for the later one. Standard errors are clustered by country. *** (**, *) denote significance at the 1% (5%, 10%) confidence level.

Table 3: Changes in Cycles Synchronization

	Whole Sample	OECD	Non OECD
T^1	0.279^{***} (0.080)	0.213^{**} (0.079)	0.369^{***} (0.127)
T^2	-0.166^{**} (0.075)	-0.079 (0.078)	-0.255^{*} (0.121)
ϕ_1	0.516^{***} (0.041)	0.532^{***} (0.039)	0.191 (0.167)
ϕ_2	-0.289^{***} (0.039)	-0.421^{***} (0.039)	0.097 (0.133)
Within R^2	0.477	0.543	0.398
Obs.	1365	1059	306

Notes: The left-hand side is the change in $\rho_{i,j}$ over the two periods 2000M1-2004M12 and 2004M5-2009M4. The variables T_i and ϕ_i are defined in the text. OECD denotes all pairs of countries involving at least one rich economy. Non-OECD denotes all pairs of developing countries. Changes in right hand side variables are measured between 2000Q1 and 2008Q4 Standard errors are clustered by country. *** (**, *) denote significance at the 1% (5%, 10%) confidence level.

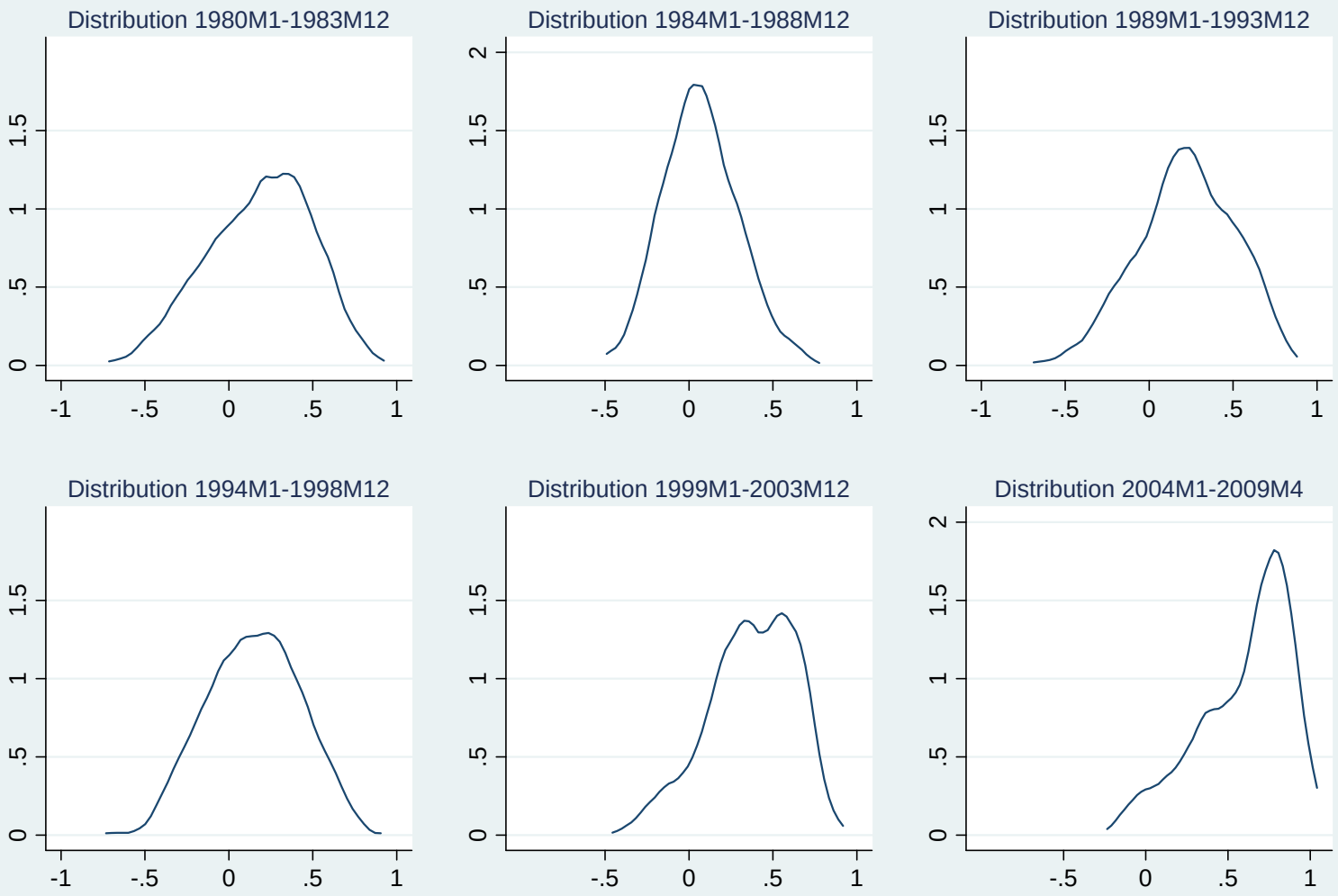

Figure 1: Twenty Four Countries - Distribution since 1980 (NSA)

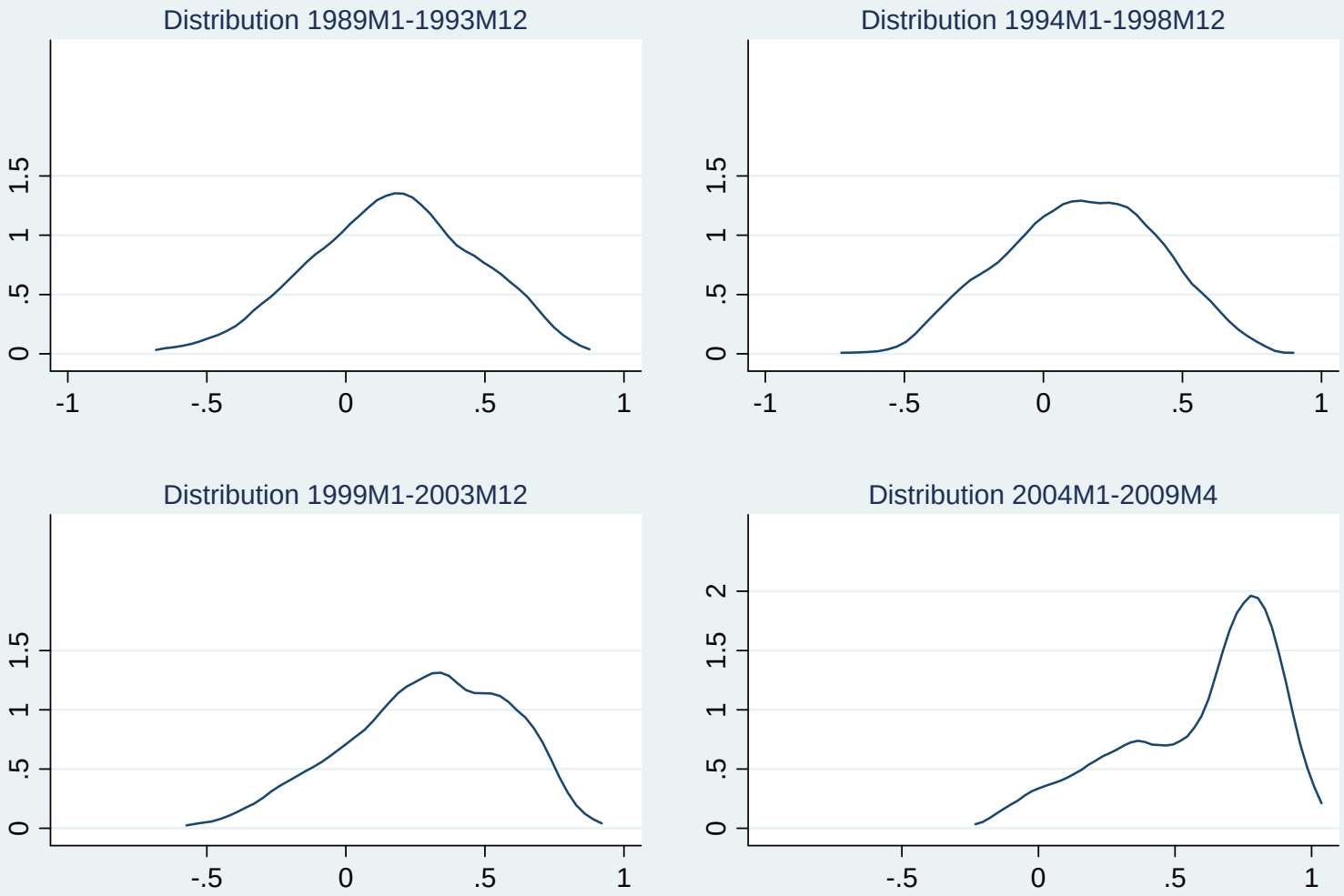

Figure 2: Twenty Nine Countries - Distribution since 1989 (NSA)

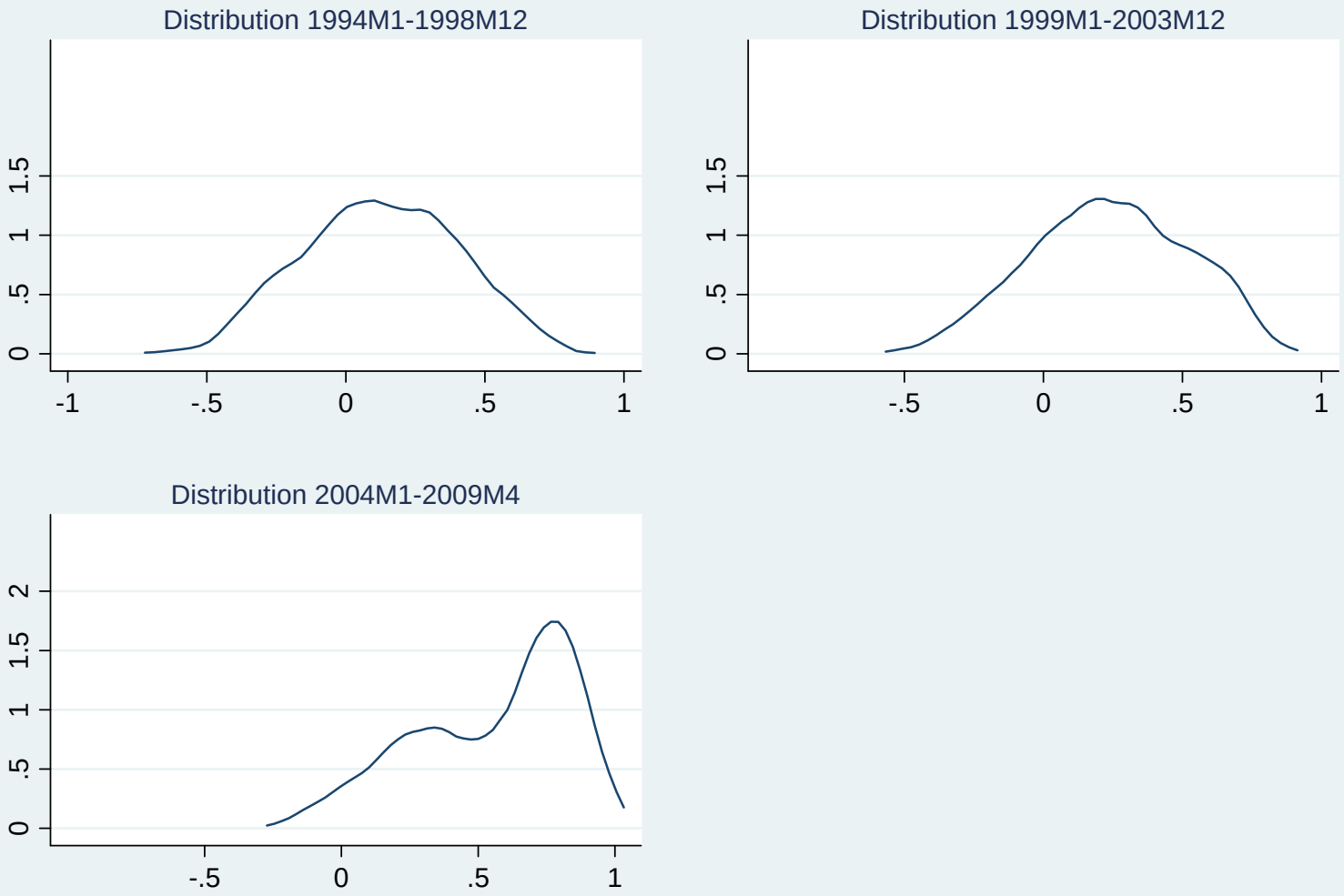

Figure 3: Thirty Four Countries - Distribution since 1994 (NSA)

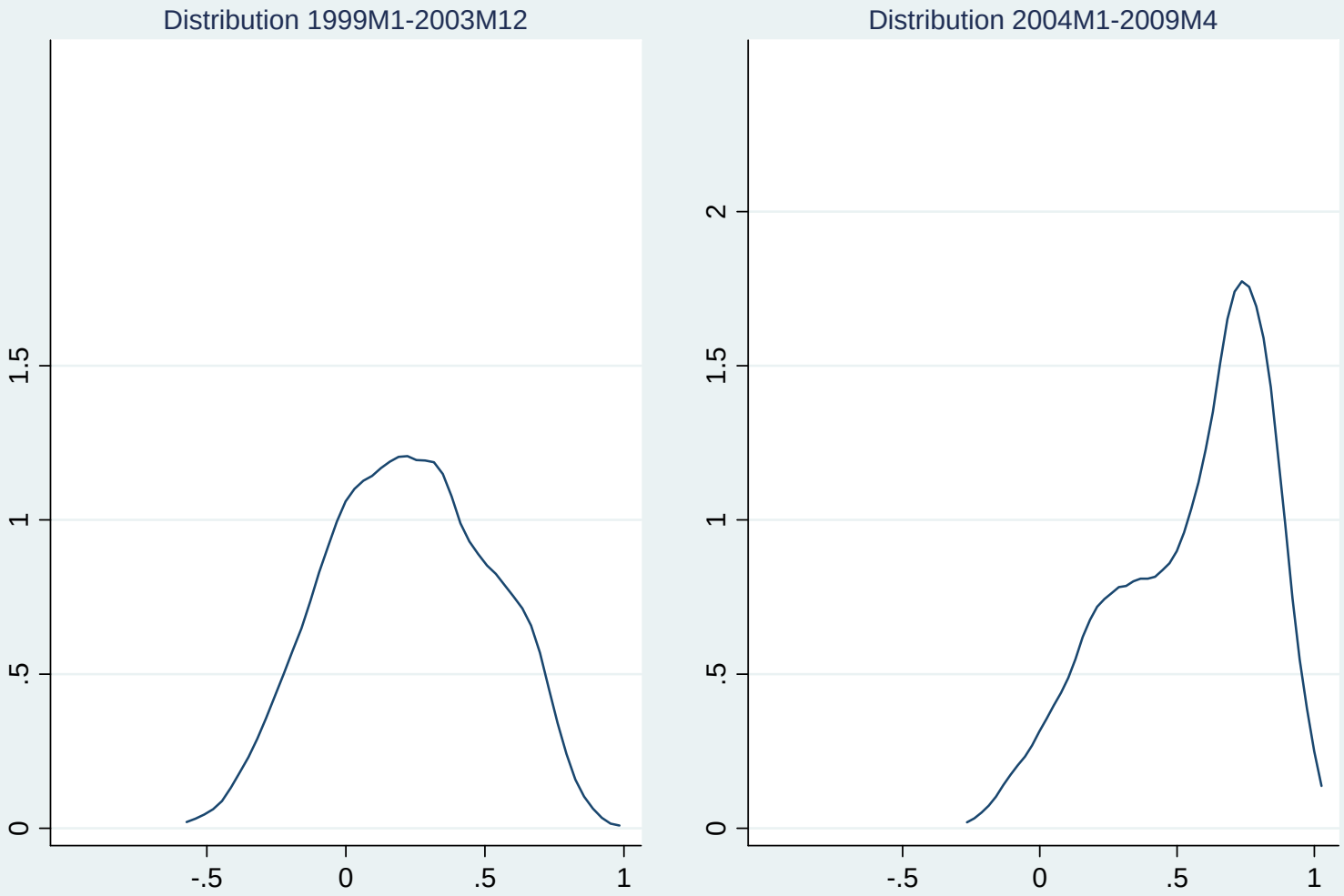

Figure 4: Thirty Eight Countries - Distribution since 1999 (NSA)

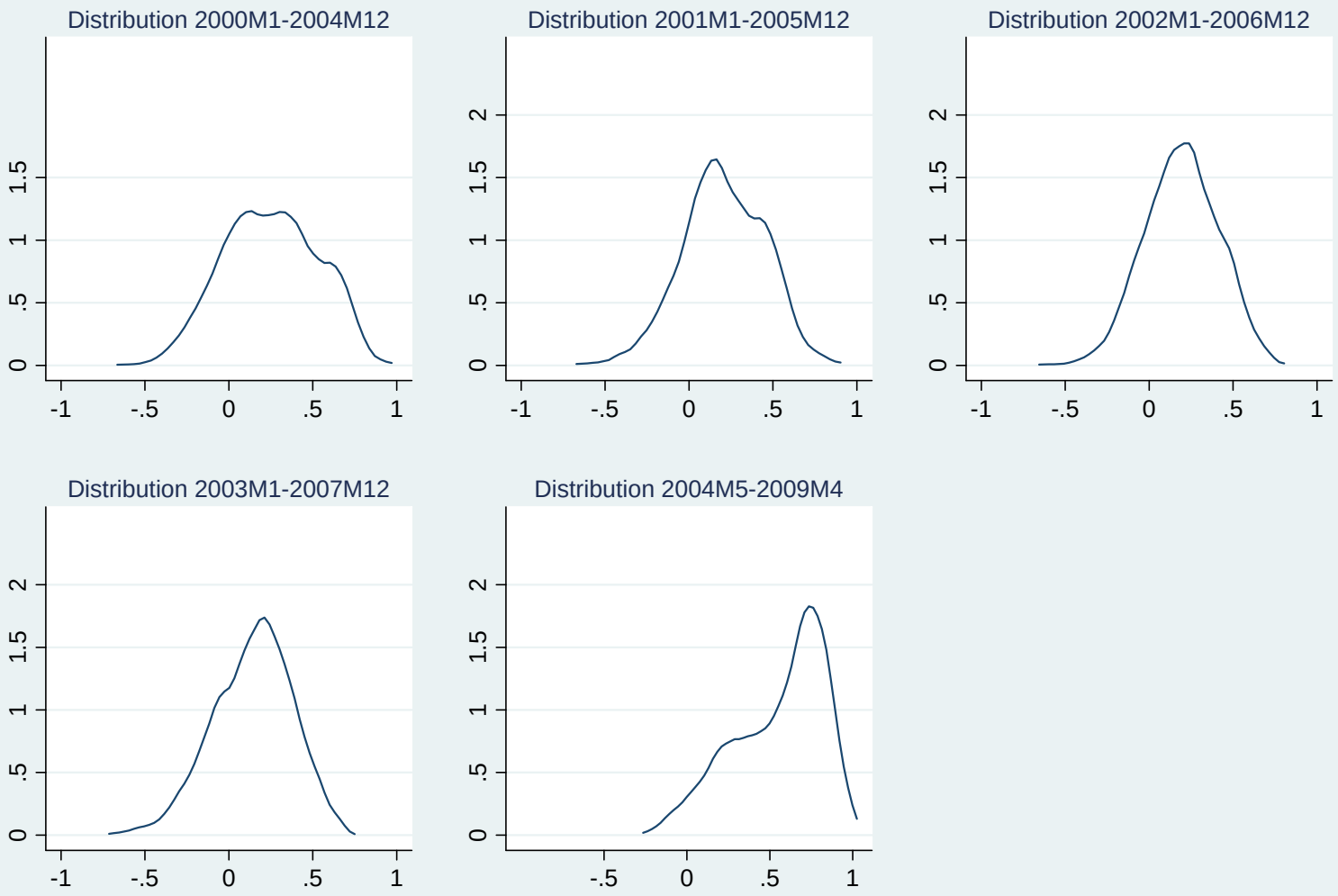

Figure 5: Thirty Nine Countries - Distribution since 2000 (NSA)

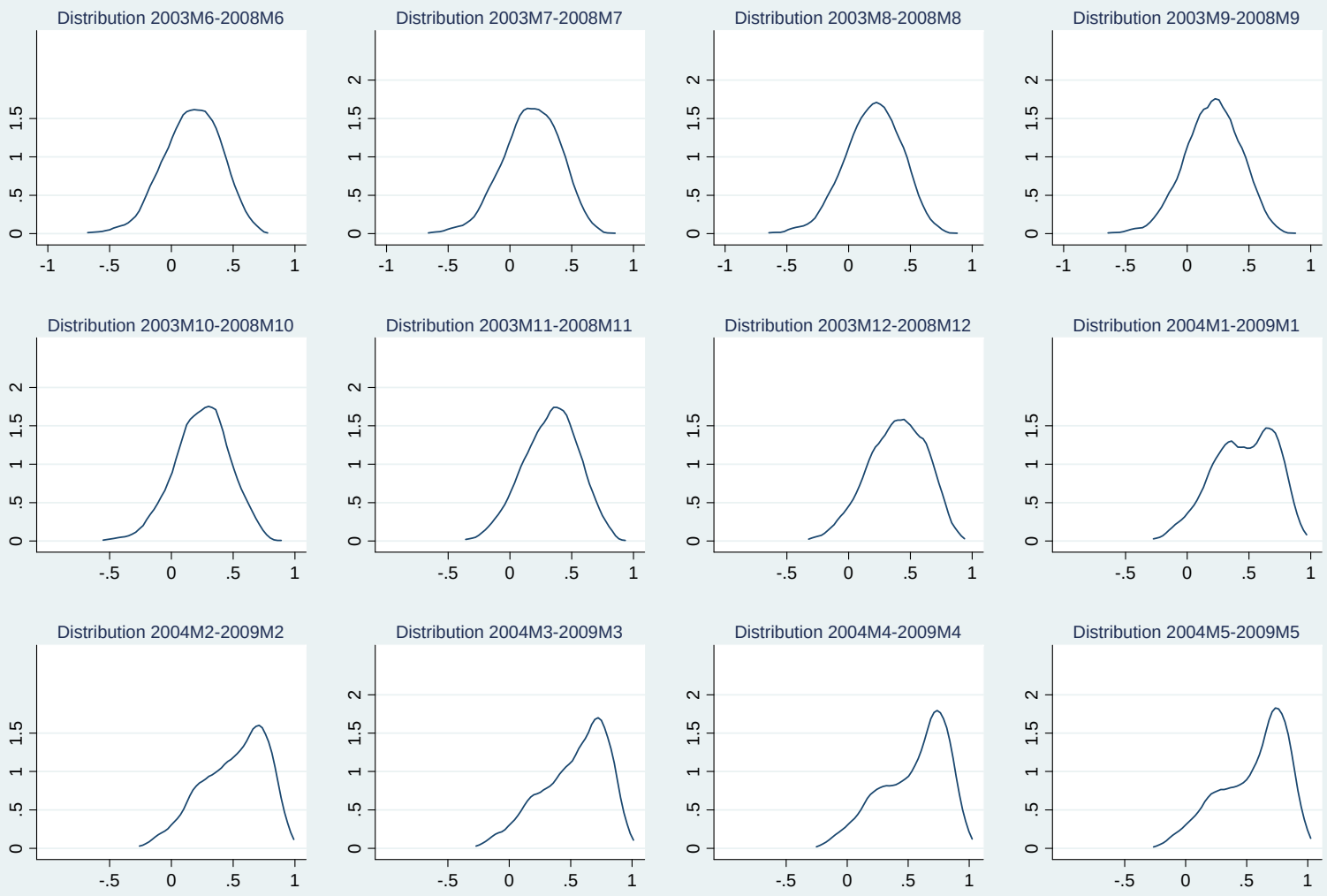

Figure 6: Thirty Nine Countries - Month by Month (NSA)

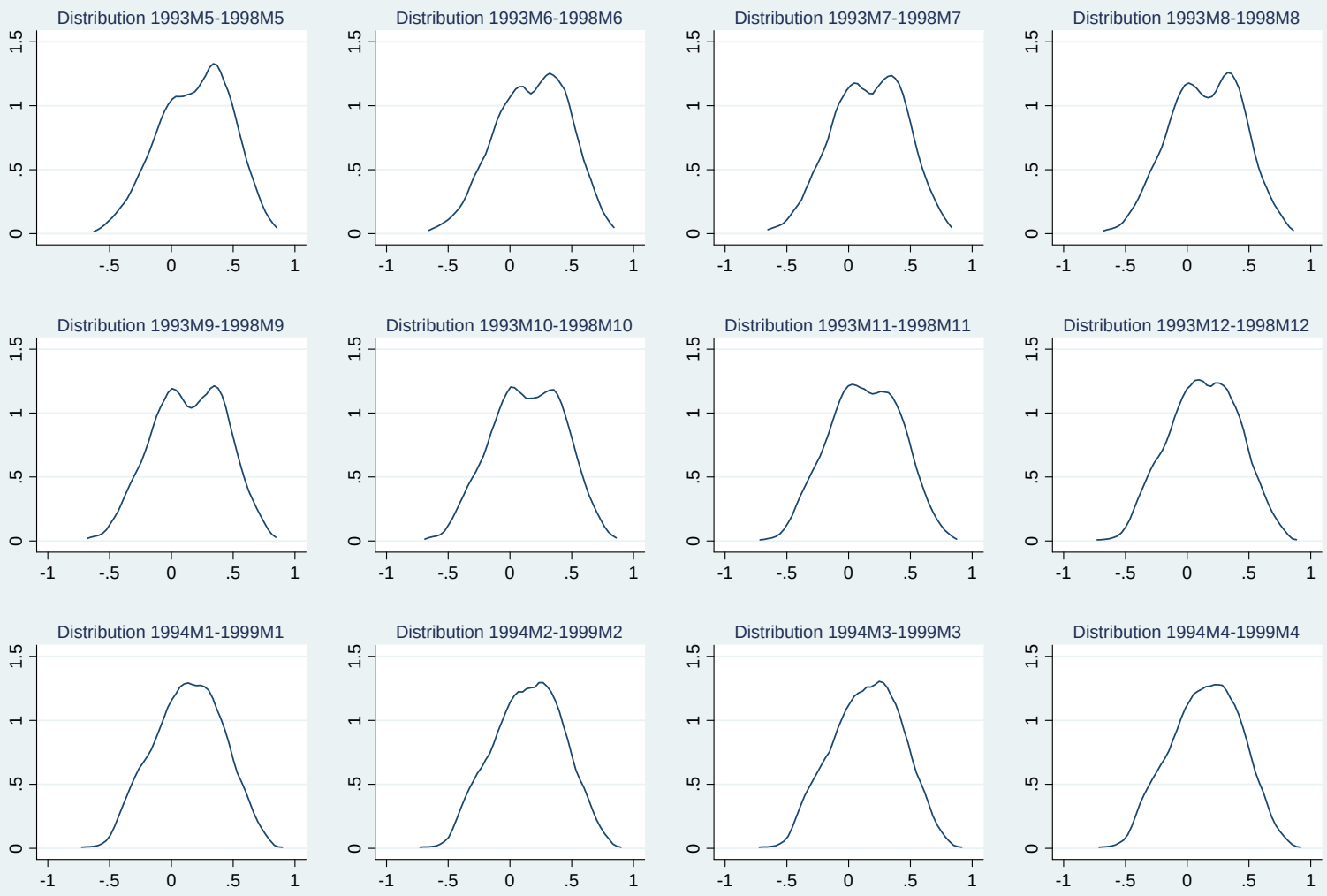

Figure 7: Twenty Nine Countries - LTCM Crisis (NSA)

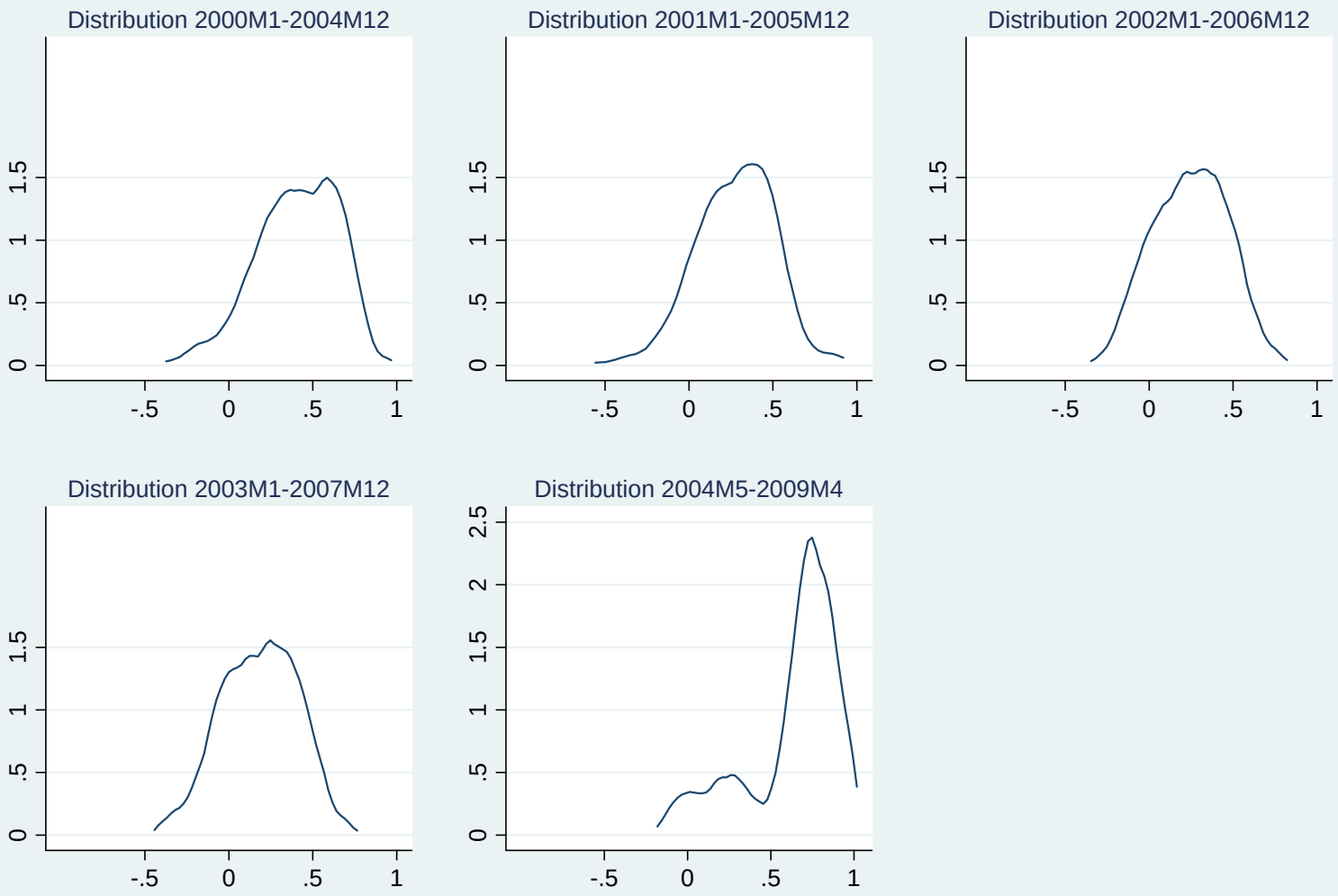

Figure 8: Nineteen OECD Countries - Distribution since 2000 (NSA)

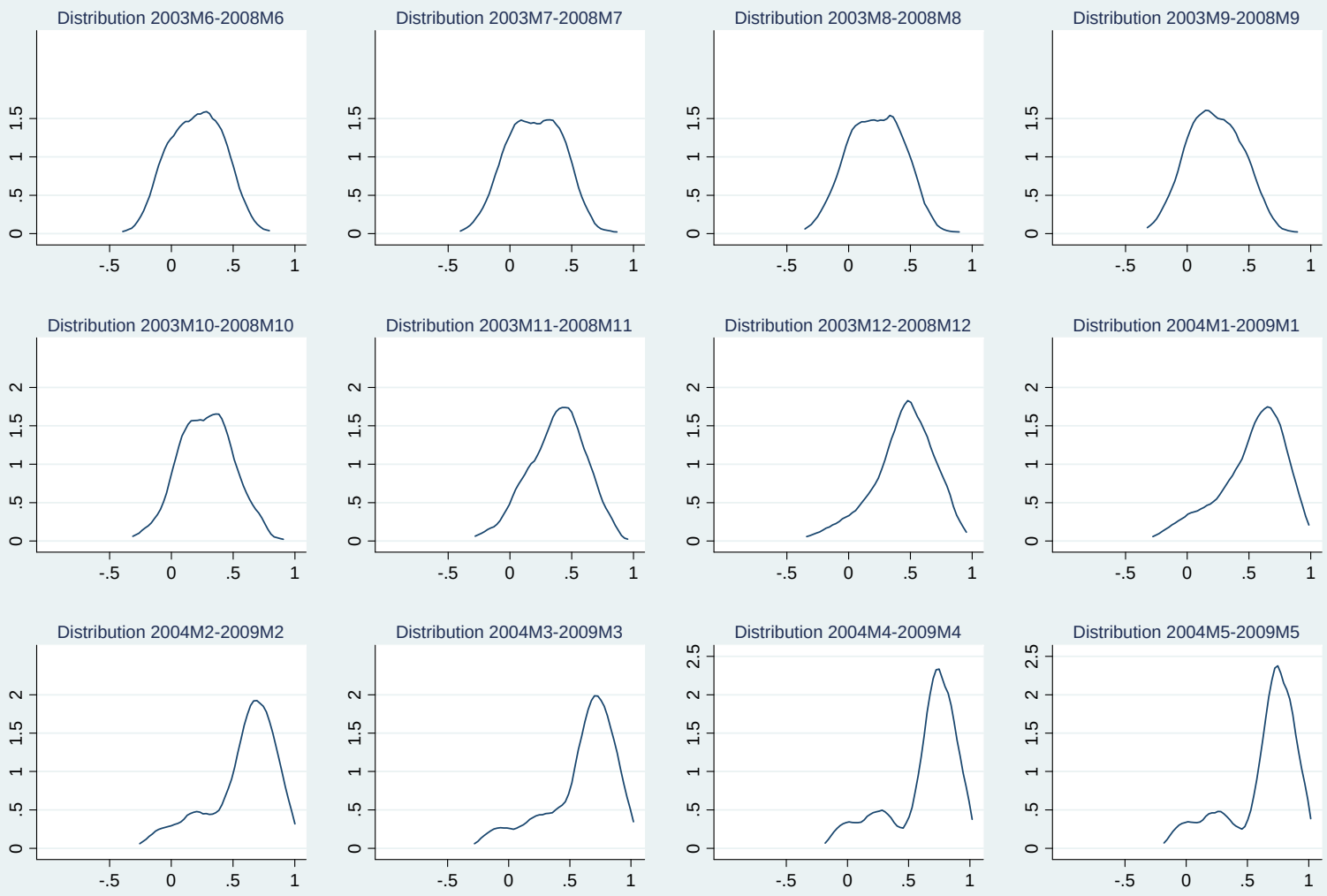

Figure 9: Nineteen OECD Countries - Month by Month (NSA)

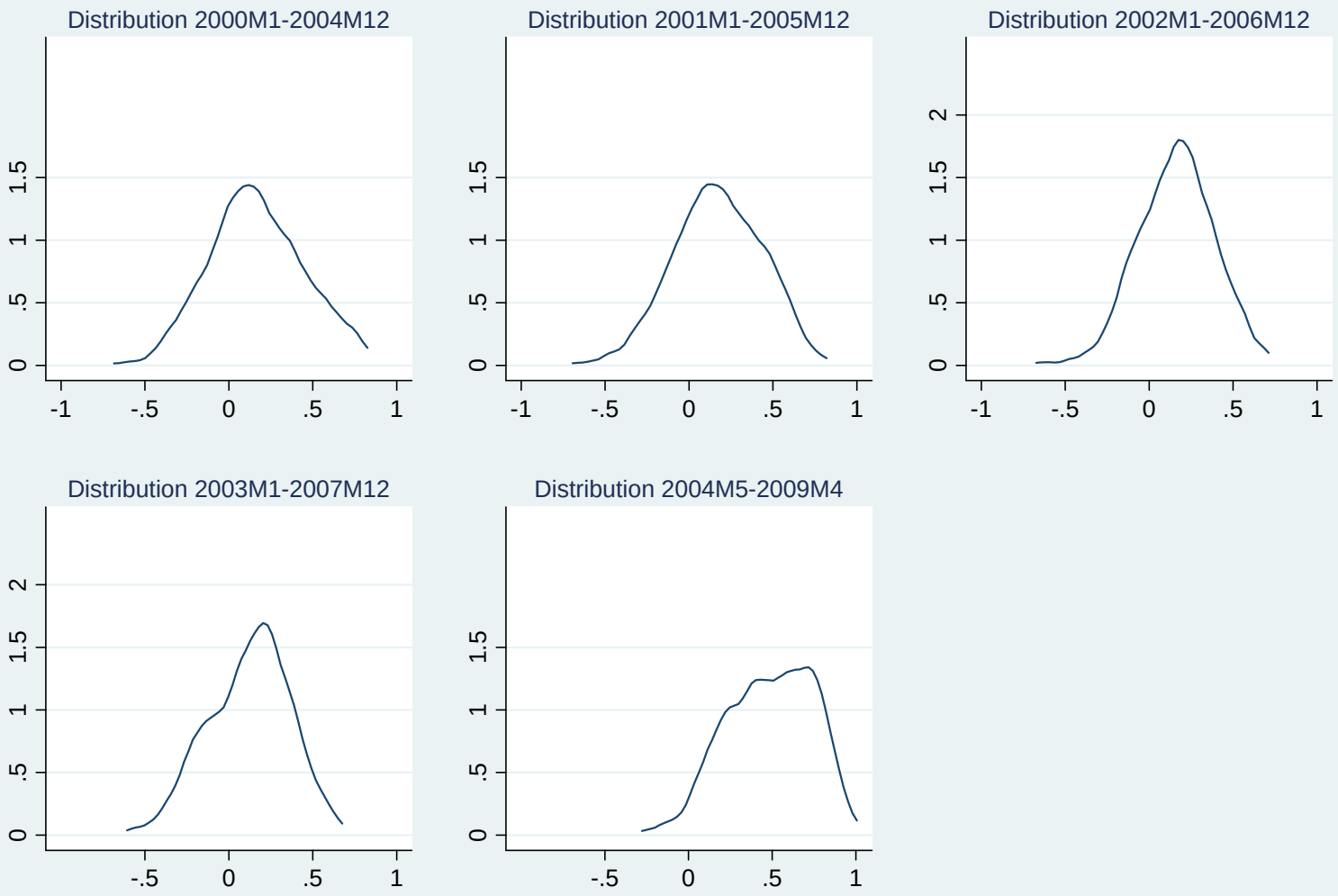

Figure 10: Twenty NON OECD Countries - Distribution since 2000 (NSA)

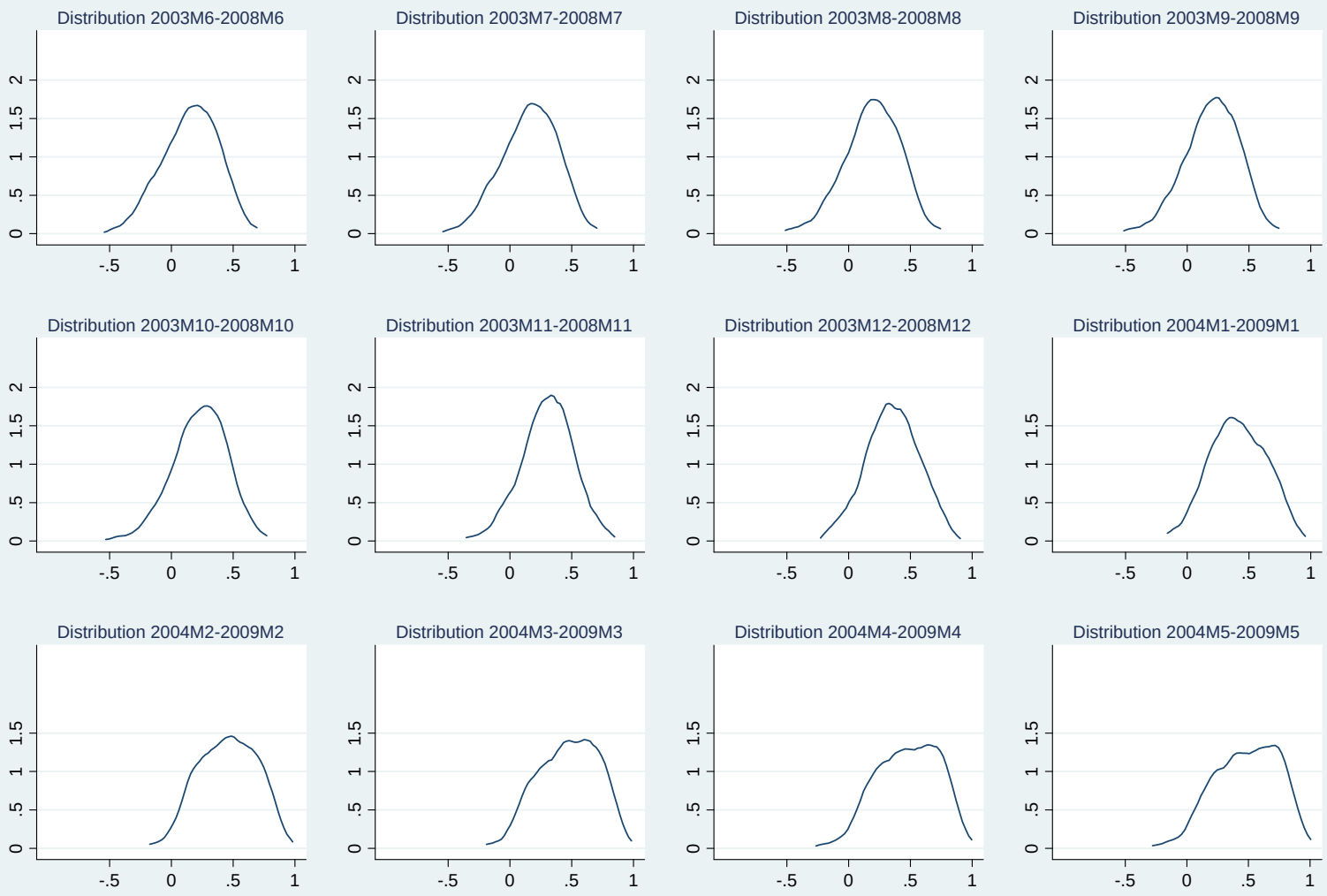

Figure 11: Twenty NON OECD Countries - Month by Month (NSA)

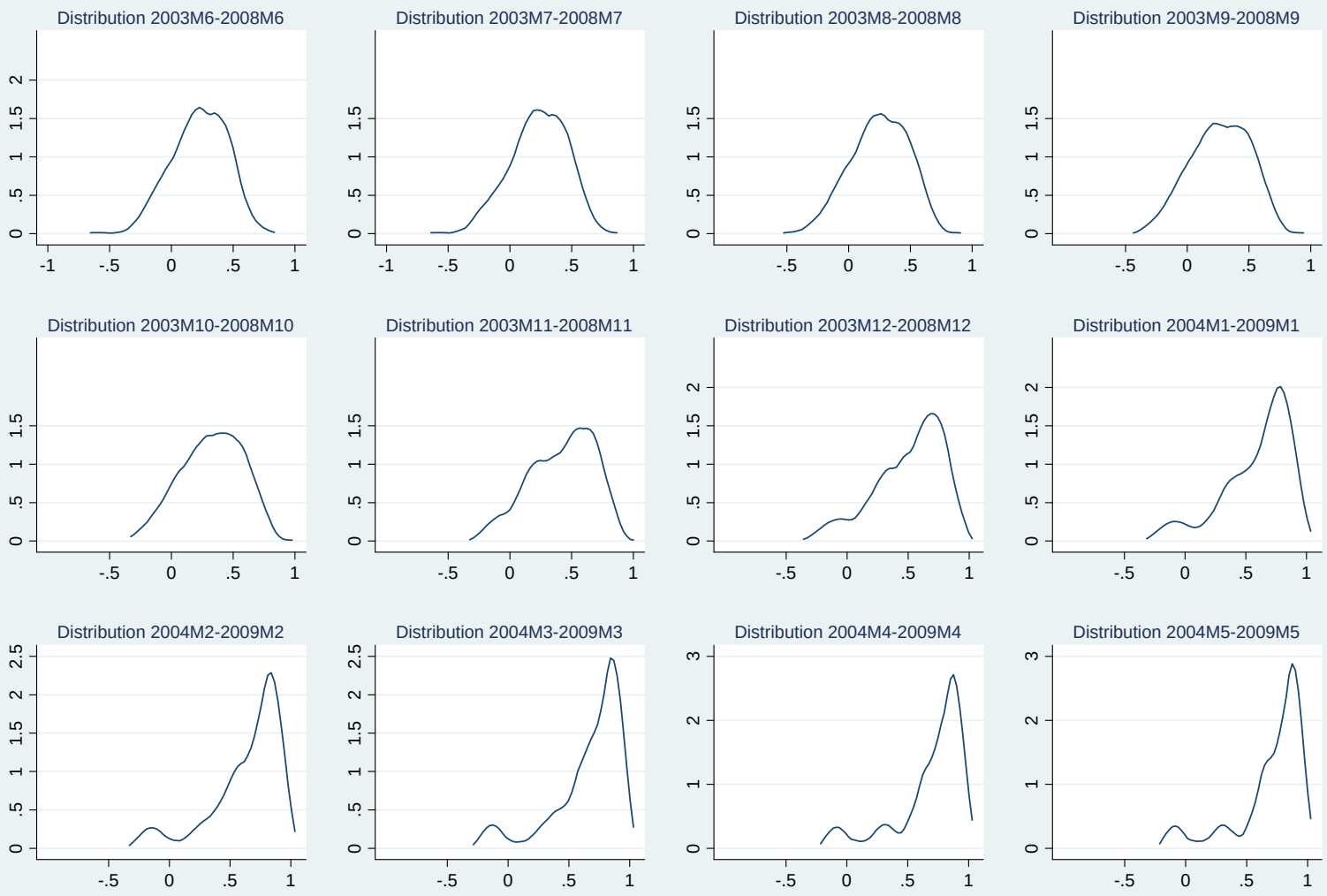

Figure 12: Twenty Eight Countries - Month by Month (Seasonally Adjusted)

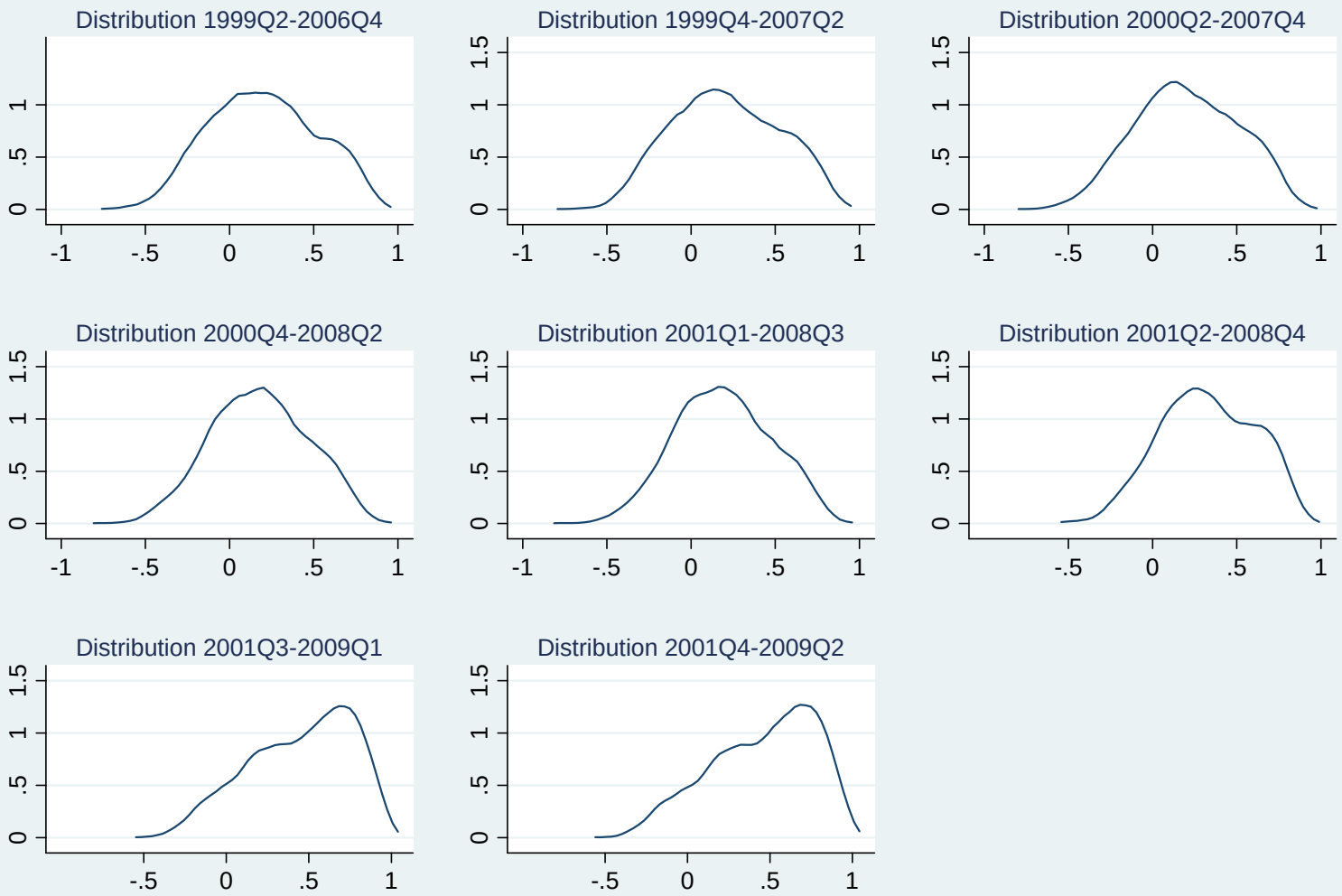

Figure 13: Fourty Four Countries - Distribution since 1999 (Quarterly NSA)