EC331
Research in Applied Economics

An Empirical Investigation into Cyclical Convergence in, and around, the eurozone

Abstract

In 2003, HM Treasury found that UK cyclical convergence is insufficient for joining the eurozone. The results in this paper show that the UK had in fact converged on the eurozone business cycle by 2000, albeit with a lead of one year. The eurozone itself has also shown marked convergence since 1990 while the results for the new EU members are less promising, with some countries showing little synchronisation with the eurozone business cycle. Comparisons drawn with the USA show that the level of convergence in much of the EU may exceed that necessary for monetary union, raising the issue of the importance of convergence.

Contents

1. Introduction

In 1997, Gordon Brown set out five tests to determine the readiness of the UK for joining monetary union in Europe. This paper aims to analyse the first of these tests, which is as follows:

"Are business cycles and economic structures compatible so that we and others could live comfortably with euro interest rates on a permanent basis?" [1]

This focus is based on the Treasury's (1997) assertion that "the need for the UK economy to come together with the eurozone economy" is the "'touchstone' towards a successful single currency"[2]. More specifically this paper's focus is on the business cycle component of the first test and updates the UK's current position in comparison to the United States of America and the rest of the European Union.

In theory business cycle convergence or synchronisation matters as it means that shocks are more symmetric across synchronised nations and the less asymmetric shocks are, the more applicable is a 'single monetary policy'[3], and hence monetary union. Divergence may arise from many factors, among which variations in industrial structures have been found to be particularly important in the USA.[4] This leads to the conclusion that the "costs of Monetary Union will be lower between regions or countries that share a similar economic structure and are affected by similar economic shocks."[5] Whether shocks are asymmetric or economic structures are different in the eurozone, are questions yet unanswered but are not within the scope of this paper.

Additionally, Corsetti, Pesenti and Blinder (1999) find that the ECB aims to set monetary policy with as little consideration for cyclicality as possible[6], possibly making the cyclical convergence condition of higher importance still as were the UK

[1] HM Treasury. (1997). *UK Membership of the Single Currency: An Assessment of the Five Economic Tests,* p9
[2] BBC News, *The UK's five tests*, 21st Nov 2002 http://news.bbc.co.uk/1/hi/uk_politics/2423783.stm
[3] HM Treasury. (2003). *The United States as a Monetary Union*, p11
[4] HM Treasury. (2003). *The United States as a Monetary Union*, p24
[5] HM Treasury. (2003). *The United States as a Monetary Union*, p11
[6] Corsetti, Giancarlo; Paolo Pesenti; Alan S. Blinder, (1999) "Stability, Asymmetry, and Discontinuity: The Launch of European Monetary Union." *Brookings Papers on Economic Activity*, Vol. 1999, No. 2, p303

to join when diverged, there would not be sympathetic monetary policy adjustments and inflation or a slump may follow.

This paper begins by describing a selection of literature relating to business cycles and discusses its relevance in determining an appropriate measure of business cycle synchronisation. Next, I discuss past convergence studies and the theory behind convergence, while section 3 outlines the data and its sources. I base comparisons of cyclical synchronisation between the regions under study and the eurozone on a similar analytical and theoretical framework, described in section 4. Measures of cyclical convergence and synchronisation are then calculated and analysed in Section 5. The paper finishes with conclusions as to whether convergence has occurred in and around the eurozone and, with the aid of the analysis of US business cycle synchronisation, whether this actually matters.

2. Theory and Empirical Ideas

The problem arising from testing business cycle synchronisation is firstly if there has been correlation over an extended period, as implied by sustained synchronisation, while testing for convergence requires an increase in synchronisation over time. Artis (2003)[7] discusses how to evaluate the level of cyclical convergence between countries by separating data into cyclical, trend and shock components with filters, such as the Baxter-King[8] filter, which directly identifies the cyclical component and the Hodrick-Prescott filter[9], which does the same but is more readily available. PricewaterhouseCoopers (2000) measure overall convergence with a composite measure of real variables, including GDP growth and productivity, and nominal Maastricht criteria, including inflation and exchange rates, finding that convergence has increased, although this method may be over-complicated for measuring business cycle convergence. Artis (2003) concludes that GDP is the most inclusive measure of economic performance and so best for determining convergence, incorporating any

[7] Artis, M. (2003) *Analysis of European and UK business cycles and shocks*. HM Treasury, p10-11
[8] Baxter, A. & King, R. (1999) ‘Measuring business cycles: approximate band-pass filters for economic time series’, *Review of Economics and Statistics*, 81(4), November: pp. 575-93; NBER Working Papers, 5022
[9] Hodrick, Robert J. & Edward C. Prescott. (1997). "Postwar U.S. Business Cycles: An Empirical Investigation," *Journal of Money, Credit, and Banking* 29 (1), February, pp. 1-16.

shocks to the economies under study, negating the requirement for separate analysis[10]. Artis compares GDP cycles using cross-country correlations, as does Belo (2001) although Belo extends this with Concordance and Spearman's Rank correlation coefficients. These additional measures, however, are "remarkably consistent across the different methods"[11] and so are not incorporated in this study.

Furthermore, Artis (2003) analyses whether the UK is idiosyncratic in her reactions to monetary policy and whether cyclical economic indicators behave differently from elsewhere[12]. Findings include larger business cycle fluctuations in the UK than the eurozone being more similar to the USA so the UK may never converge durably with the eurozone. Corsetti, Pesenti and Blinder (1999) touch on the UK idiosyncrasy explain this by a more vigorous UK reaction to monetary policy than the eurozone, in part due to high indebtedness ratios of 100% liabilities to disposable income.[13]

Artis (2003) also raises the problems of sufficiency[14], where the UK government has set no value for sufficient convergence, and endogeneity[15], where any economy is likely to undergo a structural break when joining a monetary union, rendering any previous analysis redundant. Corsetti, Pesenti and Blinder (1999) also find that the common currency may cause convergence, although this financial convergence may not lead to real convergence. In fact, a single market could foster specialisation, enhancing asymmetry and even leading to offsetting shocks.[16] There is however, some tenuous evidence towards increasing convergence since monetary union in the USA as well as catchup by poorer, more peripheral states[17]. This implies that the UK may simply converge post-union, negating the requirement for convergence.

[10] HM Treasury. (2003). *The United States as a Monetary Union*, p11
[11] Belo, F (2001) *Some facts about the cyclical convergence in the eurozone*, Banco de Portugal: Economic Research Department, September, p6
[12] Artis, M. (2003) *Analysis of European and UK business cycles and shocks*. HM Treasury. p.19-20
[13] Corsetti, Giancarlo; Paolo Pesenti; Alan S. Blinder, (1999) "Stability, Asymmetry, and Discontinuity: The Launch of European Monetary Union." *Brookings Papers on Economic Activity*, Vol. 1999, No. 2, p347
[14] Artis, M. (2003) *Analysis of European and UK business cycles and shocks*. HM Treasury. P25-26
[15] Artis, M. (2003) *Analysis of European and UK business cycles and shocks*. HM Treasury. P27-28
[16] Corsetti, Giancarlo; Paolo Pesenti; Alan S. Blinder, (1999) "Stability, Asymmetry, and Discontinuity: The Launch of European Monetary Union." *Brookings Papers on Economic Activity*, Vol. 1999, No. 2, 346-351
[17] HM Treasury. (2003). *The United States as a Monetary Union*, p23-24

Denny (2003) discusses the negative impacts of joining monetary union without synchronisation of business cycles, including permanent damage to the real economy arising from excessive interest rates, with 'losses of trade opportunities,'[18] or an inflationary boom were interest rates too low, damaging competitiveness. Deflationary policy would then be required, resulting in unemployment and economic stagnation. While the United States are still not perfectly convergent[19] there is no sign of political tension resulting from this, questioning whether convergence has a negative impact. In this vein, Lilico (1999) concludes that while the UK was divergent from euroland, this may be beneficial, as some countries can act as automatic stabilisers for others at the opposite points on their business cycles, cushioning slumps and booms. He therefore states that while insufficient convergence results in central monetary policy being inappropriate, if the UK joins the eurozone when highly synchronised, it may magnify business cycles.

The Treasury's (2003) assessment of the five tests concludes that convergence was insufficient for adoption the Euro at the time of writing but they do not indicate the level of convergence required. Denny (2003) and Artis (2003) also conclude that the UK was not sufficiently converged to the eurozone to live with the European Central Bank's interest rates. The Treasury (2003) compares the union of the USA with the eurozone and finds that there are similarities in regional variation of economic indicators but that differences in policy render some comparisons useless. Policy in the USA has evolved to deal with problems rather than 'according to an ex-ante design'[20] as in the eurozone, making comparison of the two unions difficult. However, some comparison with the USA is useful in this paper due to the successful and durable nature of the United States' monetary union. The Treasury (2003) has also identified that there may be a converged core surrounded by idiosyncratic states in the USA, bearing a resemblance to the European Union, with a possible core in Western Europe and peripheral countries in the East[21], which facilitates comparison.

This paper follows Artis' (2003) and Belo's (2001) examples in many ways, using GDP measures, the Hodrick-Prescott filter and correlation coefficients to compare

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[18] Denny, (2003) "Special report: Britain and the euro. Test 1: convergence." *The Guardian* June 10th
[19] HM Treasury. (2003). *The United States as a Monetary Union*, p24
[20] *"The United States as a Monetary Union"* 2003, HM Treasury, , p4
[21] Artis, M. (2003) *Analysis of European and UK business cycles and shocks*. HM Treasury. P21-23

business cycles. Dabrowski and Rostowski (2002) discuss Eastern European convergence, as do Sonje and Vrbanc (2000) in much more detail, but not in the framework used for this paper. By using GDP, available for all of the nations under study, it should be possible to study synchronisation and convergence for those with longer time series, and to compare the results.

3. Data Description

a. Sources

All the data pertaining to the EU-25 nations[22] is collected from the Penn World Table[23] using Real $ Gross Domestic Product (GDP) per capita in chained[24], 1996 prices. Data on the EU-10 is lacking prior to 1990, most likely due to political and structural changes in this period, but is sufficient post-1990. US Gross State Product (GSP) is from the Bureau of Economic Analysis (BEA) Regional Economic Accounts[25]. US real $ GSP in chained 2000 prices, and $ GSP in current dollars are divided by state populations to obtain per capita measures of both although real GSP data has only been available in the USA since 1990, so the nominal measure is used in this paper. Although the BEA warns of a change in measurement processes from 1997 to 1998,[26] the two sets of data are appended to provide a complete data set. Neither problem should affect the results adversely, as comparisons are inter-state in

[22] See Table (1): European Regional Classification

[23] Heston, A. Robert Summers and Bettina Aten, Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002, http://pwt.econ.upenn.edu/php_site/pwt61_form.php

[24] Real chained $ estimates derived from Fisher index, the geometric mean of Laspeyeres and Paasche Indices. Laspeyres derives real prices for 2 years using prices in the first year to weight both, Paasche using the second year. Chained fisher quantity indicies derived from fisher index multiplied by previous year's index with a base year value of 100 to give the percentage increased in real production relative to the base year. Divide this index by 100 and current dollar value of base year to obtain real chained $ estimate. This involves lower substitution bias than previous methods of calculating real values as it allows for changes in relative prices and product compositions. For more information, see http://www.bea.doc.gov/bea/regional/gsp/OnlineHelp.chm

[25] http://www.bea.doc.gov/bea/regional/gsp/default.cfm

[26] 'There is a discontinuity in the GSP time series between 1997 and 1998, occurring at the change from SIC industry definitions to NAICS industry definitions. This discontinuity results from many sources, including differences in source data and different estimation methodologies. In addition, the NAICS-based GSP estimates are consistent with U.S. gross domestic product (GDP) while the SIC-based GSP estimates are consistent with U.S. gross domestic income (GDI). This data discontinuity may affect both the levels and the growth rates of the GSP estimates. Users of the GSP estimates are strongly cautioned against appending the two data series in an attempt to construct a single time series of GSP estimates for 1977 to 2003.' from http://www.bea.doc.gov/bea/regional/gsp/default.cfm

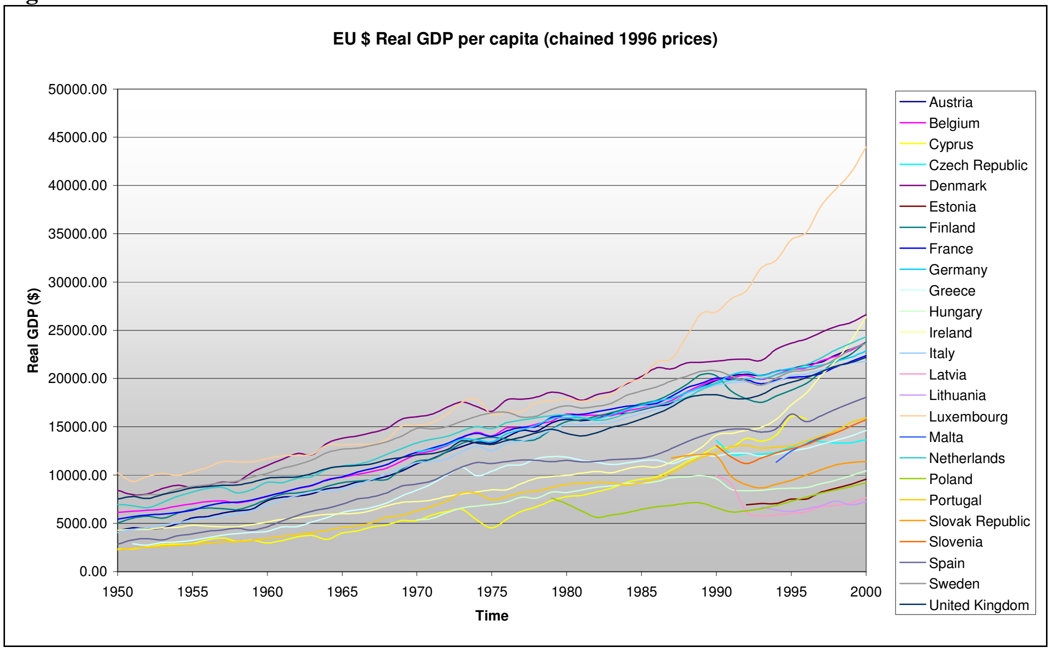
consecutive periods so each set of observations is affected in the same way by any irregularities, allowing some comparison of relative changes.

b. The European Union

Figure (1) summarises the path of $ real GDP per capita for each of the 25 nations under study. Over the period 1950 to 2000, there is a clear upward trend in GDP in every state although most Eastern European nations, including Lithuania, Latvia and Slovenia, have suffered from a fall in GDP circa 1994. There is also clear variation around this upward trend, most likely due to business cycles, as yearly data should exclude seasonal effects.

There are several nations with anomalous GDP growth paths including Luxembourg, which seems to have an abnormally high level of real GDP per capita, diverging from most other nations after 1985. Ireland has experienced a similar trend in real GDP levels, starting below most other European states in 1950, growing strongly after 1990 and reaching levels only equalled by Denmark and exceeded by Luxembourg. Eastern Europe seems to lag significantly behind the European leaders with Lithuania, Latvia and Poland showing particularly low levels of real GDP although they all exhibit growth by 1995. Greece, Portugal, Spain and Cyprus all show lower GDP levels than their counterparts in Western Europe although their growth seems to follow a very similar pattern since 1995. In fact, excluding Ireland and Luxembourg, it is clear that there has been synchronisation of GDP changes in most of the EU-25.

Figure 1



c. The United States of America

Figure (2) shows real GSP per capita in chained 2000 prices and the short time period available is clearly inadequate as there is insufficient time for a trend to become clear. There is, however, some evidence of synchronisation in GSP between states with a clear rise and then fall in GDP in 1990 / 91 with the beginning of another fall in 2001 / 02. However, this is most likely due to start and end-point distortion from the Hodrick-Prescott filter[27]. In absolute terms, the District of Columbia has a significantly higher level of real GDP then any of the other states, while the others are grouped more closely.

Due to the lack of data for real GSP prior to 1990 this analysis uses nominal GSP measures, illustrated in figure (3). This measure demonstrates a far clearer GDP growth trend over time, with most states close in terms of GSP per capita, but with some divergence. The District of Columbia has a far higher GSP than the other states after the early 1980s while Alaska had a very high GSP in the early 1980s, coming more into line with the rest of the US states in the 1990s. This variation may well be

[27] See Section (4): Empirical Methodology

to do with Alaska's industrial structure and the oil industry and may explain Alaska's divergence from the USA's cyclical path seen below.

The pattern shown by the real GDP measure with a slump setting in, in 2001 / 02, and an increase in GDP around 1990 is not reflected in nominal GDP, demonstrating the weakness of the Hodrick-Prescott filter, particularly over short periods.

Figure 2

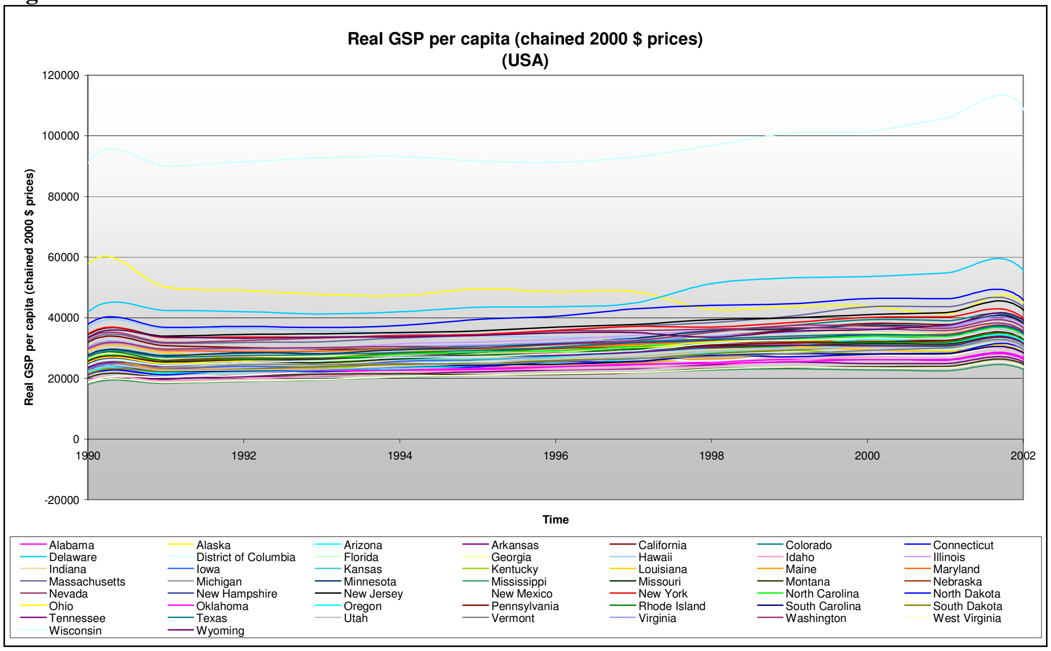
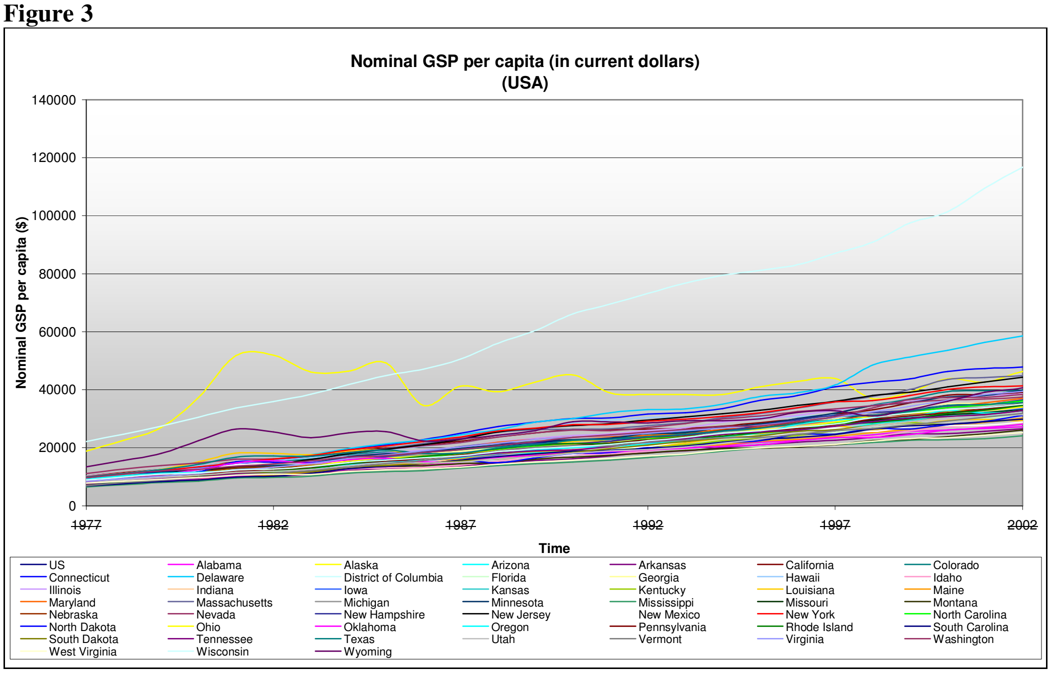


Figure 3



4. Empirical Methodology

a. Theory

My analysis hinges on Lucas'[28] assumption that business cycles can be measured as deviations of aggregate real output from trend. The Hodrick-Prescott filter[29] is used to calculate these deviations, working on the assumption that a variable such as GDP, which can be used to illustrate business cycles, is composed of a growth and a cyclical component. Equation (1) demonstrates this, where y_t is the dependent variable (GDP per capita in this case), g_t is the growth component and c_t is the cyclical component.

Under the assumption that 'growth varies smoothly over time'[30] Hodrick and Prescott measure the smoothness of the g_t path using the sum of the squares of its second difference. The analysis assumes that the average of c_t, deviation from a smooth g_t path, is zero over a long period, which leads to the programming problem for calculating the growth component, given in equation (2).

Equation 1

$$y_t = g_t + c_t \qquad for(t = 1,...,T)$$

Equation 2

$$\underset{\{g_t\}_{t=-1}^{T}}{Min}\{\sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2\}$$

Hence, the cyclical component is equal to the dependent variable minus the growth component. λ is the smoothing variable, penalising variability in the growth series and is usually around 100 for annual data[31], higher for quarterly and monthly data, as they

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[28] Lucas, Robert E. Jr (1977) "Understanding Business Cycles" *Carnegie-Rochester Conference Series on Public Policy,* 5, p7-29 from Belo, F (2001) *Some facts about the cyclical convergence in the eurozone*, Banco de Portugal: Economic Research Department, September

[29] Microsoft Excel plugin from Yvan Lengwiler's website: http://www.wwz.unibas.ch/witheo/yvan based on Robert J. Hodrick and Edward C. Prescott, "Postwar U.S. Business Cycles: An Empirical Investigation," *Journal of Money, Credit, and Banking* 29 (1), February 1997, p. 1-16

[30] Robert J. Hodrick and Edward C. Prescott, "Postwar U.S. Business Cycles: An Empirical Investigation," *Journal of Money, Credit, and Banking* 29 (1), February 1997, p3

[31] Belo, F (2001) *Some facts about the cyclical convergence in the eurozone*, Banco de Portugal: Economic Research Department, September, p3

tend to be more variable. Therefore, the second term determines the degree of smoothness of the function, while the first stops excessive deviations.

This Hodrick- Prescott filter has a number of limitations, most importantly start- and end-point distortion. Due to the filter's two-sided nature, the lack of both high and low values at the start and end of the period under study, results for the end-point are likely to be less reliable. In addition, the filter is thought[32] to smooth structural breaks, particularly relevant here, where there may be a break on joining the Euro, although there is no consensus on this view. Despite these limitations, Baxter and King (1999) find that the filter is a good approximation to the 'ideal filter' and as such, can be used with some confidence.

To measure business cycle synchronisation, and then convergence, correlation coefficients are used, due to the measure's scale free nature, to analyse relative changes in GDP. Correlation is measured by equation (3) and (4), where X_i and Y_i are the measures of cyclical disturbance and $\overline{X}$ and $\overline{Y}$ are the averages of each over time. V(X) and V (Y) denote the variances of X and Y.

Equation 3

$$Correl(X,Y) = \frac{\text{cov}(X,Y)}{\sqrt{V(X)V(Y)}}$$

Where:

Equation 4

$$Cov(X,Y) = \frac{\sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{n-1}$$

b. Application

To assess convergence and synchronisation in the EU-25 nations, the Hodrick-Prescott filter is applied to time series for each nation as well as to averages for each of the regions (Table 1). Analysis of correlations between each region, its component

[32] Belo, F (2001) *Some facts about the cyclical convergence in the eurozone*, Banco de Portugal: Economic Research Department, September, p4

nations and the eurozone[33] is carried out with correlation matrices. As well as dividing the results geographically, the sample is split pre-1990 and post-1990 where the cut-off point indicates the beginning, in July 1990, of the European Exchange Rate Mechanism (ERM). This was the first of three steps towards monetary union[34] and hence the beginning of cooperation proper between European monetary institutions.

The United States GSP figures are also filtered to determine cyclical deviations from trend and then tested for correlation. The results are grouped into data for the various Economic Regions of the USA (Table 2) while the component states are also analysed to test for intra-regional synchronisation. These regions are 'based on the homogeneity of the states in terms of economic characteristics, such as the industrial composition of the labour force, and in terms of demographic, social, and cultural characteristics'[35] as well as their geographic location, demonstrated in figure (4). This should lead to similar intra-regional business cycles, if it were an important consideration for monetary union.

[33] In the correlation matrices, values above 0.8 are coloured red to signify extremely high correlations. 0.5 to 0.8 are coloured blue to indicate some correlation. From zero to 0.5, the cell is white, little correlation, and values below -0.5 are coloured yellow to indicate some negative correlation.
[34] Committee of European Central Bankers (1989) 'The Delors Report.' From A. and A. Cowgill (2001) *Economic and Monetary Union.* British Management Data Foundation www.bmdf.co.uk
[35] BEA Regional Economic Accounts at: http://www.bea.gov/bea/regional/definitions/nextpage.cfm?key=BEA%20regions

Table 1

EU-25[1]	*EU-15*[2]	*Euro Zone*[3]	*Non-Euro*[4]	*EU-10*[5]	*Potential Entrants*[6]	*Later Entrants*[7]
Greece	Greece	Greece	Sweden	Estonia	Estonia	Cyprus
Germany	Germany	Germany	Denmark	Lithuania	Lithuania	Poland
France	France	France	United Kingdom	Slovenia	Slovenia	Malta
Italy	Italy	Italy		Cyprus		Latvia
Spain	Spain	Spain		Poland		Slovak Republic
Netherlands	Netherlands	Netherlands		Malta		Hungary
Belgium	Belgium	Belgium		Latvia		Czech Republic
Austria	Austria	Austria		Slovak Republic		
Portugal	Portugal	Portugal		Hungary		
Finland	Finland	Finland		Czech Republic		
Ireland	Ireland	Ireland				
Luxembourg	Luxembourg	Luxembourg				
Estonia	Sweden					
Lithuania	Denmark					
Slovenia	United Kingdom					
Cyprus						
Poland						
Malta						
Latvia						
Slovak Republic						
Hungary						
Czech Republic						
Sweden						
Denmark						
United Kingdom						

[1] EU-25 summarises all of the members of the enlarged European Union.
[2] EU-15 summarises all of the members of the old European Union.
[3] Euro Zone includes all members of the current European Monetary Union.
[4] Non-Euro are the nations who decided not to join the Euro but were members of the old European union.
[5] EU-10 summarises all the new EU members. Together with the EU-15 they make up the enlarged EU.
[6] Potential Entrants are the 3 Eastern European nations set to join the Euro Zone in 2007 (http://www.euractiv.com/Article?tcmuri=tcm:29-129655-16&type=Overview).
[7] Later Entrants are the further seven nations of the EU-10 hoping to join the Euro at a later date (Cyprus in 2007 although not yet ERM II; Poland in 2007 although excessive budget deficit; Malta in 2008; Latvia after 2008; Slovak Republic in 2009; Hungary in 2010 and the Czech Republic in 2010. From http://www.euractiv.com/Article?tcmuri=tcm:29-129655-16&type=Overview).

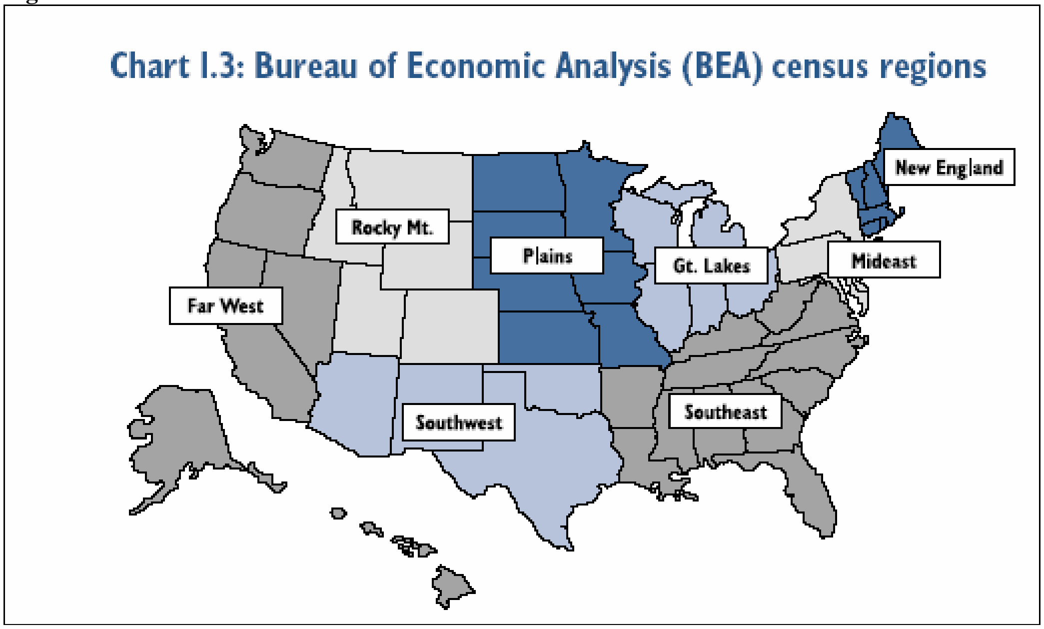
Table 2

New England Region	*Mideast Region*	*Great Lakes Region*	*Plains Region*	*Southeast Region*
Connecticut	Delaware	Illinois	Iowa	Alabama
Maine	District of Columbia	Indiana	Kansas	Arkansas
Massachusetts	Maryland	Michigan	Minnesota	Florida
New Hampshire	New Jersey	Ohio	Missouri	Georgia
Rhode Island	New York	Wisconsin	Nebraska	Kentucky
Vermont	Pennsylvania		North Dakota	Louisiana
			South Dakota	Mississippi
				North Carolina
				South Carolina
				Tennessee
				Virginia
				West Virginia

Southwest Region	*Rocky Mountain Region*	*Far West Region*
Arizona	Colorado	Alaska
New Mexico	Idaho	California
Oklahoma	Montana	Hawaii
Texas	Utah	Nevada
	Wyoming	Oregon
		Washington

Source: Bureau of Economic Analysis, http://www.bea.gov/bea/regional/docs/regions.asp

Figure 4



Source: Bureau of Economic Analysis (2003) from HM Treasury. (2003). "The United States as a Monetary Union." http://www.hm-treasury.gov.uk/documents/the_euro

5. Empirical Results and Analysis

a. The European Union

Graphically, it appears that there has been a clear increase in convergence in the EU, with regional business cycles moving very closely in the various from 1995 onwards. Figure (5) demonstrates this association, with each region peaking around 1990 and then recovering in the mid-1990s. Earlier movements had been far less co-ordinated than this although some similarities exist, particularly between the non-euro and eurozone regions.

The Later Entrants Region appears to be the most divergent from the eurozone average along with the non-euro nations up until eurozone recovery around 1996, when synchronisation increases markedly. Table (3) further highlights the degree of synchronisation between regions in the European Union: from 1950-2000, there is fairly convincing evidence that the regions move in a similar manner, with no correlation coefficients below 0.56. This can be broken down into pre-1990 and post-1990 correlations, where it is clear that synchronisation is far higher in the latter period with correlations above 0.682 for all regions with the eurozone. This result is promising for the non-euro nations, but is less so for the potential entrants hoping to join in 2007, as they appear to be the least suitable of all the regions to join the Euro although this level of synchronisation may be sufficient.

Figure 5

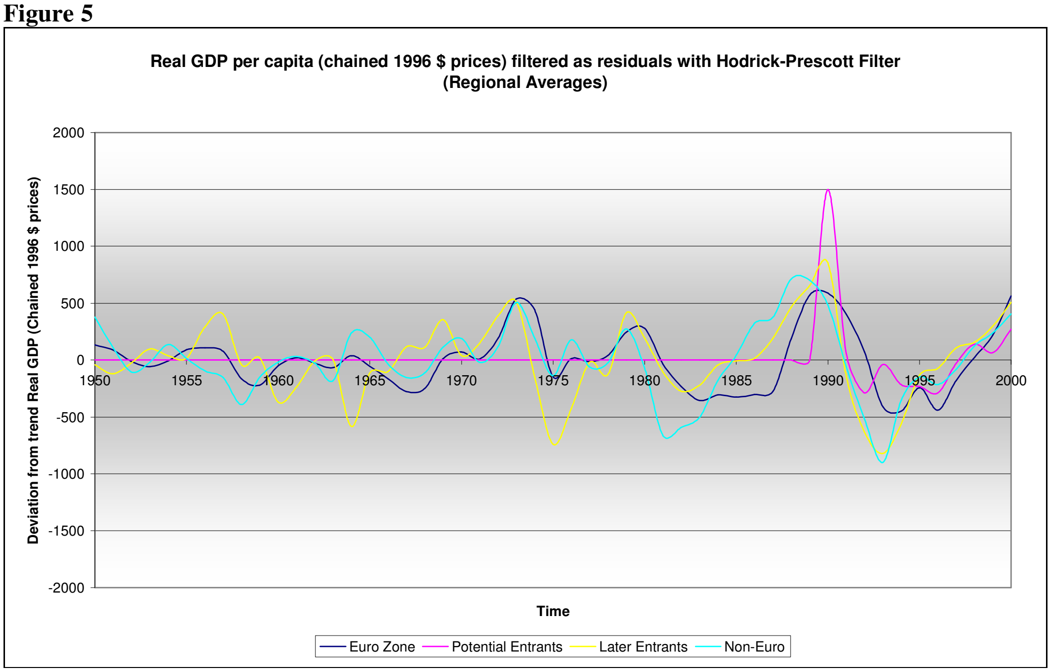


Table 3

1950 - 2000

	Euro Zone	*Potential Entrants*	*Future Entrants*	*Non Euro*
Euro Zone	1.000			
Potential Entrants	0.682	1.000		
Future Entrants	0.561	0.740	1.000	
Non Euro	0.616	0.640	0.623	1.000

1950 - 1989

	Euro Zone	*Potential Entrants*	*Future Entrants*	*Non Euro*
Euro Zone	1.000			
Potential Entrants	n/a	1.000		
Future Entrants	0.449	n/a	1.000	
Non Euro	0.558	n/a	0.414	1.000

1990 - 2000

	Euro Zone	*Potential Entrants*	*Future Entrants*	*Non Euro*
Euro Zone	1.000			
Potential Entrants	0.682	1.000		
Future Entrants	0.709	0.740	1.000	
Non Euro	0.751	0.640	0.962	1.000

Figure 6

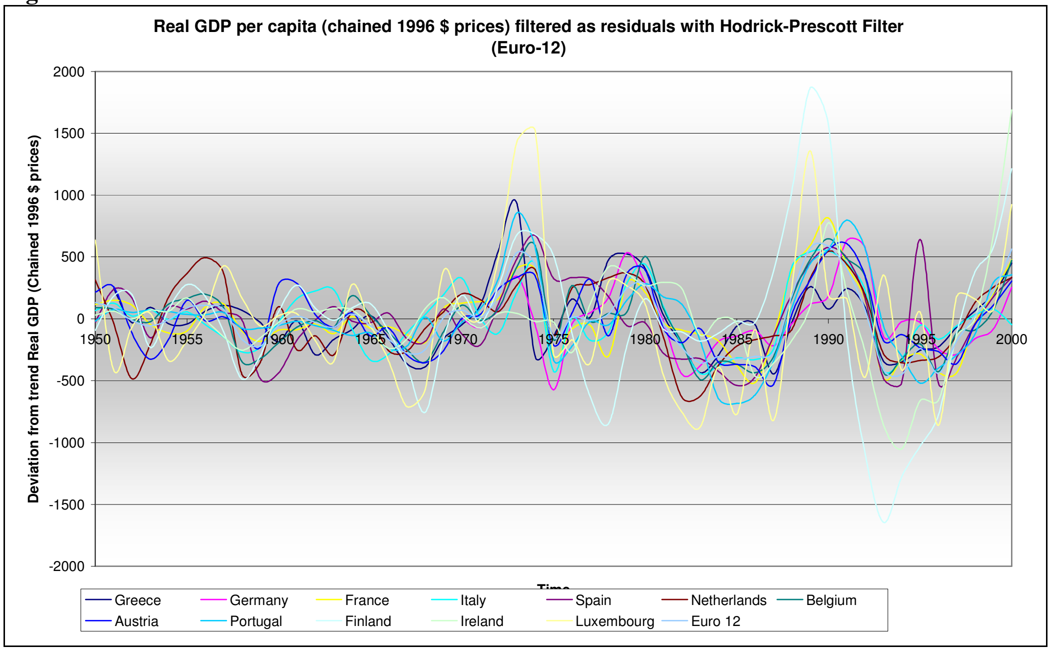


Table 4

1950 - 2000

	Euro Zone	*Greece*	*Germany*	*France*	*Italy*	*Spain*	*Netherlands*	*Belgium*	*Austria*	*Portugal*	*Finland*	*Ireland*	*Luxembourg*
Euro Zone	1.000												
Greece	0.699	1.000											
Germany	0.638	0.664	1.000										
France	0.909	0.518	0.583	1.000									
Italy	0.767	0.379	0.641	0.754	1.000								
Spain	0.737	0.413	0.430	0.661	0.553	1.000							
Netherlands	0.777	0.568	0.706	0.615	0.570	0.564	1.000						
Belgium	0.928	0.597	0.660	0.835	0.769	0.745	0.779	1.000					
Austria	0.807	0.568	0.752	0.769	0.653	0.567	0.652	0.777	1.000				
Portugal	0.820	0.583	0.651	0.807	0.684	0.575	0.573	0.793	0.781	1.000			
Finland	0.704	0.335	0.032	0.693	0.486	0.450	0.394	0.582	0.388	0.391	1.000		
Ireland	0.672	0.487	0.316	0.594	0.391	0.377	0.469	0.554	0.443	0.474	0.590	1.000	
Luxembourg	0.737	0.553	0.416	0.574	0.475	0.532	0.553	0.619	0.507	0.562	0.449	0.295	1.000

1950 - 1989

	Euro Zone	*Greece*	*Germany*	*France*	*Italy*	*Spain*	*Netherlands*	*Belgium*	*Austria*	*Portugal*	*Finland*	*Ireland*	*Luxembourg*
Euro Zone	1.000												
Greece	0.661	1.000											
Germany	0.688	0.791	1.000										
France	0.863	0.438	0.533	1.000									
Italy	0.776	0.315	0.650	0.749	1.000								
Spain	0.723	0.368	0.295	0.594	0.463	1.000							
Netherlands	0.711	0.494	0.758	0.462	0.475	0.526	1.000						
Belgium	0.916	0.538	0.592	0.762	0.734	0.734	0.719	1.000					
Austria	0.789	0.543	0.667	0.685	0.588	0.506	0.553	0.702	1.000				
Portugal	0.828	0.555	0.518	0.792	0.660	0.591	0.432	0.743	0.683	1.000			
Finland	0.601	0.159	0.014	0.621	0.479	0.435	0.213	0.535	0.353	0.395	1.000		
Ireland	0.386	0.363	0.430	0.248	0.421	0.151	0.288	0.375	0.375	0.418	-0.099	1.000	
Luxembourg	0.859	0.560	0.574	0.708	0.571	0.601	0.587	0.709	0.592	0.678	0.504	0.156	1.000

1990 - 2000

	Euro Zone	*Greece*	*Germany*	*France*	*Italy*	*Spain*	*Netherlands*	*Belgium*	*Austria*	*Portugal*	*Finland*	*Ireland*	*Luxembourg*
Euro Zone	1.000												
Greece	0.904	1.000											
Germany	0.610	0.557	1.000										
France	0.962	0.799	0.671	1.000									
Italy	0.797	0.628	0.651	0.834	1.000								
Spain	0.758	0.591	0.596	0.752	0.757	1.000							
Netherlands	0.963	0.875	0.640	0.950	0.853	0.663	1.000						
Belgium	0.954	0.831	0.764	0.952	0.865	0.760	0.938	1.000					
Austria	0.860	0.716	0.861	0.930	0.819	0.667	0.902	0.918	1.000				
Portugal	0.822	0.746	0.831	0.850	0.757	0.541	0.899	0.875	0.951	1.000			
Finland	0.848	0.765	0.130	0.784	0.608	0.528	0.789	0.712	0.533	0.471	1.000		
Ireland	0.911	0.920	0.344	0.810	0.534	0.579	0.823	0.787	0.623	0.619	0.901	1.000	
Luxembourg	0.570	0.527	0.109	0.410	0.105	0.415	0.431	0.420	0.273	0.300	0.528	0.661	1.000

Breaking the eurozone down into its component nations and analysing as above gives the results in figure (6) and table (4). Figure (6) illustrates eurozone business cycles since 1950 and it is evident that business cycles in the eurozone followed each other much more closely post-1990. Most of the nations in this region saw a peak around 1990, followed by a sharp fall to the mid-1990s and then recovery ensued. There are many outliers to this trend; for example, Ireland and Finland reached far lower levels below trend in 1993 / (4) while Spain and Luxembourg have unusually large peaks around 1995, followed by equally abrupt falls. Clearly, the overall synchronisation in table (4) in this period is high, with many correlations over 0.5 and some over 0.8, but by decomposing the data into two periods, post-1990 convergence becomes clear. The number of nations with high correlation coefficients above 0.8, relative to the eurozone, increases from five before 1990 to eight post-1990 although Luxembourg and Germany exhibit the lowest correlations with the eurozone average. Germany may be unsynchronised because of the strain of re-unification while Luxembourg exhibits low synchronisation and divergence from most other eurozone nations in the post-1990 period.

The Eastern European countries in the potential entrants group are the most likely countries to join the eurozone next and as such, their convergence levels should be high, were this criterion important. Insufficient data makes any analysis of convergence difficult due to the nature of the Hodrick-Prescott filter, but from the patterns emerging in figure (7), it is clear that there is some synchronisation with the eurozone since 1995, particularly in Slovenia. Lithuania shows no correlation with the eurozone or Slovenia and little with Estonia, raising questions as to their suitability to join the eurozone in less than two years. Table (5) clarifies this trend, Slovenia's and Estonia's correlations with the eurozone are around 0.7, while Lithuania has a low correlation coefficient of 0.115.

Figure 7

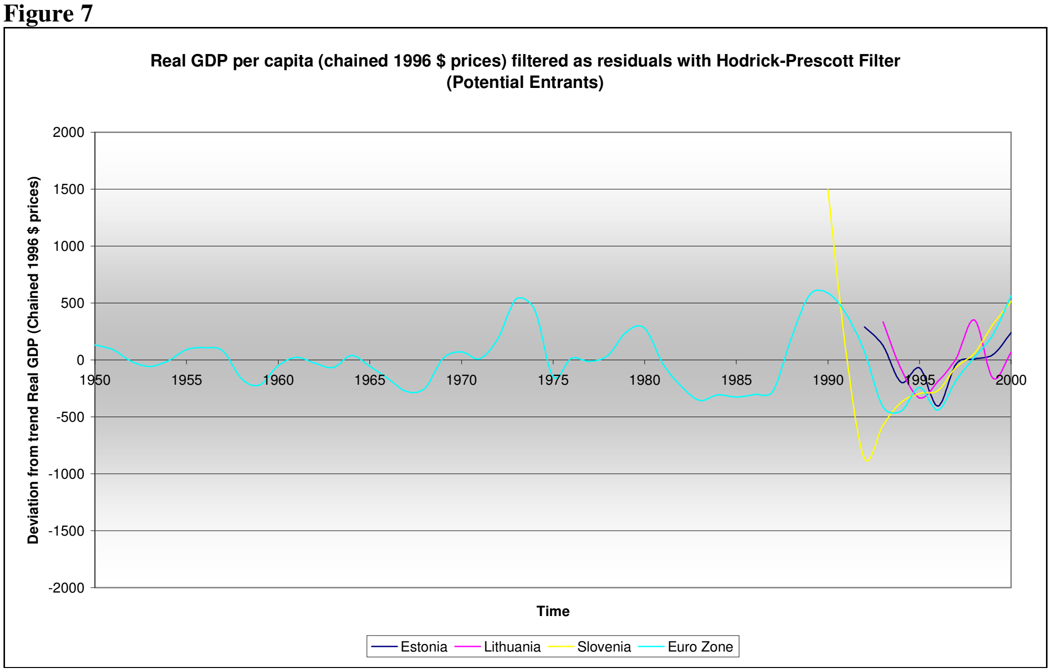


Table 5
1990 - 2000

	Euro Zone	*Estonia*	*Lithuania*	*Slovenia*
Euro Zone	1.000			
Estonia	0.682	1.000		
Lithuania	0.115	0.504	1.000	
Slovenia	0.730	0.026	-0.012	1.000

The data for the future entrants is also unreliable as little is available before the 1990s. However, the data for Cyprus, Hungary and Poland goes back further making any conclusions more convincing. Table (6) and figure (8), therefore, have little meaning for the other countries in the period up to 1990 but illustrate that pre-1990 Poland was similar, while Cypriot and Hungarian business cycles bore little resemblance to the eurozone. Post 1990, Latvia, Slovakia and Hungary bear the highest degree of resemblance to the eurozone average whilst the others seem to show little correlation. For Poland this marks a period of divergence with correlations decreasing although, graphically it can be seen that up to 2000 Poland appears to be moving similarly to the eurozone. Latvia, Slovakia and Hungary not only seem to follow the eurozone but all correlate closely with their counterparts in this region, while Cyprus, Poland and Malta seem to have far less integrated business cycles. The picture here is very confused due to the lack of data but there does appear to be a group of nations in Eastern Europe including Latvia, Slovakia and Hungary who are synchronised with the eurozone.

Figure 8

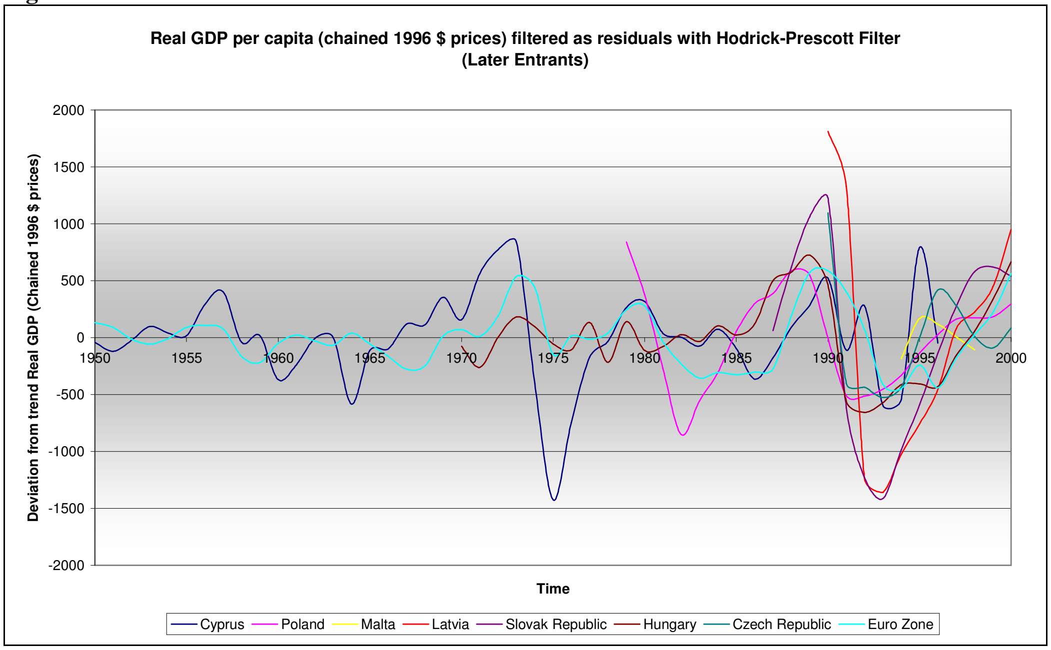


Table 6

1950 - 2000

	Euro Zone	*Cyprus*	*Poland*	*Malta*	*Latvia*	*Slovak Republic*	*Hungary*	*Czech Republic*
Euro Zone	1.000							
Cyprus	0.371	1.000						
Poland	0.411	0.236	1.000					
Malta	-0.107	0.856	0.195	1.000				
Latvia	0.846	0.329	0.435	-0.042	1.000			
Slovak Republic	0.640	0.469	0.818	0.025	0.788	1.000		
Hungary	0.479	0.138	0.619	-0.382	0.688	0.866	1.000	
Czech Republic	0.351	0.550	0.601	0.674	0.592	0.798	0.589	1.000

1950 - 1989

	Euro Zone	*Cyprus*	*Poland*	*Malta*	*Latvia*	*Slovak Republic*	*Hungary*	*Czech Republic*
Euro Zone	1.000							
Cyprus	0.349	1.000						
Poland	0.633	0.305	1.000					
Malta	n/a	n/a	n/a	1.000				
Latvia	n/a	n/a	n/a	n/a	1.000			
Slovak Republic	1.000	1.000	0.800	n/a	n/a	1.000		
Hungary	0.286	0.097	0.544	n/a	n/a	0.970	1.000	
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.000

1990 - 2000

	Euro Zone	*Cyprus*	*Poland*	*Malta*	*Latvia*	*Slovak Republic*	*Hungary*	*Czech Republic*
Euro Zone	1.000							
Cyprus	0.464	1.000						
Poland	0.260	0.455	1.000					
Malta	-0.107	0.856	0.195	1.000				
Latvia	0.846	0.329	0.435	-0.042	1.000			
Slovak Republic	0.601	0.520	0.844	0.025	0.788	1.000		
Hungary	0.670	0.418	0.807	-0.382	0.688	0.879	1.000	
Czech Republic	0.351	0.550	0.601	0.674	0.592	0.798	0.589	1.000

The data for the non-euro area is clearer and the correlations in table (7) demonstrate a marked convergence to the eurozone average on the part of Sweden, with an increase of over 0.4, to nearly 0.9. Figure (9) shows this, where a slump began around 1990 and recovery proper began in 1996 mirroring the eurozone. Denmark demonstrates some synchronisation with the eurozone and convergence post-1990. Up to 1980, figure (9) shows that the UK business cycle closely resembles the eurozone. UK business cycle synchronisation actually appears to have diminished since 1990, although there are some similarities. The UK behaves similarly to the eurozone post-1990, recovering in 1993, with the Euro following 1 year after. Growth slows in 1995 for both, although the eurozone cycle falls, moving to above trend growth by 1997 in the UK and 1998 in the eurozone. In 1998, UK growth slows while the eurozone grows continuously from 1996. There are also larger business cycle variations in the UK than the Euro up until the late 1990s, validating Artis' (2003) conclusions[36]. However, these three countries seem to be well synchronised, converging to each other and the eurozone after 1990.

Figure 9

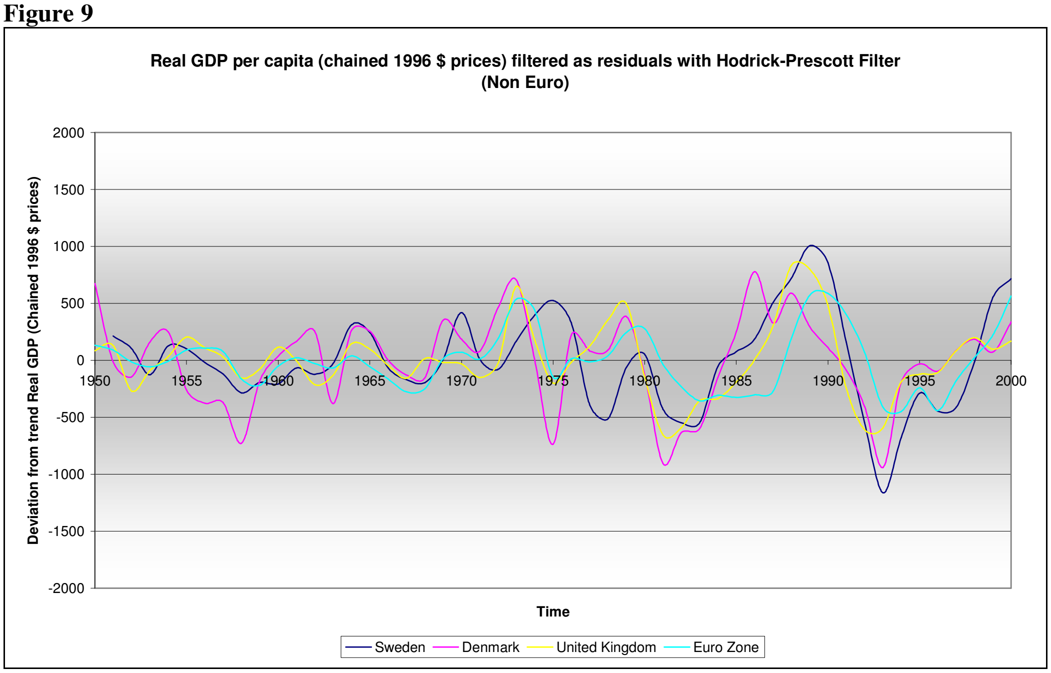


Table 7

1950 - 2000

	Euro Zone	Sweden	Denmark	United Kingdom
Euro Zone	1.000			
Sweden	0.641	1.000		
Denmark	0.376	0.528	1.000	
United Kingdom	0.570	0.636	0.665	1.000

1950 - 1989

	Euro Zone	Sweden	Denmark	United Kingdom
Euro Zone	1.000			
Sweden	0.450	1.000		
Denmark	0.349	0.454	1.000	
United Kingdom	0.636	0.582	0.620	1.000

1990 - 2000

	Euro Zone	Sweden	Denmark	United Kingdom
Euro Zone	1.000			
Sweden	0.887	1.000		
Denmark	0.543	0.785	1.000	
United Kingdom	0.512	0.787	0.842	1.000

[36] Artis, M. (2003) *Analysis of European and UK business cycles and shocks*. HM Treasury, p19-20

b. The United States of America

In relation to the average business cycle for the USA, table (8) shows that most of the regions are well synchronised except the Southwest and the Rocky Mountains, which have correlation coefficients well below 0.6 and appear not to be synchronised with any of the other regions bar themselves. New England, the Southeast and the Far West have the highest synchronisation with the USA as well as bearing the highest resemblance to the other regions.

Figure 10

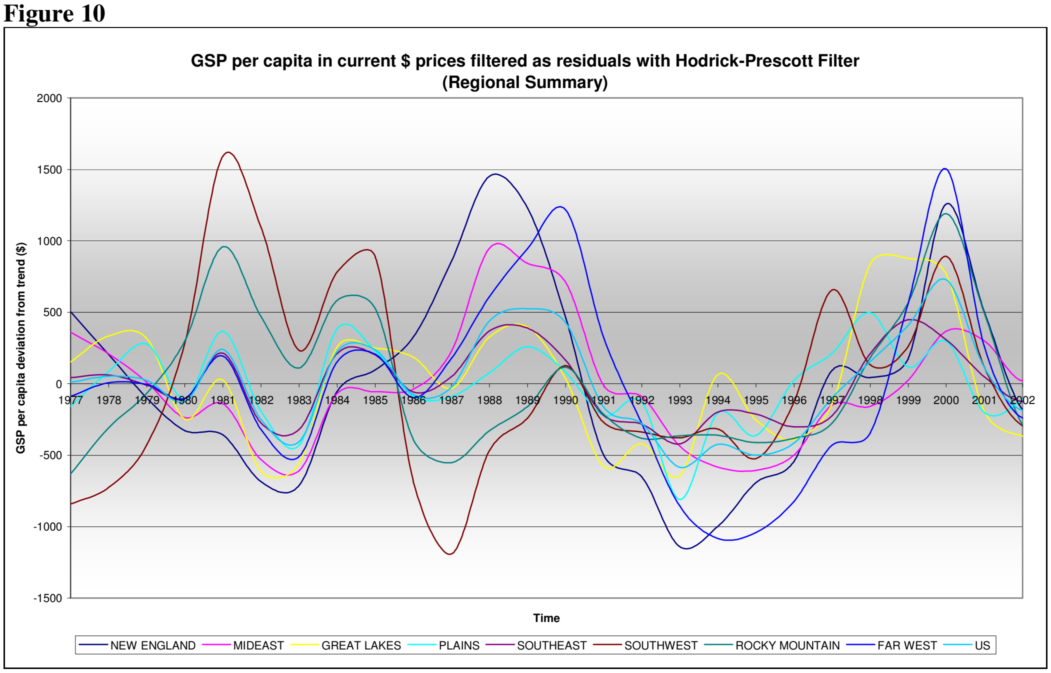


Table 8

	US	NEW ENGLAND	MIDEAST	GREAT LAKES	PLAINS	SOUTHEAST	SOUTHWEST	ROCKY MOUNTAIN	FAR WEST
US	1.000								
NEW ENGLAND	0.832	1.000							
MIDEAST	0.785	0.876	1.000						
GREAT LAKES	0.763	0.632	0.455	1.000					
PLAINS	0.720	0.489	0.403	0.689	1.000				
SOUTHEAST	0.932	0.773	0.717	0.838	0.711	1.000			
SOUTHWEST	0.302	-0.112	-0.200	0.076	0.392	0.188	1.000		
ROCKY MOUNTAIN	0.544	0.139	0.003	0.356	0.424	0.451	0.853	1.000	
FAR WEST	0.913	0.781	0.817	0.510	0.500	0.764	0.213	0.479	1.000

When the above regions are split down to a state level, there are many intra-regional differences. New England, illustrated in figure (11) is well synchronised as Vermont and New Hampshire are the only real outliers. Table (9) shows that they have little statistical correlation with the other states in this region, but figure (11) demonstrates that even these states are not particularly divergent from the US average.

Figure 11

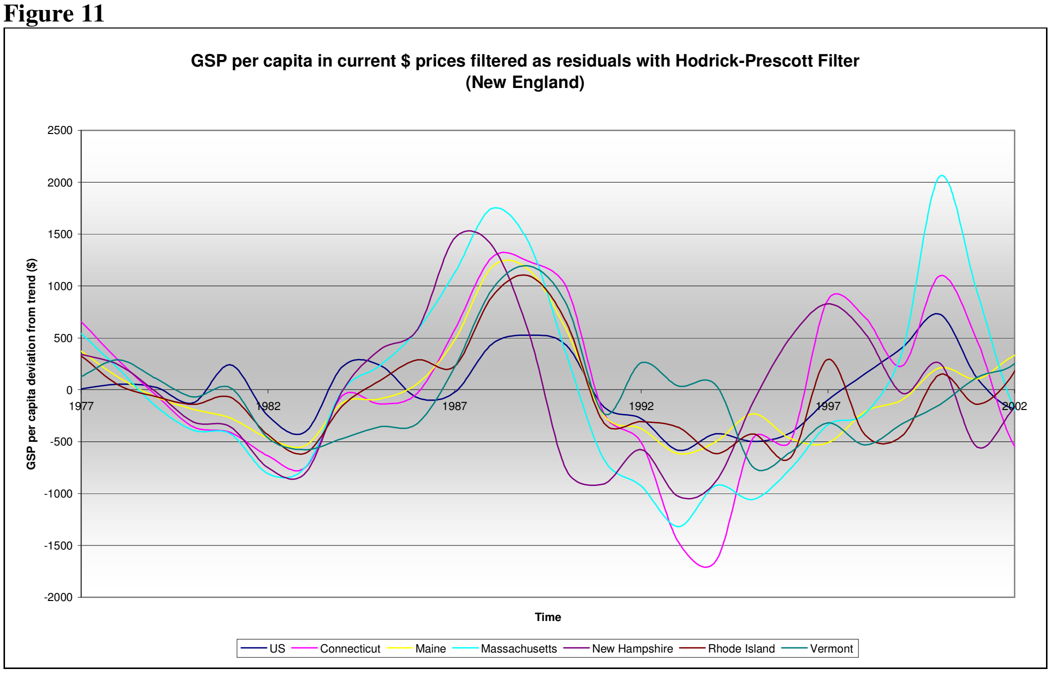


Table 9

	New England						
	US	*Connecticut*	*Maine*	*Massachusetts*	*New Hampshire*	*Rhode Island*	*Vermont*
US	1.000						
Connecticut	0.794	1.000					
Maine	0.655	0.689	1.000				
Massachusetts	0.825	0.825	0.778	1.000			
New Hampshire	0.398	0.628	0.533	0.601	1.000		
Rhode Island	0.571	0.612	0.862	0.612	0.510	1.000	
Vermont	0.421	0.376	0.791	0.450	0.176	0.798	1.000

The Mideast is far less synchronised than New England, primarily because of the effect of the District of Columbia, which bears little resemblance to the other states. Delaware diverges after 1987 but excepting these outliers, figure (12) shows close business cycle synchronisation, emphasised by table (10), where most coefficients are over 0.7. Table (10) shows that correlations with the USA average are non-negligible while figure (12) illustrates the similarities between many of the states and the USA over the sample period.

Figure 12

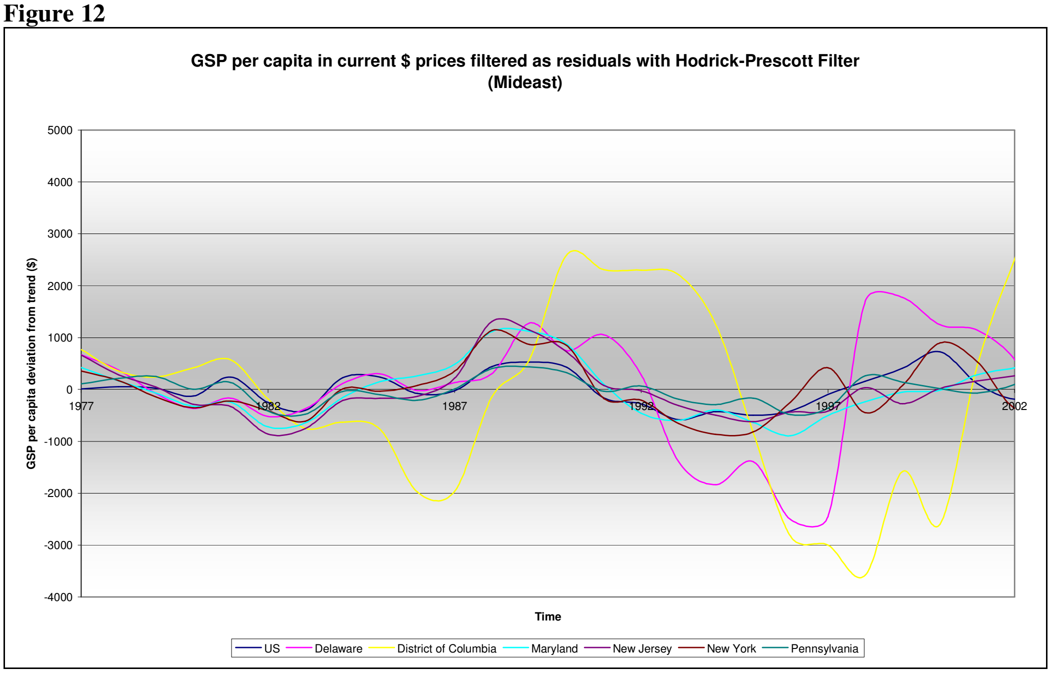


Table 10

	MidEast						
	US	*Delaware*	*District of Columbia*	*Maryland*	*New Jersey*	*New York*	*Pennsylvania*
US	1.000						
Delaware	0.686	1.000					
District of Columbia	-0.177	0.060	1.000				
Maryland	0.650	0.571	0.304	1.000			
New Jersey	0.589	0.508	0.297	0.920	1.000		
New York	0.800	0.445	-0.125	0.731	0.742	1.000	
Pennsylvania	0.644	0.634	0.355	0.767	0.812	0.490	1.000

The Great Lakes region shows the highest correlation of any US economic region. Figure (13) shows that every state bar Michigan follows a very similar business cycle, and Michigan's path is still synchronised, exhibiting similarly timed cycles. Table (11) clarifies this, with every coefficient exceeding 0.6 and some as high as 0.9.

Figure 13

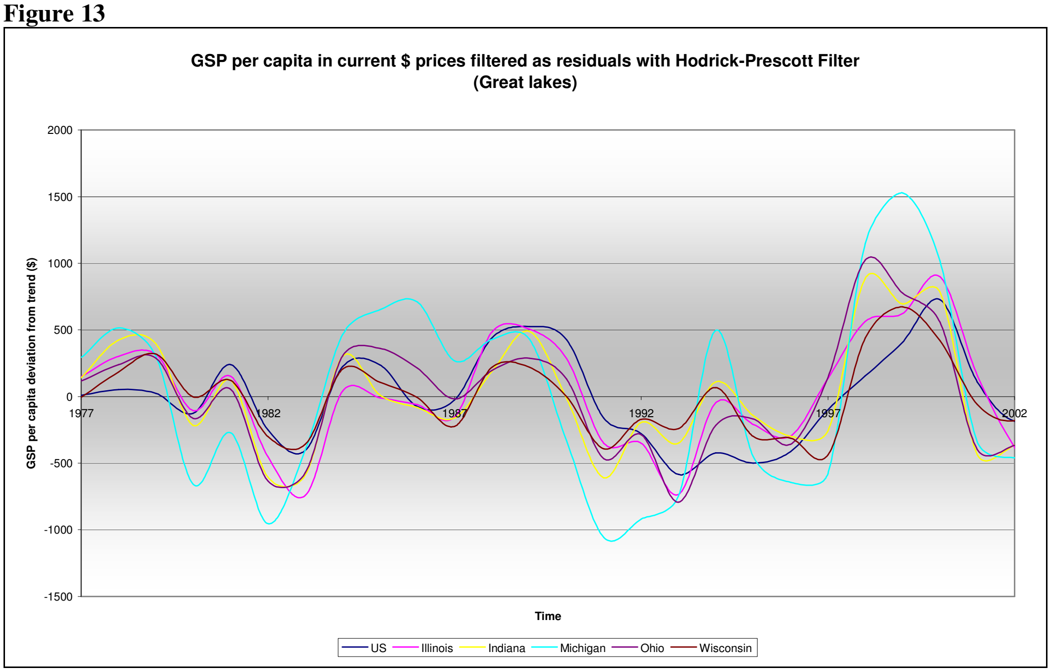


Table 11

Great Lakes						
	US	*Illinois*	*Indiana*	*Michigan*	*Ohio*	*Wisconsin*
US	1.000					
Illinois	0.821	1.000				
Indiana	0.678	0.841	1.000			
Michigan	0.619	0.734	0.858	1.000		
Ohio	0.732	0.845	0.901	0.857	1.000	
Wisconsin	0.729	0.766	0.903	0.845	0.812	1.000

The Plains region exhibits little statistical correlation, with only eight out of twenty-eight coefficients in table (12) exceeding 0.5 – the arbitrary cut-off point for evidence of synchronisation. North Dakota, in particular, bears less resemblance to the USA or any other state empirically or graphically. Figure (14) does, however, serve to show that there is some similarity in business cycles up to 1987 although, after this point the US business cycle seems to be mirrored by some of the states including South Dakota confirming Corsetti, Pesenti and Blinder's (1999)[37] offsetting shocks. Figure (14)

[37] Corsetti, Giancarlo; Paolo Pesenti; Alan S. Blinder, (1999) "Stability, Asymmetry, and Discontinuity: The Launch of European Monetary Union." *Brookings Papers on Economic Activity*, Vol. 1999, No. 2, 346-351

shows much variability in the Plains states' business cycles in comparison to the USA business cycle although some, including Minnesota, follow a similar long-run path.

Figure 14

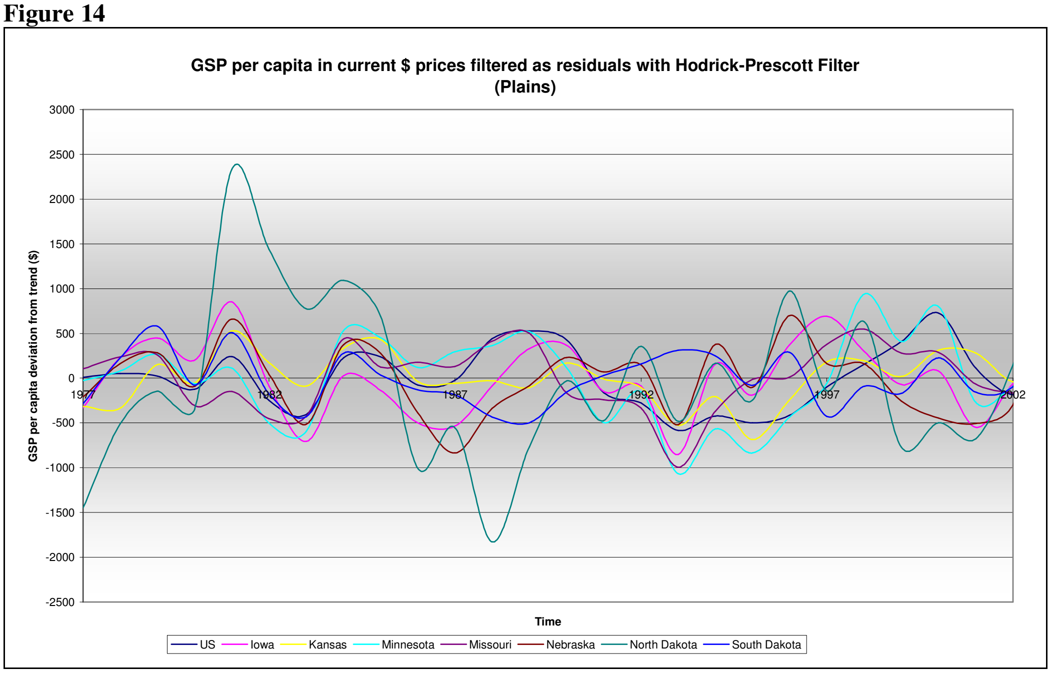


Table 12

	Plains							
	US	*Iowa*	*Kansas*	*Minnesota*	*Missouri*	*Nebraska*	*North Dakota*	*South Dakota*
US	1.000							
Iowa	0.333	1.000						
Kansas	0.599	0.390	1.000					
Minnesota	0.847	0.384	0.600	1.000				
Missouri	0.669	0.385	0.312	0.798	1.000			
Nebraska	-0.037	0.739	0.251	0.077	0.045	1.000		
North Dakota	-0.206	0.394	0.421	-0.063	-0.259	0.651	1.000	
South Dakota	-0.146	0.296	0.122	-0.038	-0.238	0.575	0.491	1.000

The most striking feature in figure (15) is Louisiana's business cycle, seeming to bear little or no resemblance to the other states in the Southeast or even the USA average. Another feature of the Southeast is that most states appear to be entering a depression in 1999, whilst the USA was still growing, although by 2000, the USA begins to follow this pattern. Table (13) shows that Florida, Georgia, North and South Carolina and Virginia are all closely correlated to the United States average, but the other states show far lower correlation.

Figure 15

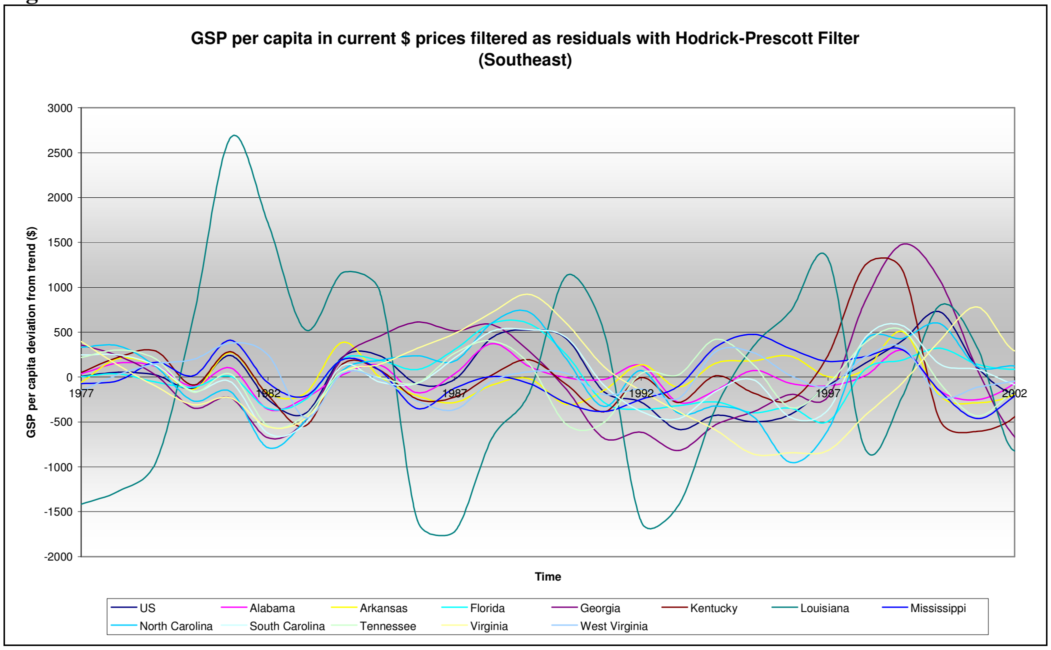


Table 13

	SouthEast												
	US	*Alabama*	*Arkansas*	*Florida*	*Georgia*	*Kentucky*	*Louisiana*	*Mississippi*	*North Carolina*	*South Carolina*	*Tennessee*	*Virginia*	*West Virginia*
US	1.000												
Alabama	0.427	1.000											
Arkansas	0.006	0.514	1.000										
Florida	0.829	0.470	-0.131	1.000									
Georgia	0.721	0.327	0.160	0.629	1.000								
Kentucky	0.333	0.531	0.647	0.172	0.494	1.000							
Louisiana	0.185	-0.165	0.112	-0.134	-0.173	-0.068	1.000						
Mississippi	-0.080	0.347	0.772	-0.182	0.099	0.564	0.284	1.000					
North Carolina	0.783	0.513	-0.039	0.853	0.695	0.332	-0.405	-0.227	1.000				
South Carolina	0.765	0.578	0.119	0.793	0.730	0.501	-0.230	0.044	0.846	1.000			
Tennessee	0.207	0.622	0.545	0.324	0.478	0.650	-0.493	0.527	0.509	0.518	1.000		
Virginia	0.665	0.319	-0.394	0.845	0.358	-0.146	-0.258	-0.585	0.781	0.620	0.055	1.000	
West Virginia	0.115	0.288	0.603	-0.045	0.028	0.588	0.374	0.707	-0.061	0.208	0.303	-0.310	1.000

Figure (16) illustrates the low synchronisation between the Southwest's and the USA's business cycles. Up to 1986, the states are closely correlated, except for Arizona, which follows the US closely. After this, the states appear to diverge. Table (14) confirms this as Arizona and the USA correlate somewhat, while there is little correlation within the rest of the region. New Mexico, Oklahoma and Texas correlate closely but are unsynchronised with the USA.

Figure 16

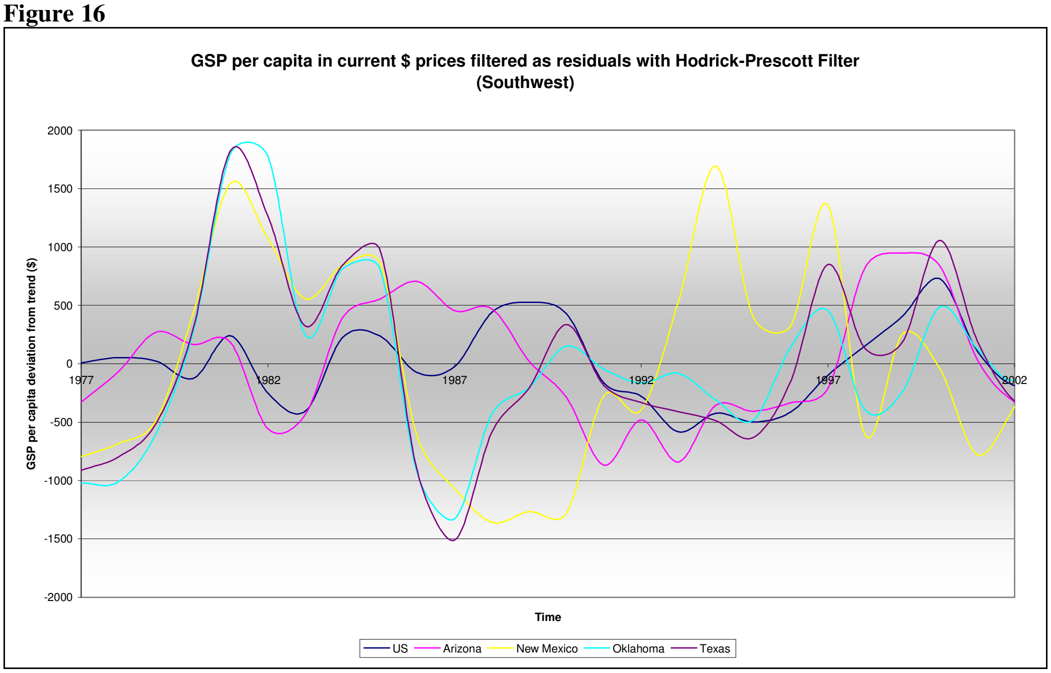


Table 14

	SouthWest				
	US	*Arizona*	*New Mexico*	*Oklahoma*	*Texas*
US	1.000				
Arizona	0.689	1.000			
New Mexico	-0.389	-0.184	1.000		
Oklahoma	0.095	-0.109	0.642	1.000	
Texas	0.304	0.125	0.582	0.928	1.000

The Rocky Mountains states form two groups, one including Colorado and Utah, with high correlations with the USA average, the other far less correlation. Further inter-state comparisons in figure (17) and table (15) yield few conclusions except for a distinct lack of co-ordination between the business cycles of Idaho, Montana and Wyoming and the USA, although Montana and Wyoming have a high correlation coefficient of nearly 0.8.

Figure 17

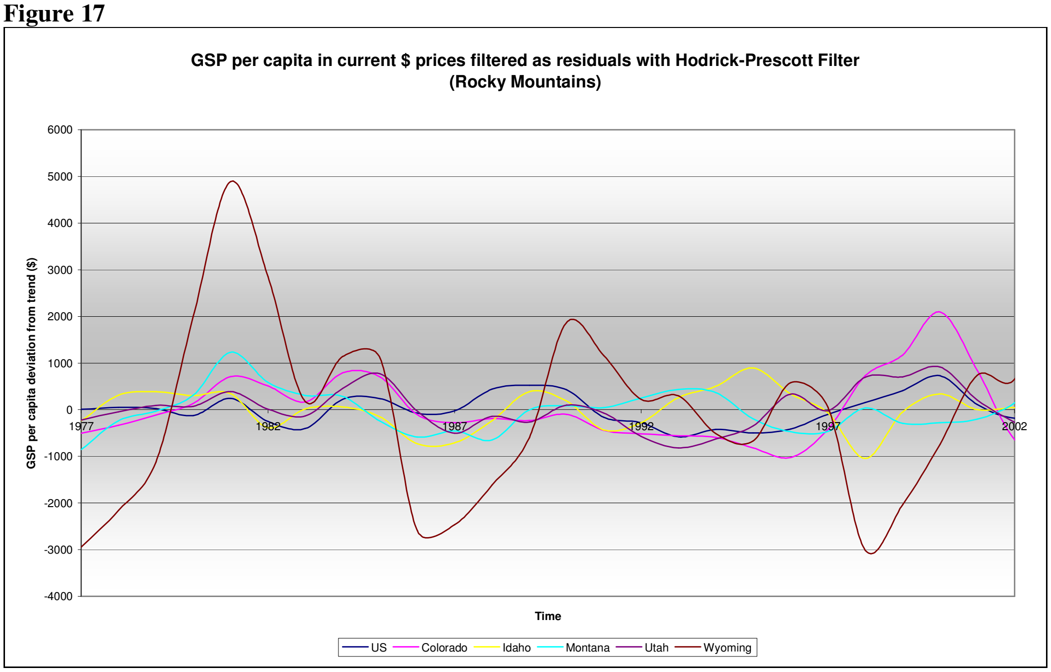


Table 15

Rocky Mountain						
	US	*Colorado*	*Idaho*	*Montana*	*Utah*	*Wyoming*
US	1.000					
Colorado	0.646	1.000				
Idaho	-0.096	-0.132	1.000			
Montana	-0.191	0.037	0.221	1.000		
Utah	0.607	0.794	-0.105	-0.173	1.000	
Wyoming	-0.097	0.036	0.311	0.767	0.008	1.000

Figure (18) shows that the Far West, excluding Alaska and Hawaii, is synchronised with the USA average. These outliers, particularly Alaska, show huge GSP divergences in relation to the USA. California shows particularly high correlation with the USA, while Nevada, Oregon and Washington show some synchronisation. However, the levels of inter-state correlation shown in table (16) are generally very low, excepting California and Washington, and Nevada and Oregon.

Figure 18

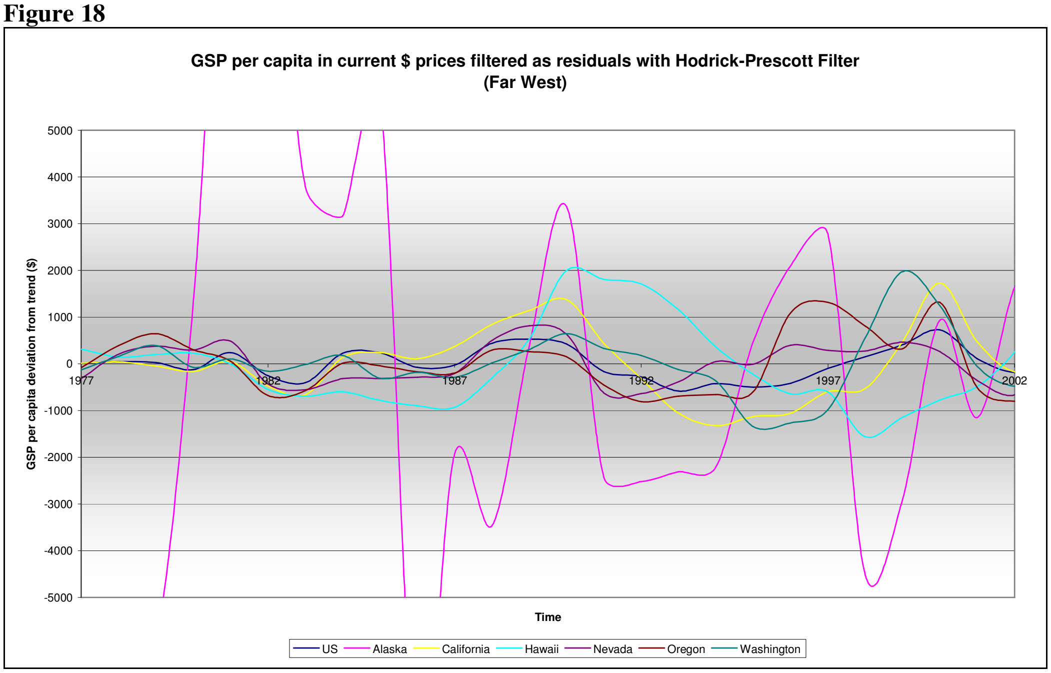


Table 16

	Far West						
	US	*Alaska*	*California*	*Hawaii*	*Nevada*	*Oregon*	*Washington*
US	1.000						
Alaska	0.027	1.000					
California	0.888	-0.025	1.000				
Hawaii	-0.176	-0.017	0.094	1.000			
Nevada	0.541	0.033	0.321	-0.098	1.000		
Oregon	0.504	-0.089	0.283	-0.414	0.679	1.000	
Washington	0.659	-0.167	0.623	-0.012	0.239	0.200	1.000

c. Summary

In the European Union there appears to be significant convergence between the various regions, as determined by the Banco de Portugal[38] in 2001. In the eurozone, there is significant convergence by individual nations to the eurozone average as well

[38] Belo, F (2001) *Some facts about the cyclical convergence in the eurozone*, Banco de Portugal: Economic Research Department, September, p17

as convergence by extra-EU nations to this average, particularly on the part of Sweden and to a lesser extent, Denmark. While the UK actually seems to be diverging from the eurozone in table (7), there is marked synchronisation after 1975, with the UK preceding most eurozone movements by one year, explaining the low correlation coefficients. By lagging UK business cycles by one year, figure (19) and table (17), correlations increase to over 0.7 for the whole period and 0.8, post-1990, demonstrating not only high synchronisation, but also convergence. The findings relating to the EU-10, made up of the potential and future entrants are mixed, possibly due to insufficient data. Lithuania, in particular shows very little synchronisation with the Euro despite expecting to join the Euro in 2007.

Figure 19

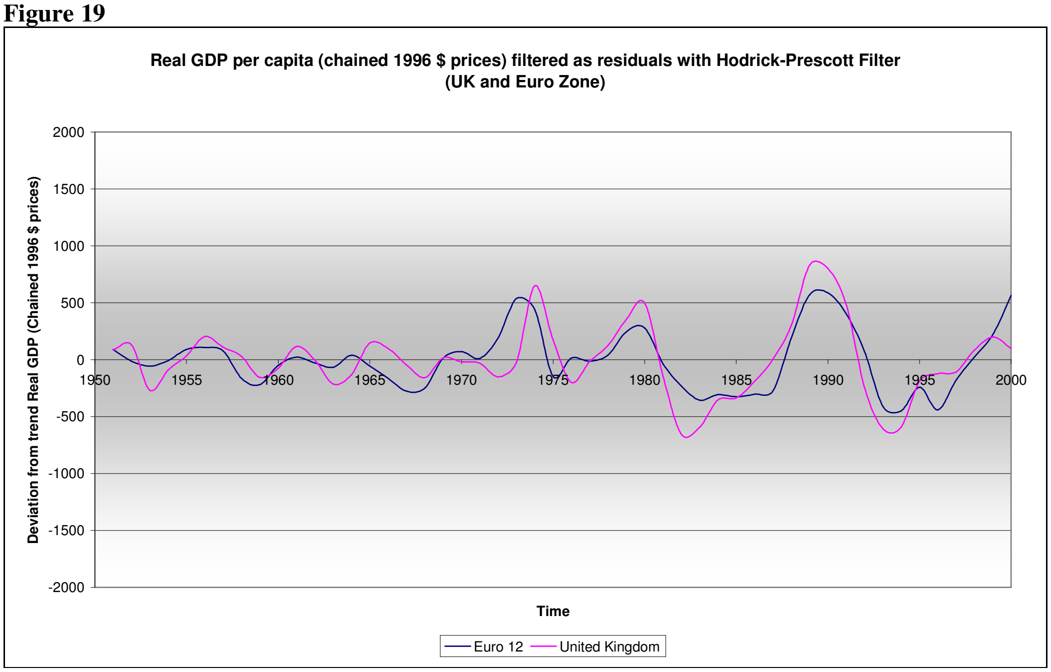


Table 17

1950 - 2000

	Euro 12	*United Kingdom*
Euro 12	1.000	
United Kingdom	0.767	1.000

1950 - 1989

	Euro 12	*United Kingdom*
Euro 12	1.000	
United Kingdom	0.724	1.000

1990 - 2000

	Euro 12	*United Kingdom*
Euro 12	1.000	
United Kingdom	0.841	1.000

In comparison, the US shows less synchronisation than the EU, with some regions exhibiting weak synchronisation, particularly the Southwest and Rocky Mountain regions. On an intra-regional level, there are some well-synchronised regions, for example, the Great Lakes, but there are regions that exhibit little or no synchronisation, including the Plains, Southwest and Rocky Mountain regions. This is mostly in line with HM Treasury's analysis of the USA[39], which identifies the core regions (those mostly in synchronisation) as the Mideast, New England, the Great Lakes and the Plains and the outliers as the Southwest and the Rocky Mountains. The only exception to this is the Plains region, which demonstrates low correlations in this study.

In general, there is more synchronisation between individual nations in the EU, with a much higher number of high correlations relative to the USA[40], which may help to counter other barriers to union not experienced in the USA. One such barrier is the level of labour mobility in the EU, where language barriers are likely to inhibit the free flow of labour when compared to the USA[41]. On a regional scale, the EU appears to be convergent since 1995 as business cycles move in a similar manner to the Euro Average, demonstrated by correlation coefficients over 0.64 for all regions since 1990. The same is true of the Core regions in the USA, although there are clear outlier regions for which correlation coefficients are very low.

6. Conclusions

Despite the relatively simple statistical tools used to analyse GDP and GSP, it is possible to draw some powerful conclusions. Firstly, regardless of its relevance as a test for checking the suitability of nations for joining the Euro, convergence in the EU has increased by the measures used here. It is clear, not only graphically, but also statistically, that synchronisation of business cycles in a number of EU countries, particularly in the eurozone has risen since 1990. It is also probable that were Sweden, the UK and Denmark, willing to join monetary union, their levels of synchronisation would be high enough to absorb the shock of losing autonomous monetary policy. A

[39] HM Treasury. (2003). *The United States as a Monetary Union*. p12
[40] Appendix 2: Detailed Cross-State and Country Correlation Matrices
[41] HM Treasury. (2003). *The United States as a Monetary Union. Executive Summary,*p4

clear trend for increasing synchronisation in the late 1990s is demonstrated in figures (5) and (9), but is not shown in the tables. All of the regions in figure (5) and the states in figure (9) are following a very similar pattern into the year 2000. Of the EU-10, Latvia, Slovakia, Hungary, Estonia and Slovenia are the most synchronised with the eurozone, while the other five nations are likely to be unsuitable for monetary union on the grounds of cyclical convergence. The particularly high convergence exhibited by the Euro-12 may also point to Artis' (2003) endogeneity argument that monetary union fosters convergence. If this is so, then convergence may not need to be as high as previously thought, in order for monetary union to succeed.

The USA's low correlation figures point to cyclical convergence perhaps not being particularly important for monetary union. Obviously, there are massive differences between the USA and the EU, not only politically, but also geographically and in national identities. This reduces the relevance of the experiences of the USA, but loose conclusions can and should be drawn from this: as long as there is clear regional synchronisation, then this should be sufficient for union. It appears that on a state level, translating to a national level in the EU, convergence is not vital for monetary and / or political union. These findings agree with the Treasury (2003)[42] who determine that "regional cyclical differences are a feature of a functioning monetary union" in the USA, although vast differences to the EU decrease the applicability of the US experience.

There is little evidence as to whether convergence is result of, or a prerequisite for union, or if convergence matters, as suggested by Lilico[43] (1999). The USA does not answer these questions, as data on business cycles before the union of the USA was not available. The EU provides little evidence either way, the eurozone countries have exhibited synchronisation from the beginning of the data set, converging since 1990, while actual convergence has decreased between the UK and the eurozone, although a one-year lag shows high synchronisation and convergence since 1990. This shows endogenous convergence by eurozone nations as well as exogenous convergence by the UK although the UK's association with the eurozone may serve to increase the symmetry of shocks in both regions.

[42] HM Treasury. (2003). *The United States as a Monetary Union*. P24
[43] Lilico, A. (1999). "Is cyclical convergence a good thing?" *European Journal*, May/June

The implication for Gordon Brown's first test is therefore ambiguous. The UK exhibits divergence from the eurozone, with correlations post-1990 lower than any seen in the eurozone, indicating unsuitability for euro membership. However, synchronisation is high and increasing, if HM Treasury takes into account the one-year lead shown by the UK economy. Post-1990, lagged correlation coefficients are in fact higher than those exhibited by many key euro members are. Whether this indicates convergence is not clear, but appropriate policy to slow the economy's next business cycle movement could markedly improve the UK's synchronisation with mainland Europe, resulting in the UK passing the first test. Whether it needs to pass such a test before joining European monetary union, is yet unproven.

a. Extensions and Criticisms

i. A longer period of study would further enhance the reliability of the Hodrick-Prescott filter, improving the business cycle estimations. This is particularly important for the EU-10, as data is lacking, maybe in five or ten years sufficient data will be available to obtain results that are more reliable.

ii. The data for the USA was particularly lacking, in that an appended dataset was used, reducing the continuity of the data. At the same time, the use of nominal data introduces the risk that changes in prices affected the measurement of business cycles in this study. Ideally, a continuous dataset of real data, preferably from before the union of the United States would be used.

iii. The use of an improved filter such as the Band-Pass filter developed by Baxter and King[44] would improve the power of any conclusions concerning business cycles. This is recommended as the Hodrick-Prescott filter has a number of limitations explained in section 4.

[44] 'Measuring business cycles: approximate band-pass filters for economic time series', Baxter, A. and King, R. (1999), *Review of Economics and Statistics*, 81(4), November: pp. 575-93; *NBER Working Papers*, 5022.

iv. The use of further business cycle variables such as investment, unemployment[45] and consumer spending may enhance the reliability of analysis: rather than relying on one variable, a composite variable representing business cycles[46] could be used.

v. A regression to determine the importance of business cycle convergence in economic growth would help to determine the appropriate levels of convergence needed for successful monetary union. This could be carried out for the eurozone region, analysing relative performance and convergence levels, providing sufficient data is available and would greatly improve the power of any conclusions regarding the necessity of cyclical convergence.

vi. The assessment of convergence levels is problematic as a large dataset is required for filters to work effectively. This was a problem here, particularly for the EU-10 resulting in weak analysis. The importance of convergence has also yet to be determined. This can be carried out either through analysis of the potential entrants when they join the eurozone, or through regression of eurozone members' economic performance and convergence levels.

Word Count: 5293 words (excluding tables, figures, appendices and headings)

[45] Used in Sonje, V, & I. Vrbanc (2000). *Measuring the Similarities of Economic Developments in Central Europe: A Correlation between the Business Cycles of Germany, Hungary, the Czech Republic and Croatia.* Croatian National Bank Working Paper
[46] Hawksworth, J. & L. Barton. (2000) "EMU Convergence Indices" *PricewaterhouseCoopers European Economic Outlook*, January

Appendix 1: The Five Economic Tests

The 'five economic tests' are

1. Are business cycles and economic structures compatible so that we and others could live comfortably with euro interest rates on a permanent basis?
2. If problems emerge is there sufficient flexibility to deal with them?
3. Would joining EMU create better conditions for firms making long-term decisions to invest in Britain?
4. What impact would entry into EMU have on the competitive position of the UK's financial services industry, particularly the City's wholesale markets?
5. In summary, will joining EMU promote higher growth, stability and a lasting increase in jobs?

Clearly, empirical analysis of these issues is difficult, due to the tests' subjective nature. This paper's focus on the first test, specifically the business cycle component, is due to its statistically less ambiguous nature although the government sets no numerical target.

Appendix 2: Detailed Cross-Country Correlations

Below are correlation matrices detailing the coefficients for all of the EU nations in this study, as well as for all of the states in the USA.

The EU (1)

	Euro Zone	Greece	Germany	France	Italy	Spain	Netherlands	Belgium	Austria	Portugal	Finland	Ireland	Luxembourg
Euro Zone	1.000												
Greece	0.699	1.000											
Germany	0.638	0.664	1.000										
France	0.909	0.518	0.583	1.000									
Italy	0.767	0.379	0.641	0.754	1.000								
Spain	0.737	0.413	0.430	0.661	0.553	1.000							
Netherlands	0.777	0.568	0.706	0.615	0.570	0.564	1.000						
Belgium	0.928	0.597	0.660	0.835	0.769	0.745	0.779	1.000					
Austria	0.807	0.568	0.752	0.769	0.653	0.567	0.652	0.777	1.000				
Portugal	0.820	0.583	0.651	0.807	0.684	0.575	0.573	0.793	0.781	1.000			
Finland	0.704	0.335	0.032	0.693	0.486	0.450	0.394	0.582	0.388	0.391	1.000		
Ireland	0.672	0.487	0.316	0.594	0.391	0.377	0.469	0.554	0.443	0.474	0.590	1.000	
Luxembourg	0.737	0.553	0.416	0.574	0.475	0.532	0.553	0.619	0.507	0.562	0.449	0.295	1.000
Estonia	0.682	0.602	0.686	0.653	0.423	0.486	0.697	0.751	0.734	0.810	0.263	0.524	0.617
Lithuania	0.115	0.126	-0.071	0.044	-0.231	-0.345	0.269	0.034	0.164	0.340	0.096	0.095	0.452
Slovenia	0.730	0.495	0.045	0.735	0.577	0.500	0.665	0.615	0.495	0.380	0.908	0.721	0.458
Cyprus	0.371	0.421	0.477	0.451	0.389	0.211	0.219	0.272	0.206	0.366	0.141	0.268	0.243
Poland	0.411	0.508	0.208	0.292	0.397	0.217	0.499	0.255	0.112	-0.026	0.534	0.237	0.490
Malta	-0.107	-0.125	-0.195	-0.366	0.352	0.504	-0.340	-0.182	-0.607	-0.772	-0.165	0.021	-0.119
Latvia	0.846	0.717	0.285	0.800	0.734	0.584	0.812	0.748	0.644	0.569	0.902	0.793	0.476
Slovak Republic	0.640	0.492	-0.189	0.609	0.543	0.410	0.526	0.481	0.224	0.206	0.933	0.641	0.443
Hungary	0.479	0.205	-0.073	0.507	0.248	0.275	0.252	0.289	0.128	0.142	0.848	0.552	0.339
Czech Republic	0.351	0.149	-0.251	0.364	0.414	0.256	0.297	0.299	0.101	-0.019	0.668	0.394	0.048
Sweden	0.641	0.276	0.119	0.632	0.470	0.535	0.464	0.562	0.301	0.263	0.880	0.484	0.384
Denmark	0.376	0.377	0.325	0.284	0.306	0.192	0.371	0.268	0.156	0.051	0.402	0.187	0.379
United Kingdom	0.570	0.421	0.246	0.482	0.426	0.437	0.531	0.416	0.305	0.250	0.608	0.265	0.536

The EU (2)

	Estonia	Lithuania	Slovenia	Cyprus	Poland	Malta	Latvia	ovak Repub	Hungary	Czech Republic	Sweden	Denmark	United Kingdom
Euro Zone													
Greece													
Germany													
France													
Italy													
Spain													
Netherlands													
Belgium													
Austria													
Portugal													
Finland													
Ireland													
Luxembourg													
Estonia	1.000												
Lithuania	0.504	1.000											
Slovenia	0.026	-0.012	1.000										
Cyprus	0.107	-0.788	0.373	1.000									
Poland	-0.130	-0.064	0.539	0.236	1.000								
Malta	-0.252	-0.653	-0.174	0.856	0.195	1.000							
Latvia	0.111	0.032	0.890	0.329	0.435	-0.042	1.000						
Slovak Re	-0.064	-0.018	0.865	0.469	0.818	0.025	0.788	1.000					
Hungary	0.266	0.092	0.825	0.138	0.619	-0.382	0.688	0.866	1.000				
Czech Re	-0.478	-0.343	0.777	0.550	0.601	0.674	0.592	0.798	0.589	1.000			
Sweden	0.236	-0.190	0.866	0.026	0.641	0.164	0.893	0.855	0.754	0.572	1.000		
Denmark	-0.114	-0.290	0.623	0.260	0.786	0.005	0.686	0.800	0.507	0.557	0.528	1.000	
United Kir	-0.227	-0.122	0.876	0.217	0.835	-0.190	0.762	0.885	0.687	0.804	0.636	0.665	1.000

The USA (1)

	US	Alabama	Alaska	Arizona	Arkansas	California	Colorado	Connecticut	Delaware	District of Columbia	Florida	Georgia	Hawaii	Idaho	Illinois	Indiana	Iowa	Kansas
US	1.000																	
Alabama	0.427	1.000																
Alaska	0.027	-0.177	1.000															
Arizona	0.689	0.321	-0.178	1.000														
Arkansas	0.006	0.514	0.023	0.176	1.000													
California	0.888	0.308	-0.025	0.454	-0.300	1.000												
Colorado	0.646	-0.125	0.232	0.668	0.008	0.498	1.000											
Connecticut	0.794	0.334	-0.201	0.521	-0.207	0.746	0.340	1.000										
Delaware	0.686	0.274	-0.234	0.472	-0.140	0.717	0.553	0.531	1.000									
District of Columbia	-0.177	0.151	0.070	-0.607	-0.125	0.060	-0.418	-0.364	0.060	1.000								
Florida	0.829	0.470	-0.130	0.631	-0.131	0.794	0.378	0.653	0.661	-0.015	1.000							
Georgia	0.721	0.327	-0.352	0.892	0.160	0.524	0.616	0.670	0.559	-0.633	0.629	1.000						
Hawaii	-0.176	0.125	-0.017	-0.677	-0.142	0.094	-0.504	-0.223	-0.037	0.877	-0.151	-0.625	1.000					
Idaho	-0.096	0.022	0.230	-0.275	0.295	-0.123	-0.132	-0.249	-0.377	0.235	-0.156	-0.280	0.251	1.000				
Illinois	0.821	0.324	-0.245	0.720	0.166	0.595	0.575	0.755	0.522	-0.445	0.580	0.813	-0.352	0.016	1.000			
Indiana	0.678	0.461	-0.315	0.723	0.440	0.383	0.476	0.494	0.471	-0.367	0.543	0.766	-0.326	0.032	0.841	1.000		
Iowa	0.333	0.360	0.321	0.134	0.431	0.101	0.014	0.223	-0.125	-0.057	0.026	0.007	0.083	0.276	0.399	0.375	1.000	
Kansas	0.599	0.036	0.477	0.479	-0.037	0.476	0.665	0.307	0.347	-0.152	0.346	0.270	-0.236	-0.283	0.343	0.190	0.390	1.000
Kentucky	0.333	0.531	-0.157	0.488	0.647	-0.019	0.210	0.234	0.272	-0.283	0.172	0.494	-0.270	-0.211	0.496	0.694	0.451	0.169
Louisiana	0.185	-0.165	0.857	-0.056	0.112	0.086	0.366	-0.018	-0.185	-0.089	-0.134	-0.173	-0.079	0.306	0.023	-0.161	0.472	0.551
Maine	0.655	0.517	-0.217	0.307	-0.269	0.729	-0.014	0.689	0.505	0.177	0.868	0.382	0.116	-0.076	0.438	0.328	0.053	0.063
Maryland	0.650	0.491	-0.257	0.272	-0.315	0.753	-0.011	0.629	0.571	0.304	0.848	0.338	0.225	-0.179	0.390	0.268	0.020	0.164
Massachusetts	0.825	0.253	-0.239	0.648	-0.298	0.827	0.468	0.825	0.578	-0.286	0.849	0.742	-0.304	-0.172	0.718	0.497	-0.033	0.314
Michigan	0.619	0.359	-0.391	0.842	0.296	0.359	0.518	0.430	0.481	-0.477	0.614	0.888	-0.559	-0.164	0.734	0.858	0.049	0.206
Minnesota	0.847	0.488	-0.104	0.824	0.137	0.651	0.544	0.696	0.610	-0.346	0.744	0.748	-0.355	-0.336	0.730	0.763	0.384	0.600
Mississippi	-0.080	0.347	0.233	0.188	0.772	-0.442	-0.038	-0.198	-0.415	-0.317	-0.182	0.099	-0.325	0.387	0.162	0.379	0.520	-0.062
Missouri	0.669	0.487	-0.268	0.713	0.269	0.437	0.304	0.770	0.370	-0.572	0.559	0.753	-0.509	-0.191	0.763	0.692	0.385	0.312
Montana	-0.191	-0.099	0.618	-0.323	0.171	-0.203	0.037	-0.565	-0.117	0.509	-0.212	-0.578	0.364	0.221	-0.415	-0.207	0.256	0.255
Nebraska	-0.037	0.335	0.351	-0.169	0.568	-0.209	-0.223	-0.240	-0.316	0.223	-0.209	-0.304	0.277	0.238	-0.087	0.075	0.739	0.251
Nevada	0.541	0.422	0.033	0.401	0.293	0.321	0.125	0.488	0.024	-0.248	0.394	0.408	-0.098	0.339	0.654	0.604	0.678	0.125
New Hampshire	0.398	0.474	-0.262	0.581	0.037	0.263	-0.019	0.628	0.056	-0.535	0.504	0.588	-0.495	-0.322	0.417	0.389	0.156	0.075
New Jersey	0.589	0.535	-0.367	0.167	-0.235	0.664	-0.127	0.664	0.508	0.297	0.758	0.292	0.314	-0.131	0.423	0.329	0.091	0.018
New Mexico	-0.389	-0.301	0.579	-0.184	0.397	-0.569	0.106	-0.630	-0.592	-0.102	-0.591	-0.349	-0.169	0.304	-0.325	-0.218	0.211	0.159
New York	0.800	0.293	-0.140	0.397	-0.294	0.849	0.294	0.888	0.445	-0.125	0.714	0.545	-0.020	-0.128	0.641	0.339	0.134	0.329
North Carolina	0.783	0.513	-0.439	0.633	-0.039	0.730	0.378	0.657	0.790	0.002	0.853	0.695	-0.069	-0.206	0.691	0.711	-0.006	0.211
North Dakota	-0.206	-0.114	0.756	-0.169	0.323	-0.332	0.086	-0.472	-0.285	0.072	-0.325	-0.412	-0.013	0.085	-0.379	-0.189	0.394	0.421
Ohio	0.732	0.492	-0.271	0.840	0.351	0.440	0.507	0.639	0.503	-0.514	0.547	0.853	-0.454	-0.206	0.845	0.901	0.394	0.368
Oklahoma	0.095	-0.242	0.904	-0.109	0.100	0.002	0.406	-0.215	-0.151	0.057	-0.174	-0.288	-0.020	0.168	-0.144	-0.218	0.339	0.600
Oregon	0.504	0.145	-0.089	0.526	0.183	0.283	0.337	0.604	0.014	-0.667	0.195	0.573	-0.414	0.043	0.691	0.578	0.556	0.285
Pennsylvania	0.644	0.720	-0.254	0.320	0.088	0.614	0.060	0.519	0.634	0.355	0.713	0.318	0.312	-0.049	0.488	0.558	0.312	0.158
Rhode Island	0.571	0.465	-0.072	0.171	-0.287	0.649	-0.123	0.612	0.260	0.266	0.689	0.176	0.258	-0.066	0.276	0.185	0.208	0.167
South Carolina	0.765	0.578	-0.394	0.608	0.119	0.645	0.296	0.718	0.692	-0.116	0.793	0.730	-0.126	-0.089	0.792	0.741	0.169	0.133
South Dakota	-0.146	0.112	0.088	-0.062	0.431	-0.190	-0.018	-0.490	-0.213	0.274	-0.200	-0.239	0.254	0.318	-0.150	0.121	0.296	0.122
Tennessee	0.207	0.622	-0.459	0.470	0.545	-0.060	-0.018	0.123	0.115	-0.160	0.324	0.478	-0.241	-0.003	0.413	0.690	0.125	-0.203
Texas	0.304	-0.218	0.793	0.125	0.132	0.138	0.627	0.005	0.019	-0.154	-0.079	-0.016	-0.180	0.134	0.146	0.032	0.408	0.707
Utah	0.607	0.043	0.207	0.677	0.209	0.382	0.794	0.412	0.406	-0.589	0.279	0.651	-0.571	-0.105	0.621	0.502	0.303	0.640
Vermont	0.421	0.434	-0.142	-0.061	-0.239	0.541	-0.236	0.376	0.288	0.565	0.603	-0.027	0.541	0.088	0.201	0.142	0.167	0.002
Virginia	0.665	0.319	-0.242	0.291	-0.394	0.830	0.184	0.577	0.683	0.312	0.845	0.358	0.201	-0.208	0.348	0.212	-0.167	0.254
Washington	0.659	0.218	-0.167	0.489	0.107	0.623	0.673	0.344	0.770	0.003	0.475	0.568	-0.012	-0.177	0.563	0.592	0.022	0.367
West Virginia	0.115	0.288	0.288	0.146	0.603	-0.174	0.109	-0.135	-0.035	0.024	-0.045	0.028	-0.059	0.342	0.289	0.360	0.622	0.128
Wisconsin	0.729	0.487	-0.246	0.767	0.407	0.473	0.586	0.384	0.598	-0.179	0.647	0.742	-0.280	0.004	0.766	0.903	0.277	0.338
Wyoming	-0.097	-0.157	0.846	-0.394	-0.004	-0.032	0.036	-0.379	-0.250	0.452	-0.224	-0.609	0.379	0.311	-0.408	-0.476	0.325	0.410

The USA (2)

	Kentucky	*Louisiana*	*Maine*	*Maryland*	*Massachusetts*	*Michigan*	*Minnesota*	*Mississippi*	*Missouri*	*Montana*	*Nebraska*	*Nevada*	*New Hampshire*	*New Jersey*	*New Mexico*	*New York*	*North Carolina*
US																	
Alabama																	
Alaska																	
Arizona																	
Arkansas																	
California																	
Colorado																	
Connecticut																	
Delaware																	
District of Columbia																	
Florida																	
Georgia																	
Hawaii																	
Idaho																	
Illinois																	
Indiana																	
Iowa																	
Kansas																	
Kentucky	1.000																
Louisiana	-0.068	1.000															
Maine	0.008	-0.242	1.000														
Maryland	0.023	-0.256	0.944	1.000													
Massachusetts	0.000	-0.139	0.778	0.722	1.000												
Michigan	0.572	-0.256	0.332	0.327	0.593	1.000											
Minnesota	0.527	-0.018	0.526	0.511	0.683	0.720	1.000										
Mississippi	0.564	0.284	-0.268	-0.388	-0.302	0.243	0.066	1.000									
Missouri	0.497	-0.043	0.483	0.409	0.643	0.681	0.798	0.232	1.000								
Montana	0.003	0.435	-0.317	-0.260	-0.532	-0.385	-0.202	0.165	-0.535	1.000							
Nebraska	0.312	0.437	-0.199	-0.167	-0.428	-0.152	0.077	0.512	0.045	0.453	1.000						
Nevada	0.493	0.225	0.381	0.276	0.356	0.384	0.442	0.469	0.489	-0.074	0.294	1.000					
New Hampshire	0.263	-0.259	0.533	0.413	0.601	0.472	0.599	0.181	0.752	-0.597	-0.111	0.363	1.000				
New Jersey	0.074	-0.357	0.918	0.920	0.665	0.247	0.474	-0.333	0.417	-0.321	-0.108	0.343	0.437	1.000			
New Mexico	0.032	0.575	-0.749	-0.723	-0.596	-0.202	-0.348	0.543	-0.350	0.495	0.395	-0.137	-0.370	-0.801	1.000		
New York	-0.017	-0.005	0.759	0.731	0.880	0.320	0.573	-0.364	0.565	-0.489	-0.238	0.428	0.516	0.742	-0.603	1.000	
North Carolina	0.332	-0.405	0.748	0.768	0.782	0.714	0.760	-0.227	0.590	-0.315	-0.276	0.287	0.421	0.744	-0.654	0.638	1.000
North Dakota	0.070	0.607	-0.486	-0.478	-0.548	-0.298	-0.063	0.370	-0.259	0.755	0.651	-0.090	-0.321	-0.532	0.626	-0.500	-0.492
Ohio	0.736	-0.066	0.332	0.318	0.541	0.857	0.869	0.316	0.838	-0.351	0.070	0.553	0.542	0.305	-0.235	0.417	0.689
Oklahoma	-0.075	0.875	-0.337	-0.337	-0.247	-0.324	-0.047	0.180	-0.246	0.633	0.414	-0.001	-0.378	-0.411	0.642	-0.131	-0.398
Oregon	0.379	0.195	0.095	-0.001	0.413	0.418	0.557	0.302	0.661	-0.416	0.137	0.679	0.523	0.121	-0.069	0.462	0.191
Pennsylvania	0.418	-0.253	0.749	0.767	0.470	0.356	0.613	-0.052	0.409	0.034	0.110	0.450	0.282	0.812	-0.619	0.490	0.789
Rhode Island	-0.019	-0.103	0.862	0.863	0.612	0.150	0.469	-0.259	0.384	-0.165	0.005	0.368	0.510	0.819	-0.528	0.725	0.583
South Carolina	0.501	-0.230	0.722	0.721	0.702	0.711	0.688	0.044	0.691	-0.380	-0.158	0.541	0.436	0.704	-0.619	0.609	0.846
South Dakota	0.036	0.076	-0.344	-0.299	-0.365	-0.059	-0.038	0.317	-0.238	0.493	0.575	0.002	-0.273	-0.254	0.334	-0.379	-0.167
Tennessee	0.650	-0.493	0.246	0.199	0.209	0.673	0.402	0.527	0.438	-0.185	0.014	0.337	0.480	0.257	-0.080	0.022	0.509
Texas	0.091	0.871	-0.319	-0.306	-0.078	-0.082	0.166	0.195	-0.022	0.468	0.324	0.128	-0.291	-0.376	0.582	0.009	-0.211
Utah	0.353	0.464	-0.055	-0.068	0.361	0.507	0.598	0.185	0.530	-0.173	0.103	0.299	0.168	-0.122	0.094	0.264	0.240
Vermont	-0.038	-0.259	0.791	0.809	0.450	0.017	0.247	-0.315	0.076	0.046	0.000	0.358	0.176	0.852	-0.575	0.584	0.548
Virginia	-0.146	-0.258	0.855	0.919	0.774	0.298	0.491	-0.585	0.304	-0.219	-0.292	0.084	0.280	0.830	-0.725	0.743	0.781
Washington	0.427	-0.057	0.217	0.287	0.420	0.545	0.533	-0.187	0.218	0.049	-0.190	0.239	-0.128	0.241	-0.262	0.350	0.615
West Virginia	0.588	0.374	-0.105	-0.155	-0.244	0.154	0.114	0.707	0.129	0.375	0.556	0.498	-0.145	-0.157	0.348	-0.261	-0.061
Wisconsin	0.653	-0.108	0.364	0.354	0.509	0.845	0.753	0.264	0.556	-0.062	0.073	0.528	0.241	0.337	-0.208	0.324	0.746
Wyoming	-0.288	0.763	-0.246	-0.201	-0.397	-0.618	-0.268	0.049	-0.491	0.767	0.497	-0.054	-0.507	-0.278	0.509	-0.209	-0.480

The USA (3)

	North Dakota	*Ohio*	*Oklahoma*	*Oregon*	*Pennsylvania*	*Rhode Island*	*South Carolina*	*South Dakota*	*Tennessee*	*Texas*	*Utah*	*Vermont*	*Virginia*	*Washington*	*West Virginia*	*Wisconsin*	*Wyoming*
US																	
Alabama																	
Alaska																	
Arizona																	
Arkansas																	
California																	
Colorado																	
Connecticut																	
Delaware																	
District of Columbia																	
Florida																	
Georgia																	
Hawaii																	
Idaho																	
Illinois																	
Indiana																	
Iowa																	
Kansas																	
Kentucky																	
Louisiana																	
Maine																	
Maryland																	
Massachusetts																	
Michigan																	
Minnesota																	
Mississippi																	
Missouri																	
Montana																	
Nebraska																	
Nevada																	
New Hampshire																	
New Jersey																	
New Mexico																	
New York																	
North Carolina																	
North Dakota	1.000																
Ohio	-0.185	1.000															
Oklahoma	0.728	-0.193	1.000														
Oregon	-0.128	0.646	-0.008	1.000													
Pennsylvania	-0.253	0.500	-0.261	0.106	1.000												
Rhode Island	-0.326	0.248	-0.155	0.128	0.666	1.000											
South Carolina	-0.490	0.754	-0.417	0.334	0.770	0.474	1.000										
South Dakota	0.491	-0.068	0.200	-0.022	0.063	-0.248	-0.224	1.000									
Tennessee	-0.274	0.575	-0.472	0.158	0.449	0.148	0.518	0.117	1.000								
Texas	0.611	0.096	0.928	0.239	-0.195	-0.163	-0.215	0.110	-0.382	1.000							
Utah	0.165	0.644	0.361	0.626	0.024	-0.158	0.325	0.026	-0.067	0.608	1.000						
Vermont	-0.329	0.025	-0.224	-0.089	0.738	0.798	0.451	-0.100	0.187	-0.288	-0.391	1.000					
Virginia	-0.447	0.224	-0.257	-0.076	0.673	0.745	0.620	-0.206	0.055	-0.226	0.010	0.730	1.000				
Washington	-0.185	0.526	0.005	0.200	0.479	0.062	0.554	0.018	0.202	0.199	0.451	0.192	0.401	1.000			
West Virginia	0.350	0.291	0.331	0.106	0.224	-0.159	0.208	0.281	0.303	0.328	0.247	-0.057	-0.310	0.098	1.000		
Wisconsin	-0.151	0.812	-0.095	0.394	0.619	0.194	0.735	0.179	0.611	0.106	0.538	0.214	0.356	0.737	0.419	1.000	
Wyoming	0.706	-0.476	0.846	-0.259	-0.135	-0.035	-0.475	0.341	-0.567	0.668	0.008	0.020	-0.147	-0.169	0.274	-0.309	1.000

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