Is Economic Growth Synchronicity Higher in Europe than Elsewhere?

Patrick M. Crowley[1] and Aaron Schultz[2]

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[1]Corresponding author: Texas A&M University - Corpus Christi, 6300 Ocean Drive, Corpus Christi, TX, 78412, USA. email: patrick.crowley@tamucc.edu

[2]Athinoula A. Martinos Center for Biomedical Imaging and Massachusetts General Hospital, 149 Thirteenth Street, Suite 2301, Charlestown, Massachusetts 02129, USA. email: aschultz@nmr.mgh.harvard.edu

Abstract

Synchronization of growth rates are an important feature of international business cycles, particularly in relation to regional integration projects such as the single currency in Europe. Synchronization of growth rates clearly enhances the effectiveness of European Central Bank monetary policy, ensuring that policy changes are more attuned to the dynamics of growth and business cycles in the majority of euro area member states. In this paper a dissimilarity metric is constructed by measuring the topological differences between the GDP growth patterns in recurrence plots for individual countries. The results show that synchronization of growth rates were higher among the euro area member states during the second half of the 1980s and from 1997 to roughly 2002. Apart from these two time periods, euro area member states do not appear to be more synchronized than a group of major international countries, suggesting that apart from specific times when European integration initiatives were being implemented, globalization was the dominant factor behind international business cycle synchronization.

Keywords: Euro area, business cycles, growth cycles, recurrence plots, synchronicity, convergence

JEL classification: C49, E32, F49

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1 Introduction

In economics, economic growth is one of the most important variables indicating the expansion of economic activity taking place in a country. Traditionally economic growth is measured as the rate of change in the real (inflation-adjusted) gross domestic product (GDP) per capita of a country. Because of new linkages between countries through such mechanisms as a greater relative volume of international trade, capital flows and the diverse operations of multinational corporations, one might expect there to be an increased likelihood that growth rate movements will be more synchronized between countries. Logically one would expect that this is particularly the case for countries that are part of regional trade agreements or a single currency, for example. So specifically one might expect that growth rates would be more synchronous for euro area member states than for member states/countries outside the single currency area. Regionalization though has also occurred against the backdrop of increased globalization in recent decades, with foreign trade and capital flows becoming a much more important feature of the global economic landscape than previously, so it is not clear which will dominate.

In this short paper we explore this issue within a very simple framework of the pattern of growth rates between countries. This is what most economists refer to as synchronicity - that is, the co-movement of growth rates through time - and we use this definition of synchronization in this paper rather than the normal definition used by physicists. The starting point for the methodology used in this paper is Crowley (2008), where the intermittency of synchronization in the euro area was noted by using recurrence plot methods. The motivation of the paper is to extend this research by constructing a simple measure of synchronization to specifically ascertain the extent of this synchronicity, rather than focusing on both synchronization and convergence, as with cross recurrence plot methods. A simple metric is constructed which indicates the direction of growth, and it is used to identify group similarity in growth patterns in the European Union rather than just pairwise comparisons, as in Crowley (2008).

The paper is organized as follows: in section 2 we review the economic issues surrounding synchronization of growth rates in the euro area, while in section 3 we outline the general approach taken here. Section 4 presents the results and section 5 concludes.

2 Business and growth cycles synchronization and convergence

2.1 Background

In macroeconomics, we first distinguish between the concepts of convergence and synchronization. By convergence we mean the proximity of growth rates with growth rates of other coun-

tries/member states or collections thereof. By synchronicity we mean the similarity of movement in these growth rates over time. Clearly growth rates do not have to converge to have high levels of synchronicity and also high levels of convergence do not have to be associated with high levels of synchronicity[1]. Although monetary policy will likely be an important factor in determining the level of both convergence and synchronicity between countries/member states, many other factors other than monetary policy are likely to also be relevant, factors such as the dominant transmission mechanism, the level of public sector indebtedness, and the stage of development of the financial system. Indeed, in terms of European Central Bank (ECB) monetary policy, given that monetary policy varies over the business cycle, convergence in growth rates is likely to be less important than synchronicity of growth rates between member states.

The synchronicity in movement of economic growth rates is economically important for 2 underlying reasons:

1. the more globalized the world becomes, the more likely that trade and financial flows will cause greater "synchronization" in growth rates between countries - known in the literature as the "international business cycle"; and

2. for collections of countries that use the same currency (such as the euro area member states of the European Union), similar movements in economic growth rates can either indicate

i) *ex-ante* the suitability for adopting the same monetary policy (- known as the optimal currency area (OCA) theory[2]); or

ii) *ex-post*, the fact that monetary policy has been a factor in making these countries have similar patterns of growth (- known as the endogenous OCA theory).

There has long been recognition of the propagation phenomenon of business cycles between countries (- the main mechnanisms being trade and capital flows). The main indicator of this propagation is the synchronicity of turning points in business cycles (noted by Backus and Kehoe (1992) and Backus, Kehoe, and Kydland (1995) in the real business cycle literature) but what is not recognized is that the economic growth dynamic between these turning points (usually the recessions or peaks of business cycles) can be radically different between countries. This observation has given rise to the notion and study of growth cycles in the context of the dynamic of economic growth between these turning points (see Kontolemis (1997) and Zarnowitz and Ozyildirim (2002)). From an empirical perspective there have been some efforts to empirically extract

[1] As for example if growth rates were mean reverting and the amplitudes of cyclical activity were small.
[2] The original and seminal contribution here was made by Mundell (1961).

cycles for measurement and comparison across countries using frequency domain techniques (see Gallegati and Gallegati (2007), Crowley and Lee (2005) and Crivellini, Gallegati, Gallegati, and Palestrini (2004)) but only limited research has been conducted in this area.

In the euro area context, there has been a recognition for some time that with closer cooperation in monetary policy, firstly under the exchange rate mechanism (ERM) of the European Monetary System (EMS) and the run up to Economic and Monetary Union (EMU), and then secondly during the shift to the adoption of the euro within the EMU process (- using specified economic convergence criteria), that synchronisation of euro area growth rates would likely increase. But measuring this has been more problematic for a variety of reasons - notably the short data span available and the exceptional circumstances surrounding events in the early part of this decade (9/11, Iraq invasion, German structural problems etc). Despite these issues, there has been a variety of empirical research of different types done on this topic, with a good summary of the literature in de Haan, Inklaar, and Jong-a Pin (2008b), and other notable contributions by Artis and Zhang (1997) who first recognized the existence of a separately identifiable European business cycle, followed by Artis and Zhang (1999), and then mostly studies that have tried to measure whether the "European business cycle" has become stronger since the inception of EMU and the introduction of the euro and a single monetary policy (see Altavilla (2004), Sensier, Artis, Osborn, and Birchenhall (2004), Valle e Azevedo (2002), De Haan, Inklaar, and Sleijpen (2002), Süssmuth (2002), and more recently Böwer and Guillemineau (2006), Giannone and Reichlin (2006), and de Haan, Inklaar, and Jong-a Pin (2008a)).

This is an important issue for monetary policy of the ECB for several reasons:

a) First, the OCA theory suggests that similar growth rates in member states will ease the problems associated with the differential impact of monetary policy on these countries.

b) Second, not only do growth rates matter, but also the dynamics of growth also matters - thus the idea that similar frequency growth cycles between countries in a monetary union will also ease the problems of implementing monetary policy across a collection of member states or countries, creating less "stress" within the euro area than otherwise would be the case. Higher synchronicity of growth rates within the euro area implies that cyclical features of business and growth cycles are similar between member states and so monetary policy can be more easily formulated.

c) Third, OCA theory also suggests that even without this increased synchronicity of business and growth cycles, increased mobility of factors of production can counter this and so aid implementation of monetary policy as resources can flow from one country to another to

offset the differential impact of monetary policy. With the advent of the single market in the EU after 1992, labor and capital mobility have increased, but it is still widely acknowledged that language and cultural barriers impose greater barriers to mobility of factors of production than they do in many other monetary unions (such as the US or Canada).

d) Fourth, another offset to lack of synchronisation can be found in autonomy of fiscal policy, perhaps at a national or member state level, or at the supra-national level. This has caused considerable concerns in the euro area recently, as the Stability and Growth pact (SGP) appears to severely limit member state fiscal policy so as to counterbalance ECB monetary policy and its differential impact on certain member states, dependent largely on debt levels and any existing structural budget deficit considerations.

e) Lastly, there is also a feedback effect involved, as a single monetary policy should impact all member state growth rates across the euro area implying that an OCA might be created endogenously (- see Frankel and Rose (1997)).

Only in the last decade has the question been asked as to whether increased business cycle synchronization is driven more by global or regional factors, and whether this has changed over time. Artis and Zhang (1997) first asked whether there is a European business cycle separate from other international business cycles, while Stock and Watson (2005) first noted that cyclical convergence was much more a global rather than a regional phenomenon, but more recently, using spectral analysis Hughes Hallett and Richter (2006) showed that the convergence and lower frequencies was due to common cycles, in other words globalization.

3 Data and Methodology

3.1 Data

To measure economic growth, real quarterly Gross Domestic Product (GDP) is used. Countries/member states that have a reasonably long data span[3] were used, which in some cases required splicing data across different data sources, but also required limiting the dataset. Data was sourced from a variety of sources, but mostly Eurostat for the European countries and from the IMF International Financial Statistics for the non-European countries. Quarterly data was collected for the period 1970Q1-2008Q4, giving 156 datapoints. In order to measure economic growth at time t, g_t, the GDP at time t, y_t, is transformed by taking natural log first differences as follows:

[3] Most data in economics have a relatively short span compared to those in the sciences, but here with just over 500 datapoints this already considerably narrowed the number of countries/member states in our sample.

$$g_t = \ln(y_t) - \ln(y_{t-1}) \tag{1}$$

Due to this data transformation and also because of one missing observation for Spain at the beginning of 1970, this leaves 154 datapoints.

Three sets of countries are used in the research:

i) 9 Euro area member states: France, Germany, Spain, Ireland, Italy, Luxembourg, Portugal, Finland, Netherlands;

ii) 4 non-euro area member states/European countries: Sweden, Switzerland, UK, Denmark; and

iii) 6 international countries/entities: Euro area, US, Japan, South Africa, Canada, Australia.

The first two groups of member states/countries represent regional groupings in Europe, with the usage of the euro being the factor that distinguishes them. The third grouping represents a proxy for the international business cycle.

Next a sample of these quarterly economic growth rates are plotted. Figure 1 shows the transformed data for France, Germany and Spain. It is immediately apparent that Spain had much higher growth rates for much of the early part of the 2000s, but now has fallen into a deep recession. Figure 2 shows economic growth rates for Ireland, Italy and Luxembourg. The data for Ireland and Luxembourg appears to have become very volatile around 1997 - this is likely because of changes in the way GDP was measured rather than any sudden increase in volatility[4]. In figure 3 the prolonged downturn in Finland is readily apparent in the early 1990s, but what is most noticeable is that growth rates become much more convergent between these three euro area member states after 1993. In figure 4 there is also a decline in growth rate volatility in the early 1990s, with all three growth rates tightly bunched together for most of the period after 1993. Lastly figure 5 shows the growth rates of the US and Canada moving closely together but the Japanese rate clearly moves independently for the most part, and the "lost decade" of growth in the 1990s for Japan is clearly apparent.

3.2 Methodology

Recurrence plots first originated from work done in mathematics and physics but now has a considerable following in a variety of fields[5]. There are several excellent introductions available

[4] In what follows the volatility of the rate of growth is not a factor - solely the direction of growth is what is accounted for in the analysis, so this should not bias the results in any way.

[5] Norbert Marwan's website catalogues all the articles published using recurrence plots and RQA, and is a veritable mine of information on this topic. See http://www.recurrence-plot.tk

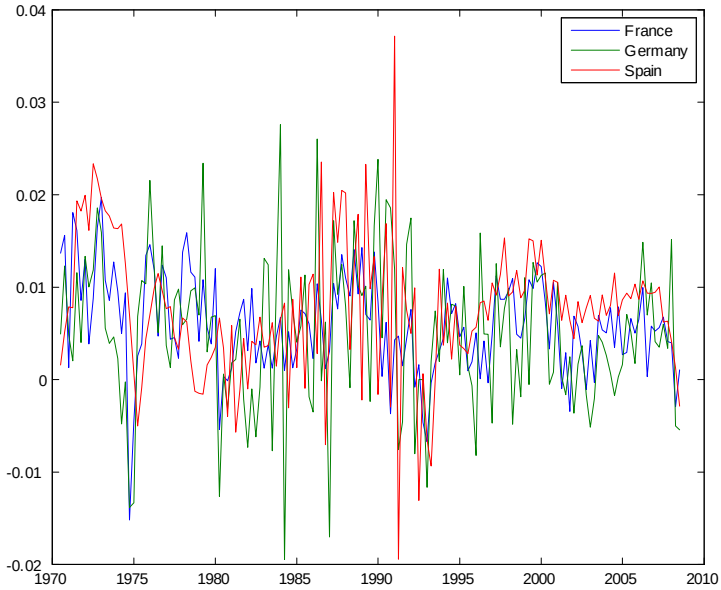

Figure 1: Quarterly log change in real GDP for France, Germany and Spain

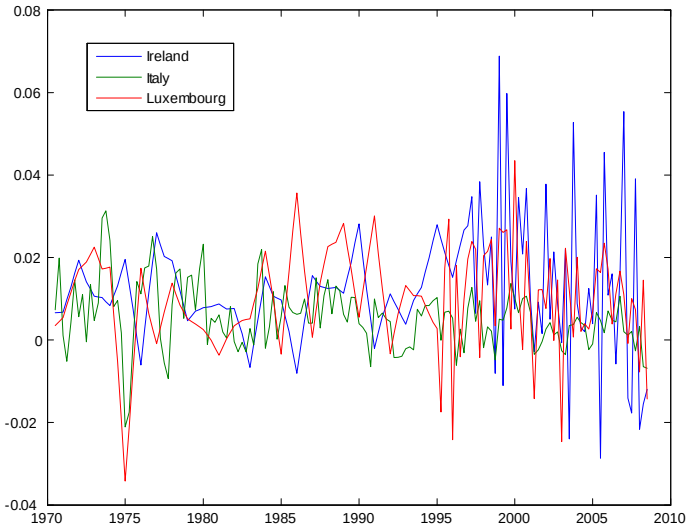

Figure 2: Quarterly log change in real GDP for Ireland, Italy and Luxembourg

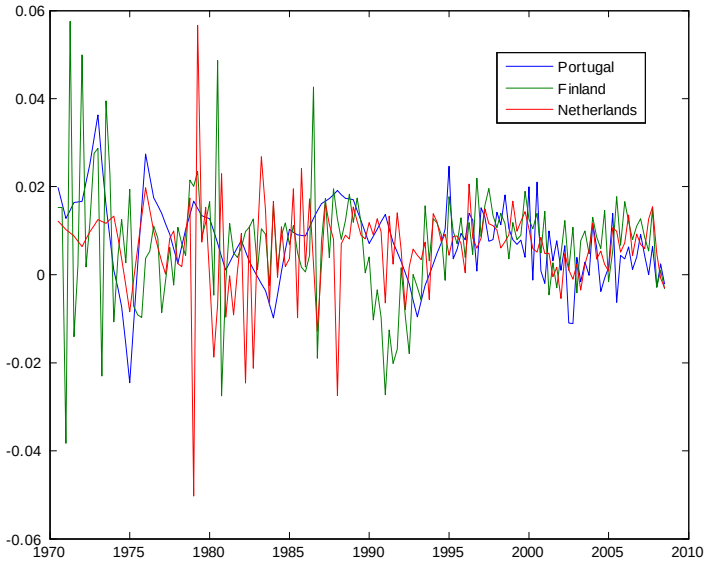

Figure 3: Quarterly log change in real GDP for Portugal, Finland, and the Netherlands

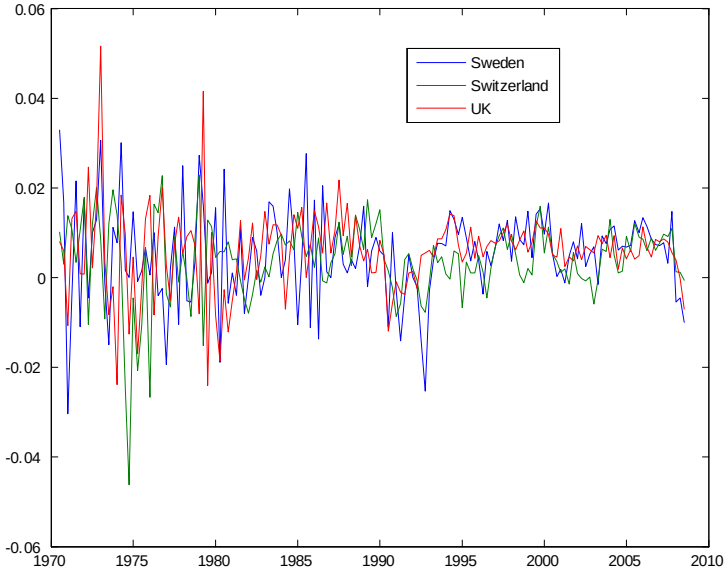

Figure 4: Quarterly log change in real GDP for Sweden, Switzerland and the UK

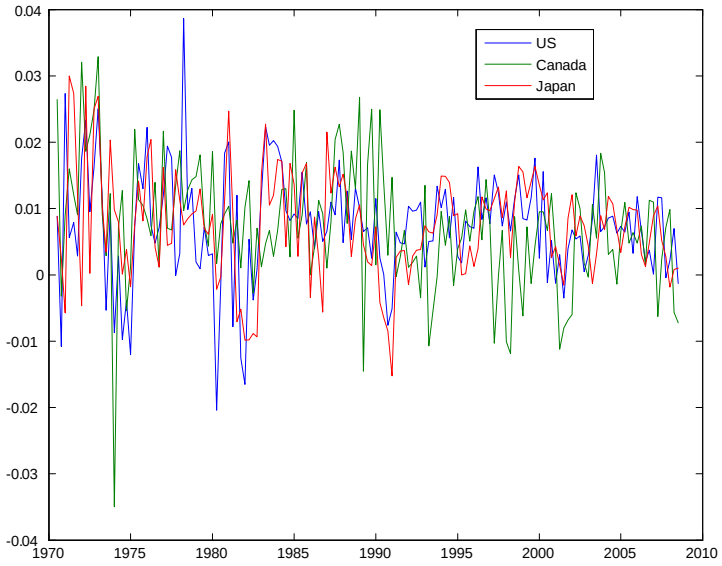

Figure 5: Quarterly log change in real GDP for the US, Canada, and Japan

on recurrence quantification analysis and recurrence plots, not least those by Marwan, Romano, Thiel, and Kurths (2007) and Webber Jr. and Zbilut (2005). There are very few papers that apply recurrence plot techniques to macroeconomic issues, the notable exceptions being Zbilut (2005), Kyrtsou and Vorlow (2005), and Crowley (2008).

In terms of the mathematical background, using Takens' embedding theorem (see Takens (1981)), the recurrence plot is a way of analysing the dynamics of phase space trajectories in deterministic systems. Takens' embedding theorem states that the dynamics can be approximated from a time series x_k sampled every t by using an embedding dimension m, and a time delay, τ, by a reconstruction of the phase-space trajectory $\overrightarrow{y}_t$, where:

$$\overrightarrow{y}_t = (x_t, x_{t+\tau}, ..., x_{t+(m-1)\tau}) \tag{2}$$

The choice of m and τ are based on methods for approximating these parameters, such as the method of false nearest neighbors and mutual information for m and τ respectively. When using cross recurrence plots, the choice of m and τ are assumed to be the same. Every point of the phase space trajectory $\overrightarrow{y}_t$, that is,x_t is tested to see whether it is close to another point of the trajectory $x_{t+\tau}$, i.e. the distance between these two points is less than a specified threshold ε. In this case the value one (a black dot in the recurrence point) is assigned to this point in a $N \times N$-array (- the recurrence plot):

$$\mathbf{R}_{i,j} = \Theta(\varepsilon - \|x_i - x_j\|)$$

Second, following Marwan, Thiel, and Nowaczyk (2002) the cross recurrence plot is definied by:

$$\mathbf{CR}_{i,j} = \Theta(\varepsilon - \|y_i - z_j\|) \tag{3}$$

where $i, j = 1, ..., N$, y_i and z_i are two embedded series, ε is the predefined "threshold", $\|\|$.is the norm (for example a Euclidean norm) and Θ is the Heaviside function. This gives a cross recurrence matrix $\mathbf{CR}_{i,j}$ which contains either 0s (the white areas in the plots) or 1s.

Third, in a recurrence plot, the main diagonal is always present, as every point in the series is identical to the same point in the series, so there will always be a leading diagonal line (1's down the main diagonal of the $\mathbf{R}_{i,j}$ matrix), once all points in the series are considered . In the cross recurrence plot if this line is present, the two series are identical, but this is obviously a special case. A line, if it appears in the cross-recurrence plot, implies similar dynamics, but these maybe offset from the main diagonal, implying phasing of the two cycles. The line closest to or on the leading diagonal, if it can be identified, is termed the "line of synchronization" or LOS.

Fourth, complexity measures can be derived to characterize the cross-dynamics of a given series. For two series these will be characterized as diagonal lines (not necessarily on the main diagonal), which demonstrate similar dynamics maybe at different points in time. Following Marwan and Kurths (2002) the distributions of the diagonal line lengths can be written as $P_t(l)$ for each diagonal parallel to the main diagonal, where $t = 0$ denotes the main diagonal, $t > 0$ denotes diagonals above the main diagonal (a lead) and $t < 0$ denotes diagonals below the main diagonal (a lagged dynamic).

The starting point in the research presented here is the analysis conducted in Crowley (2008) with recurrence plots. Here we take the example of Finland, and display in figures 6 and 7 the unthresholded and thresholded recurrence plots respectively against the euro area aggregate growth rate[6]. In the first figure the color scale denotes the distance between the two embedded phase-space trajectories for the two series with red denoting a small distance up to blue areas (in this particular plot) which denote relatively large distances. The diagonal lines indicate the synchronous dynamics in both series. It is clear that even when the values of the growth variables are far apart (as around 1980) there are some phased synchronous dynamics, even if the distances between the series are relatively large. Diagonal lines along the leading diagonal indicate coincident dynamics and it is apparent that this is intermittent, in the sense that there are gaps in these

[6]The embedding parameter was set at 4 and the time delay parameter at 1, as per Crowley (2008).

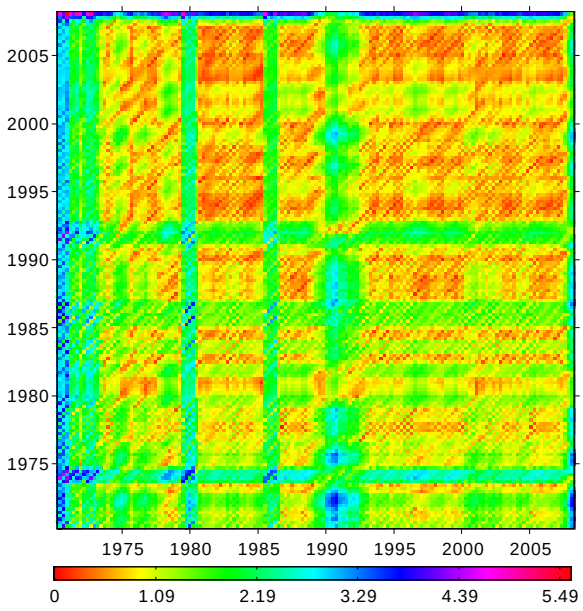

Figure 6: Unthresholded recurrence plot for Finnish vs euro area economic growth

diagonal lines (as in 1989 and 1998). The second plot considers those periods where growth is convergent (using a thresholded distance) and shows that indeed when growth rates are similar, there are synchronous periods (for example, 1982-84) - the vertical bands in the figure indicate that Finnish growth rates are close to euro area growth rates throughout the span of the euro area series, which in turn also signifies that Finnish growth rates departed significantly from the usual growth rate range observed for the euro area. The thresholded recurrence plot therefore considers synchronous dynamics given a certain degree of convergent growth rates, so it does not isolate synchronicity dynamics regardless of the degree of convergence. The main objective in this paper is to isolate synchronous dynamics irrespective of the degree of convergence in growth rates.

In order to only consider synchronous dynamics, each time series is transformed into signed values signifying the direction of movement in growth rates in each quarter and then a cumulative summation of the direction of growth was created from the signed values. We refer to these modified time-series as cumulative signed summation (CSS) series. Distance matrices for each un-embedded CSS series are created using the standard Euclidean distance metric as described in Marwan, Romano, Thiel, and Kurths (2007), where N is the total number of points in the phase space of variable X and k = the dimensions of X. In mathematical terms this is measured as:

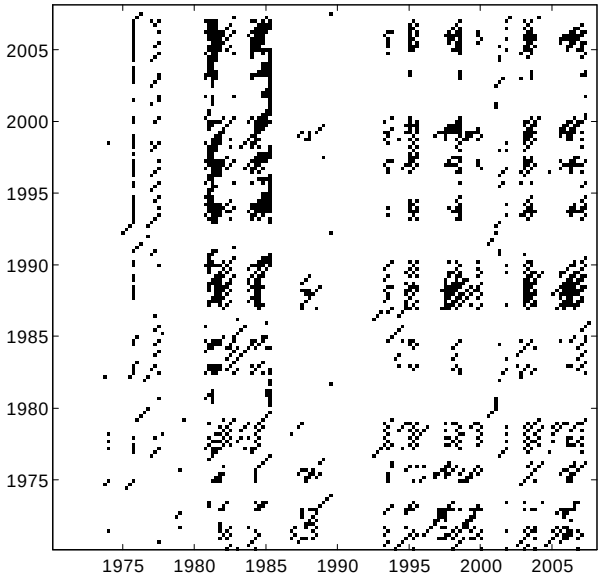

Figure 7: Thresholded recurrence plot for Finnish vs euro area economic growth

$$D_{i,j} = \sqrt{\sum_{k=1}^{n}(X_{i,k} - X_{j,k})^2} \tag{4}$$

where $i, j = 1, 2, ..., N$.To evaluate the dissimilarity between two time series, we compute a self-recurrence distance map for each time series independently. These two distance maps are then compared with "epoch" (moving window) analysis with an eight sample window incremented one sample at a time (the moving window for each distance plot is always centered on the main diagonal). For each epoch the dissimilarity is computed by taking the absolute difference between the paired values in the epochs from each time series:

$$E = |D1_{i,j} - D2_{i,j}| \tag{5}$$

where $D1$ represents the window for the first series etc, and i, j are the time points in a particular epoch. The average of this difference matrix is then the total dissimilarity between $D1$ and $D2$ for a particular epoch. The metric obtained is informative of the topological "dynamics" between the two time series. Note that this method does not employ cross-recurrence, rather the method is akin to a real-valued joint recurrence plot (i.e. comparison without thresholding). This process can be done for a single member state against all other member states in a group to create

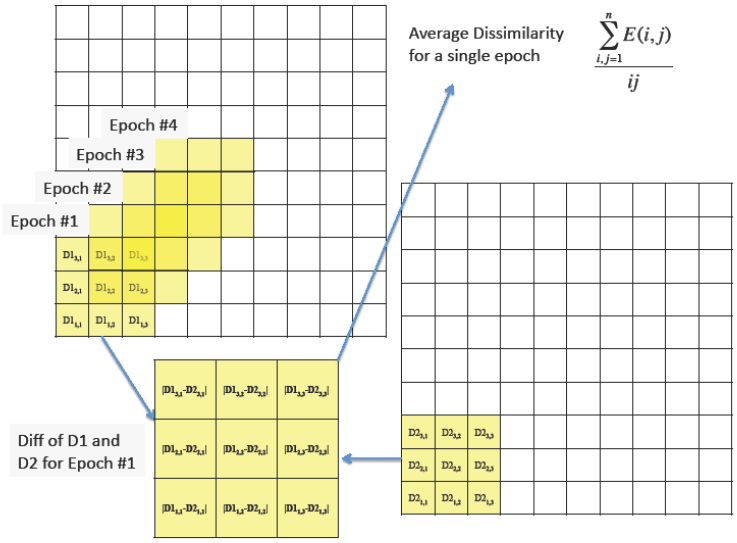

Figure 8: Dissimilarity matrix methodology

a synchronicity-proxy within a set of member states or can be repeated for each pair of time series within a set so as to create a "super" dissimilarity matrix for all member states for each epoch. In the latter case, the dissimilarity matrix at each time step is then averaged to estimate the total dissimilarity between members of the set for a particular temporal window. The final product is then a one dimensional time series denoting the synchronization in growth patterns between members of a set with smaller values indicating greater synchronicity. The methodology is illustrated by way of figure 8. Note that where there is a turning point in one particular member state/country, if this does not show up in other member states countries then dissimilarity will increase. Once the absolute differences have been evaluated for a set of countries they can be plotted to show the "within-group" average level of dissimilarity between all the members, and this is what is done below for the three sets of member states/countries that were specified in the section on data above.

4 Results: Intra-group synchronicity

4.1 Euro area member states

The synchronicity of each euro area member state is first evaluated against all other member states separately. Figure 9 shows the epoch dissimilarity measure and is revealing for several reasons. First, it is apparent that France and Germany have historically been the most synchronous member

states against other member states, as their dissimilarity measures usually form the lower envelope in the figure for much of the 1970s and 1980s. Second, the period of the ERM of the EMS from 1979 onwards clearly saw similar dissimilarities between member states, which then continuously fell until 1985, after which there is clearly divergence. Third, it is also readily apparent that from 1999 onwards dissimilarity measures for most member states converged, and although there is some fluctuation, with a general increase in dissimilarity in 2000 and then a reduction in 2002-3, then increasing in 2004-5 and a large reduction for most members states by 2007. Fourth, during the post-1999 period it is also apparent that certain member states have not followed this general trend. From 2000-2003, Spain clearly had greater dissimilarity than the average euro area member state, and then in 2004-5 Portugal was non-synchronous (and to a lesser extent Italy), followed by Ireland in 2006-7.

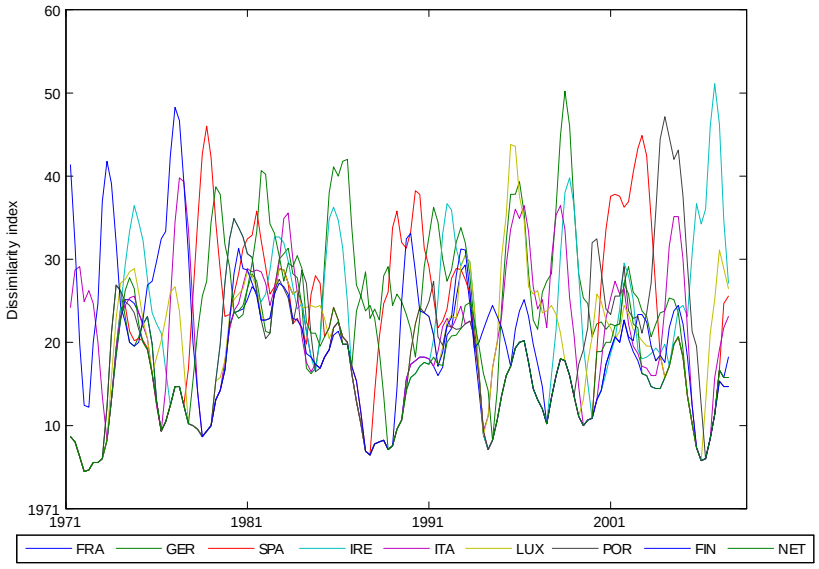

Figure 9: Within euro area dissimilarity index for individual euro area member states

Next we evaluate the simple average dissimilarity for the core member states in our sample for the euro area. Figure 10 shows the averaged dissimilarity measure in blue, together with a 4 year "moving average"[7] given by the thicker black line. The vertical pink lines indicate the "new" EMS in 1983, the signing of the Maastricht Treaty on European Union in 1991, and the inception

[7]The "moving average" measure here is a fitted moving average. Specifically a line is first fitted to the first 16 data points (4 years worth of data). Another line is fitted to points 2:17, then 3:18 and so on. For most points in the series (except for the ends) 16 fitted values are obtained for each point. Then the average of these 16 values is taken and used as the smoothed value.

of the euro in 1999[8].

Our expectation would be that growth patterns would be less synchronous (more dissimilar) during growth periods, and then more synchronicity (less dissimilarity) would be observed during recessions and in the recovery phase. What is interesting here though is that more dissimilarity is observed at the beginning of recessions (- for example 1974, 1982 and 1992), perhaps indicating different dynamic paths taken as the unique linkages between the countries impact individual member states differently as member state/country growth rates decline. In the recovery phase synchronicity clearly increases, but by no more than it does in other periods, which tends to suggest that synchronicity is not only driven by business cycles, but is also driven by other cycles in growth.

The dissimilarity measure in figure 10 fluctuates in roughly a two year cycle, with exceptionally synchronous periods occurring in the early 1970s, the late 1980s, around 1994, and again around 2007. Non-synchronous years include the early 1980s, which nearly saw the collapse of the EMS, 1993 - which corresponds to the collapse in the EMS, and 2002. The moving average indicates that during the period of the "snake" arrangements for exchange rates during the 1970s, there was an increase in dissimilarity, but then following the inception of the ERM of the EMS in 1979 this increased until the U-turn in French economic policy under Mitterand in 1983 (the "new" EMS) after which synchronicity increased until roughly 1989 when tensions between member states started to rise until the ERM crisis in 1992. What is surprising in this figure is that after the inception of the euro in 1999 synchronicity actually decreased slightly and then increased post-2005.

A further interesting exercise is to compare the dissimilarity measures between a particular member state and the euro area aggregate (- which of course is a weighted average of all member states in the euro area and therefore includes the particular member state under consideration. For illustrative purposes we take Germany as an example and plot the dissimilarity measures for Germany compared with all other member states in the euro area compared with the averaged dissimilarity measure for the euro area. This is shown in figure 11. The green shaded areas correspond to periods during which German dissimilarity was lower than the average for the euro area as a whole, while the red areas show when the German dissimilarity measure exceeded that of the average euro area member state. Clearly from around 1985 until around 2001 the German dissimilarity measure was above that of the average for the euro area, with the exception of the period from roughly 1994 to 1996.

Probably a better way to show the differences between euro area member states and the

[8] These dates could be regarded as indicative of institutional structural breaks due to significant events in the timeline to European integration.

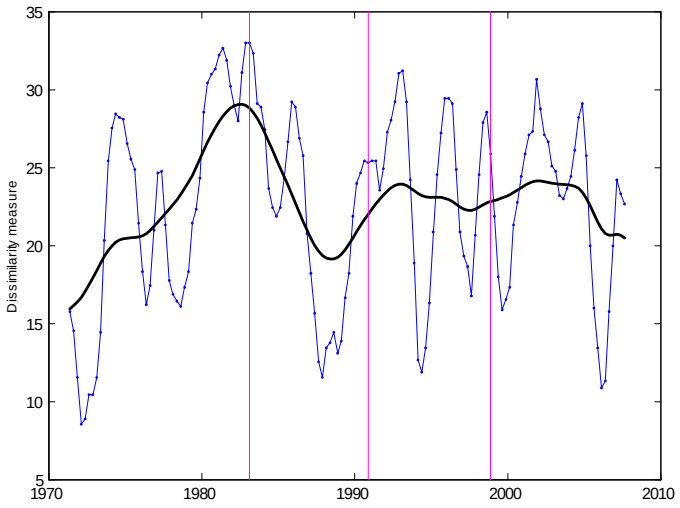

Figure 10: Averaged dissimilarity measure for euro area member states

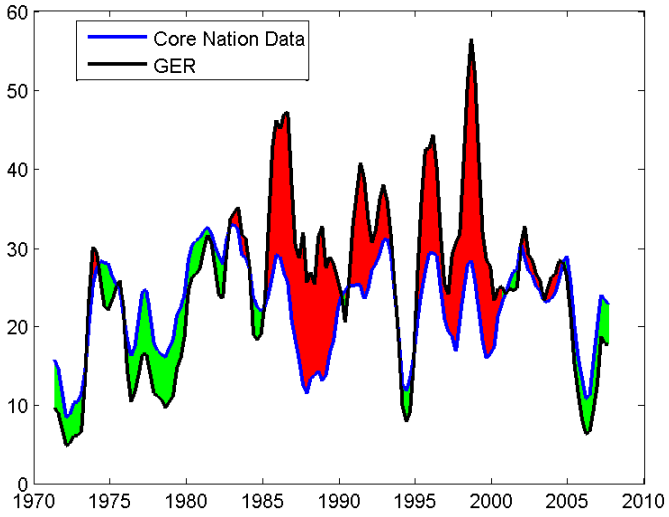

Figure 11: German growth synchronicity compared with euro area growth synchronicity

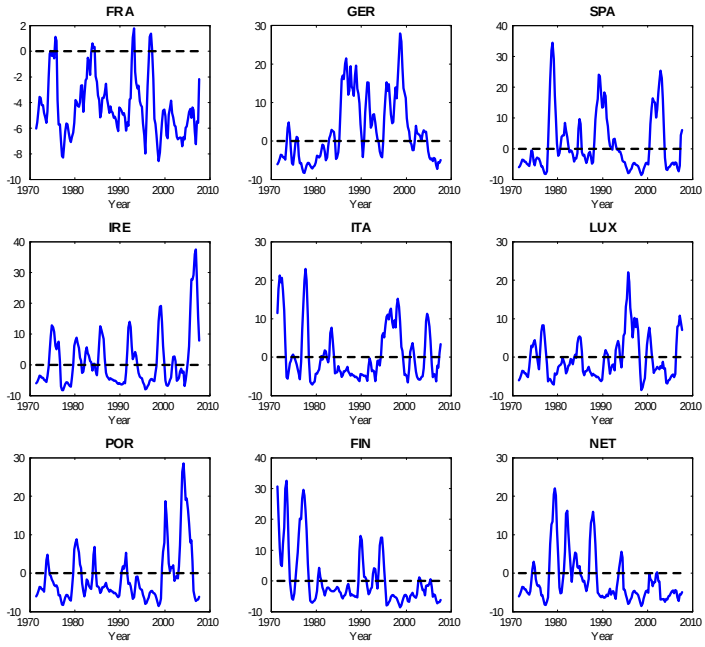

Figure 12: Individual member state dissimilarity with euro area member state average.

average is to difference these dissimilarity measures, and this is done for all euro area member states in figure 12 . Values above zero indicate greater dissimilarity than the euro area average while negative values indicate less dissimilarity than the euro area average. Clearly there are certain member states whose dissimilarity measure is fairly consistently less than the average for the euro area. Certainly France falls into this category, as does the Netherlands since about 1990 and Finland since around 1995. It is also notable that both Portugal and Ireland have recently been considerably above the average which indicates synchronicity appears not to be convergent in both these countries.

4.2 Non-euro area European member states/countries

The four non-euro area European member states/countries are now evaluated in the same manner. Figure 13 shows the epoch dissimilarity measure for the non-euro area European member states. Once again it is apparent that certain member states/countries seem to differ from the general synchronicity observed for the others. For example, most recently Denmark has clearly had much higher dissimilarity in dynamics than the other 3 member states/countries in this sub-sample. It is also noticeable that dissimilarities for the four were very similar from 1979 to 1983 and then again from 1993 through until about 2003.

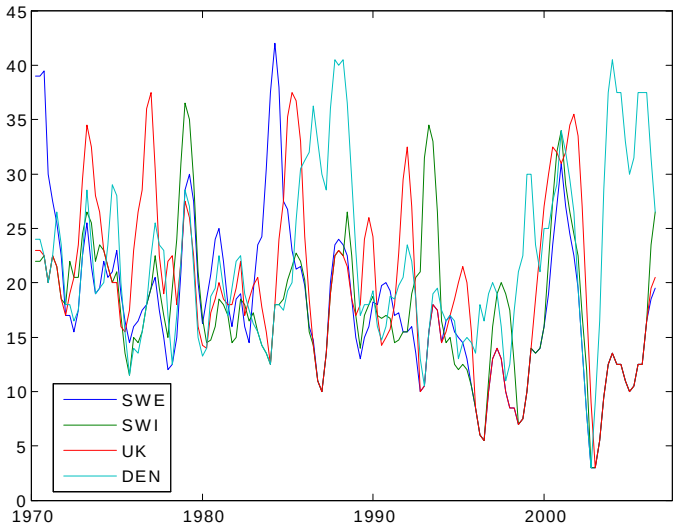

Figure 13: Within non-euro area dissimilarity index for individual member states

Figure 14 shows the average dissimilarity for these member states, some of which (Denmark and the UK) were members of the ERM of the EMS during the 1980s and into the early 1990s. In terms of business cycles, similar patterns are observed for the dissimilarity measures with respect to growth periods and recessions as for the euro area member states above. Interestingly the trend given by the 4 year moving average is towards more synchronicity during the 1970s, and then with the advent of the "new" EMS in 1983 less synchronicity occurred, but from around 1988 until 1997 there was a trend towards increased synchronicity among these countries. Since 1997 synchronicity has fallen, but still not to the levels seen in the 1970s. What is interesting in this figure is that there appears to be a wild swing in synchronicity from record non-synchronicity in around 2002 almost complete synchronicity among these member states in 2004. The reasons for this large change are not clear.

4.3 International countries

Lastly, we once again compare dissimilarity measures for all the countries in this subsample. Figure 15 shows that individual international country dissimilarities vary through time, with the same intermittency that was noted for nearly all the other data, although it is noticeable that much of the data was bunched from around 1985 through until about 2002. This implies that the international business cycle not only waxes and wanes in its effect on different countries but also varies through time.in its strength.

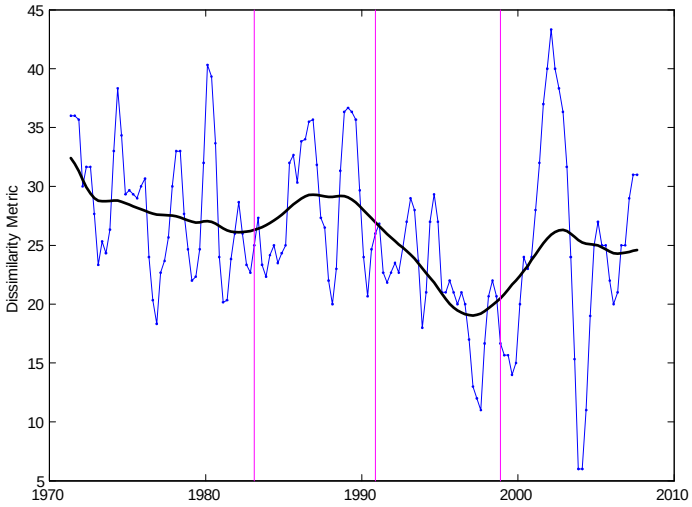

Figure 14: Averaged dissimilarity measure for non-euro area European member states

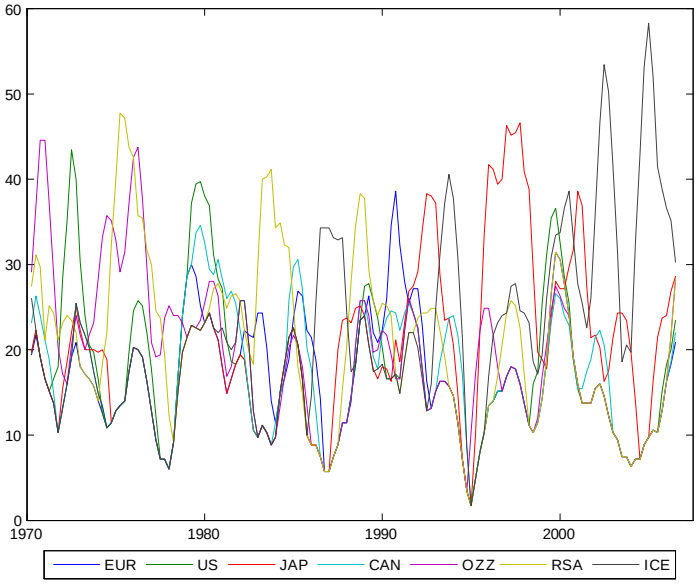

Figure 15: Within-international group dissimilarity index for individual countries

In figure 16 the average dissimilarity measure seems to generally fall going into recessions and increases in the recovery phase, and this is particularly notable in the recession of the late 1970s (the second oil price shock) and the recession of the early 1980s, but this pattern is not consistent across all recessions, with very little fall in dissimilarity in the recession of the early 1990s and in 2001 the dissimilarity metric appears to increase rather than to fall. For this group of international countries, the dissimilarity metric fell in the early 1970s and then has been intermittent since this time, with a notably large fall in dissimilarity in 1997, which here we correspond to an intermittent increase in synchronicity at this time. What is striking here is that the 4 year moving average suggests that synchronicity changes through time in a cyclical manner, with roughly a ten year cycle.

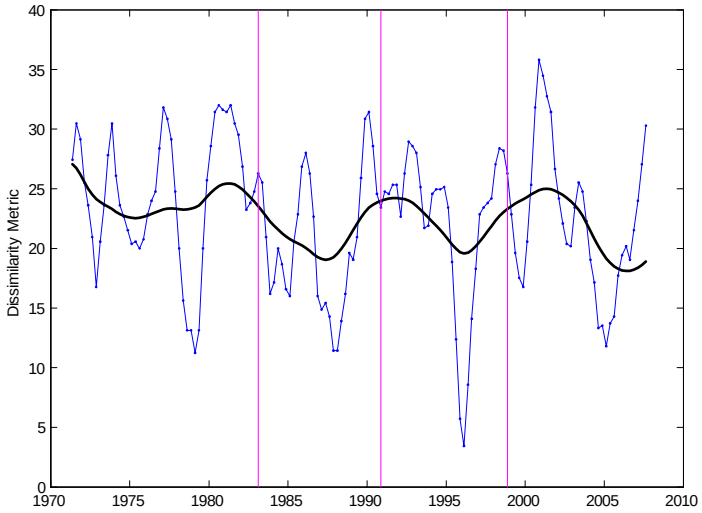

Figure 16: Averaged dissimilarity measure for International countries/entities

5 Results: Inter-group synchronicity

Given that we have obtained average dissimilarity measures for three different groups of member states/countries, it is now possible to compare these measures and thereby infer which groups have had higher levels of synchronicity over given time periods. The first exercise evaluates whether monetary union in the form of the inception of the euro has caused greater synchronization among its members compared with the rest of Europe.

5.1 Euro area vs non-euro area European member states

Figure 17 shows the difference between the dissimilarity metrics for the euro area and the non-euro area European member states. The black line plots the dissimmilarity metric for the euro area and the blue line is that of the non-euro area member states, while green areas represents periods when euro area synchronicity is greater than non-euro area member state synchronicity, while red areas signify greater synchronicity for non-euro area member states. Clearly efforts in the 1970s to coordinate exchange rates and other European economic initiatives led to higher levels of synchronicity for euro area member states. This reversed in the early 1980s but then from the advent of the "new" EMS in 1983 the euro area member states had greater synchronicity. The period from 1990 to 1993 saw slightly less synchronization in the euro area, and then there is a short period of greater synchronicity in 1994. What is somewhat surprising here is that from 1995 to 2000 there is clearly greater synchronicity in the non-euro area member states. This might be due to the efforts that all member states made to economically converge once it was clear that EMU would occur. Apart from a short period from around 2003-2005, euro area member states appear to have been more synchronous in the post-1999 era.

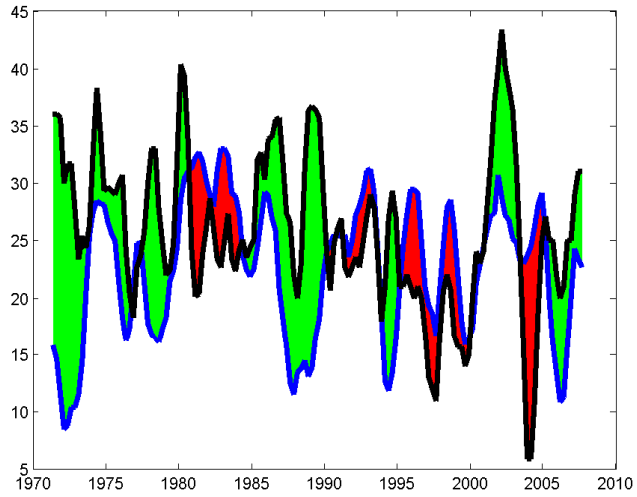

Figure 17: Comparison of dissimilarity measure for the euro area and other non-euro area European member states

Figure 18 which just looks at the moving average measures mostly reflects the patterns noted above. In the 1970s and early 1980s it is clear that euro area member states were more synchronous than non-euro area member states, but the advent of the early years of the ERM of the EMS clearly reversed this leading to a period up until roughly 1985 when non-euro area member states were

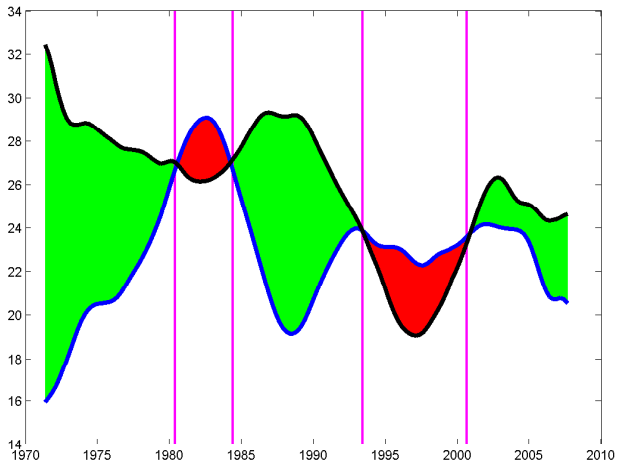

Figure 18: Comparison of dissimilarity measure moving average for the euro area and non-euro area member states

more synchronous, but then from about 1983 (the "new" EMS) there was a downward trend in synchronicity for the euro area member states leading to a period following 1985 when euro area member states were once again more synchronous than non-euro area member states. This began to reverse again in 1990 leading to the ERM crisis in 1993 when once again the non-euro member states became more synchronous, but then another turning point can be detected in 1997 after which euro area member states started becoming rapidly more synchronous, and then from the end of 2000 euro area member states became more synchronous and this trend has continued through until the mid-point of the moving average in 2006.

5.2 Euro area vs international

In figure 19 the patterns are much more complex than for the simple comparison of the euro area and the other member states. It is interesting that for much of the 1980s the patterns of growth for the international grouping and the euro area member states were remarkably similar.

Here the 4 year moving average clearly helps in understanding the trends at work in synchronicity. Figure 20 shows the overall trends at work and it is clear that in the 1970s the euro area member states were more synchronous than the international grouping, but that from 1979 through 1987 the international grouping was more synchronous. From around 1998 through 1993 the European grouping is slightly more synchronous but then this again reverses for the run up to the launch of the euro in 1999. What is interesting here is that in the early years of the euro clearly there were more synchronous dynamics in euro area member states than there were

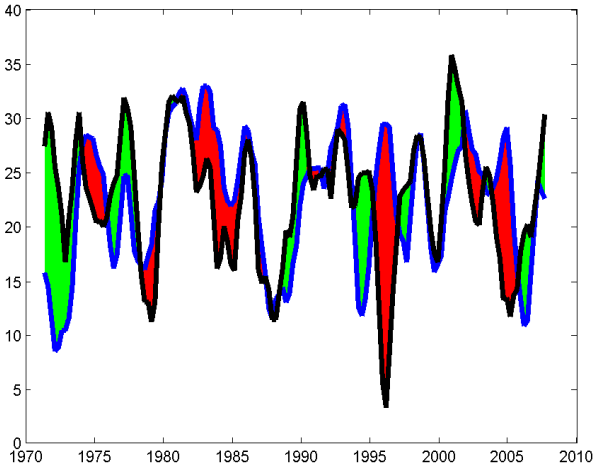

Figure 19: Comparison of dissimilarity measure for the euro area and international countries/entities

internationally, but that from around mid-2003 this trend has reversed, with the international grouping more synchronous than the euro area grouping.

5.3 Non-euro area Europe vs international

In figure 21 the comparison is made between the non-euro area member states and the international grouping. It is clear once again that the international grouping appears to be more synchronous throughout most of the data span which tends to suggest that the non-euro area member states are no more synchronous than any random grouping of international countries.

In figure 22 the moving average version of the difference between the non-euro area member states and the international grouping gives a little more insight into the trends at work in the data. There is only one sustained period when synchronicity was either at the same level or higher in non-euro area member states, and this was from 1992 through until around 2002. In all other periods the international grouping had lower average synchronicity than the European grouping.

5.4 Robustness check

One of the surprising results of using dissimilarity measures is that it suggests that during the implementation of European Union integration projects there appears to be a greater propensity for growth rates to be more synchronized than at other times. If so, this obviously has important public policy implications, so as a robustness check a weighted average synchronicity measure for the euro area was constructed. The weighted average dissimilarity measure for the euro area as

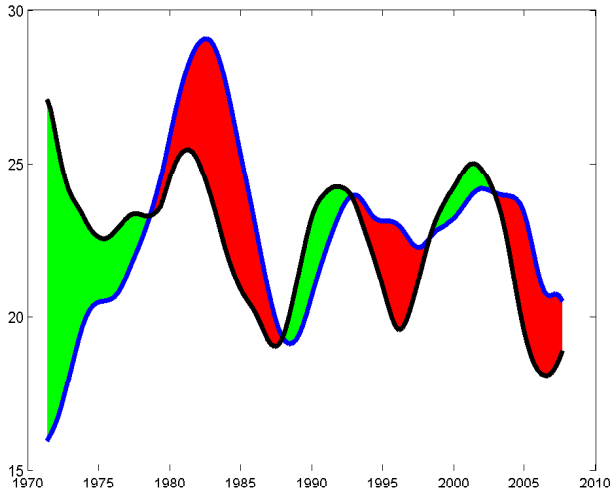

Figure 20: Comparison of dissimilarity measure moving average for the euro area and international countries/entities

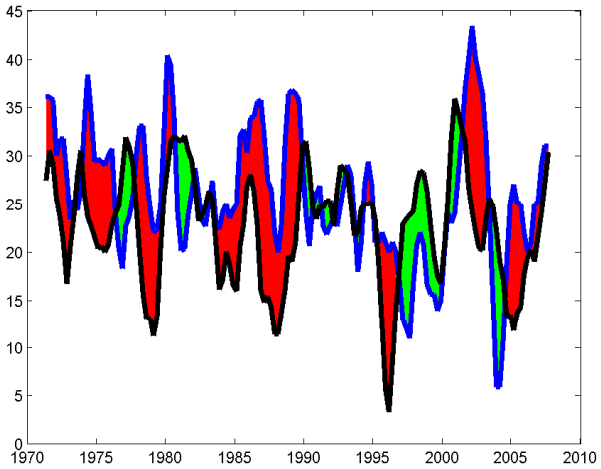

Figure 21: Comparison of dissimilarity measure for the outlying Europe and international countries/entities

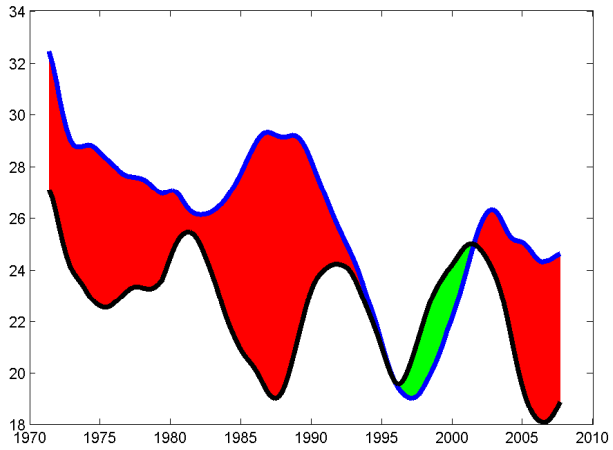

Figure 22: Comparison of dissimilarity measure moving average for outlying Europe and international countries/entities

a whole uses time-varying real GDP weights to compare the unweighted average measure against the weighted average measure - this is shown in figure 23. Clearly there is not a lot of difference between the two measures, particularly in recent years. Obviously from around 1998 to 2004 the unweighted measure appears to be lower than the weighted measure, so in figure 12 the differences are likely biased upwards (likely due to Germany), but in general the pattern of the averages are very similar.

6 Conclusions

The usual interpretation given by economists to the concept of "synchronization" between growth and business cycles relates to the pattern of growth between these countries rather than the magnitude of growth rates or the amplitude of the growth or business cycles. In this paper a dissimilarity measure was constructed to account for differences in the patterns of quarterly growth rates between three different groups of member states/countries so as to proxy the dynamic of these growth and business cycles. The expectation was that there would be more similarity between growth and business cycles for euro area member states, particularly after the launch of the euro and establishment of the ECB in 1999.

The main empirical result is that there are certain periods of time when growth rate synchronicity increased and these appear to be during the "new" EMS period after 1983 up until roughly 1990, and then again from 1997 through until 2002. After 2002 synchronicity is only higher against the non-euro area European member states, and does not appear to be more synchronous than the

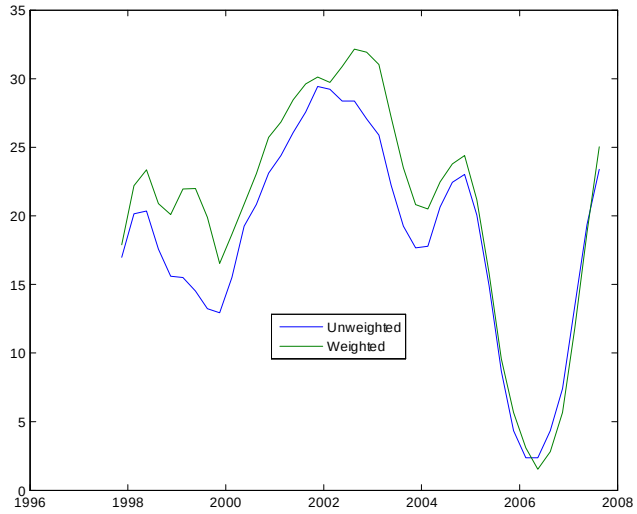

Figure 23: Unweighted average and weighted average dissimilarity measures for the euro area

international grouping of countries/entities. The corollary of this is that international business cycles, due to globalization, had a bigger impact than regional factors such as monetary union for most of the period, with only these two exceptions. These results mirror those of Hughes Hallett and Richter (2006), but here we are able to specify the occasions during which regional factors causing greater growth synchronicity tend to dominate factors stemming from the international business cycle.

A secondary and important result of this paper relates to a new stylized fact relating to the phenomenon of synchronization. There appears to be "intermittency" in synchronization of business and growth cycles between member states and countries. This intermittency does not appear to have any fixed cyclical properties, but varies according to the group of different member states/countries considered. This is shown by the wave-like fluctuations observed in synchronization of growth rates between countries, and in the averages of these measures as well.

There is clearly a considerable amount of future research which is prompted by these findings. First, the groups of member states/countries are relatively small, so perhaps shortening the data set so as to include more member states/countries would lead to more generally robusts results (- and this is particularly the case for the non-euro area groupings). Second it would be informative in the case of the euro area itself to construct a real GDP weighted average so that smaller member states such as Luxembourg, which are clearly relatvely unimportant in determining overall euro area synchronicity, do not possess the same relative importance as a country such as Germany,

whose GDP makes up just less than a fifth of total GDP. Third, more research is clearly needed to understand the nature of the "intermittency" in synchronization of business and growth cycles and it's causes.

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