BUSINESS CYCLE SYNCHRONIZATION IN THE EUROPEAN UNION: THE EFFECT OF THE COMMON CURRENCY

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ABSTRACT

In this paper, I analyse the synchronization of business cycles within the E.U., as this is an important ingredient for the implementation of a successful monetary policy. The business cycles of twelve E.U. countries and two groups of countries are extracted for the period 1989Q1-2010Q2 using as a benchmark series for the comparisons the cycle of G3, the group of the largest European economies (Germany, France and Italy). The sensitivity of the data to alternative cycle extraction methodologies is explored employing the Hodrick-Prescott and Baxter-King filters using alternative parameter specifications and leads/lags. The strength of cycle synchronization is measured using linear regressions, cross-correlation coefficients and the Cycle Synchronization Index (CSI). To assess whether synchronization is stronger after the introduction of the common currency, we also test two sub-samples pre- and post-EMU (1999Q1). The empirical results provide evidence that cycle synchronization within the eurozone's has become stronger in the common currency period.

Keywords: Business Cycle, Synchronization, Eurozone.

JEL classification: E32, E52, C53

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1. Introduction

The European economic and monetary union is a reality since 1999, when eleven[1] of the fifteen members of the European Union adopted a common currency, the euro. In 2002 the euro was put in circulation by the European Central Bank (ECB) and substituted the national currencies of participant countries. Many economists have criticised the effectiveness of the creation of a common currency area between such a diverse group of countries. The criticism stemmed from the question whether the business cycles of this group of countries is adequately synchronized so that across-the-board monetary policy will be effective to all countries in the group. If business cycles are not synchronized, then monetary policy will be ineffective and even destabilizing for some countries: countries that face an expansionary phase in their cycle will require a contractionary monetary policy to defuse inflationary pressure and countries that are in a recession will require an expansionary monetary policy to stimulate growth. De Grawue (2000) points that wage and labour mobility rigidities within the E.U. combined with the lack of monetary policy can increase the costs of a country participating in the monetary union. Altavilla (2004) stresses that weak synchronization can produce asymmetric transmission of ECB's monetary policy while cycle synchronization can reduce the probability of asymmetric shock transmission within the EMU. Emerson et al. (1992) conclude that a common currency, increased trade and financial integration lead to better cycle synchronization. On the contrary, Krugman (1991) believes that EMU countries' business cycles will become less synchronized as commercial integration will lead to a specialization process in national economies. Thus, the issue of whether EU's business cycles are synchronized is very important to both academics and policy makers.

Several studies in the empirical literature deal with shedding light to this issue. Their approach is diverse in three respects: the way business cycles are extracted, how synchronization is measured and which countries are included in the sample and which are used as the reference cycle, resulting in mixed and conflicting results. Most recent business cycle studies define the cycles as deviations from a long-term "trend", contrary to the classical absolute expansions and contractions in real output that was measured by Burns and Mitchell (1946). The reason is that the former creates a business cycle measure with the property of stationarity and with respect to the later, as economies grow in absolute terms over time, absolute recessions appear much less frequent. Some studies, in an effort to use longer and higher frequency data, instead of dealing with the GDP, use the industrial production index

[1] Greece joined the monetary union in 2001.

as a proxy for aggregate economic activity although, as it is pointed by De Haan et. Al. (2008), this measure suffers from high volatility and it accounts for less than 20% of eurozone's aggregate output. This is the reason, in this paper, I follow the GDP approach.

Several methods are used in the literature in extracting the cycles from the long-term trend. Some examples are: Christodoulakis et al. (1995), Dickerson et al. (1998), and Inklaar and Haan (2001) that use the Hodrick-Prescott (1997) (HP) filter. Wynne and Koo (2000), Bergman (2008) and Gouveia and Correia (2008) employ the Baxter and King (1995) (BK) band pass filter. Several studies also, in an effort to improve the robustness of their results to the extraction methodology, employ more than one cycle extraction methods: Altavilla (2004), Perez et al. (2007) and Darvas and Szapary (2008) use both the HP and the BK filter, Montoya and de Haan (2008) employs the HP and the Christiano–Fitzgerald (2003) filter. Massmann and Mitchell (2004) extract the cycles using seven alternative methods[2]. Other significant and very promising[3] line of research follows the time-frequency approach. A prominent example is Hallet and Richter (2008) that deal with a set of five EU countries and Leon and Georgikopoulos (2006) studying the case of Greece. Canova (1998), among others, highlights the problem of the sensitivity of the results to the detrending methodologies.

In measuring the strength of cycle synchronization most studies use a correlation coefficient, but there are some different approaches as well: Koopman and Azevedo (2003) use phase correlations by estimating an unobserved components model, while Croux et al. (2001) use the dynamic correlation that is defined in the frequency domain and Harding and Pagan (2002) applied a non-parametric concordance index that utilizes a binary indicator of cycle phases. Altavilla (2004) calculates a concordance index and cross-correlations.

In calculating potential historical changes in the strength of cycle synchronization as a result of stronger economic integration within the E.U. an obvious approach is to compare the correlation coefficients in two sub-samples arbitrarily separated by important policy changes such as the formation of the Exchange Rate Mechanism I (ERM I). In this respect, see Artis and Zhang (1997) and (1999), Dickerson et al. (1998) and Wynne and Koo (2000). Inklaar and Haan (2001) follow the two papers by Artis and Zhang (1997) and (1999) using the same set of countries but distinguishing

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[2] Beveridge-Nelson decomposition, unobserved components models, linear regression models, moving average, phase-average-trend, Hodrick–Prescott and Baxter–King filters.

[3] See the discussion on the advantages of using the time-frequency approach in page 73 of Hallet and Richter (2008).

four sub-periods. Massmann and Mitchell (2004), avoiding the arbitrary selection of sub-samples, use rolling windows.

The empirical evidence on the strength of cycle synchronization within E.U. countries is somewhat conflicting. Artis and Zhang (1997) and (1999) find that ERM[4] countries' cycle affiliation shifted from the U.S. to Germany after the formation of the ERM. In contrast, Dickerson et al. (1998) and Inklaar and de Haan (2001) find that these cycles are less synchronized in the ERM era. Massmann and Mitchell's (2004) rolling windows approach supports the evidence of Inklaar and de Haan (2001) as they find that cycle correlations are getting stronger in the 1970's reaching a maximum of 0.80 but become statistically insignificant in the mid to late 1980's. They rise again in the late 1980's and drop significantly in the early 1990's. Montoya and de Haan (2008) arrive at similar results studying the period 1975-2005. Agresti and Mojon (2003) find high correlations for most countries with the exception of some peripheral economies (Greece, Portugal and Finland). Altavilla (2004) although finds that cycle synchronization is lower than expected, nonetheless, EMU countries' business cycles affiliation appear to have moved from the U.S. to the euro area and also his results support the existence of a common European macroeconomic cycle. Bergman (2008) concentrating on Sweden and Finland found that Sweden's decision not to join the EMU in 1999 has reversed its previous cycle synchronization trend towards the European cycle, while Finland's decision to join the common currency strengthened its previously weak cycle synchronization to the European one. Darvas and Szapary (2008) studying new and old EU members find evidence in support of increased synchronization after the participation in the EMU. Fidrmuc and Korhonen (2006) in a survey study focusing on CEEC[5] find that cycle synchronization is adequately high not to hinder monetary union membership. Gouveia, and Correia, (2008) find that synchronization is not uniform: large countries appear increasingly synchronized while Spain, Belgium, the Netherlands and Greece appear less synchronized since the EMU. Hallet and Richter (2008) find that there is no general convergence, but rather some tendency towards convergence in short run volatility at the cost of business cycle lengths. Wynne and Koo (2000) present empirical evidence supporting the claim by Frankel and Rose (1998) that countries with developed commercial relations between them present higher cross-correlation of their business cycles. On the other hand, de Haan et al. (2002) conclude that a common currency can weaken synchronization across countries by removing the stabilizing properties of exchange rate changes.

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[4] E.U.'s Exchange Rate Mechanism (ERM) was established in 1979 providing increased exchange rate stability for member countries.

[5] Central and East European Countries.

Most of these studies use as a critical point of comparison the establishment of the ERM as data availability in the recent years after the introduction of the common currency hindered the power of statistical tests. In this paper, I use data that span ten years before the common currency, 1989Q1-1998Q4, to twelve and a half years after the introduction of the euro. In this manner, I use a balanced mix of pre and expanded up-to-date post EMU observations in the effort to assess the possible changes in the strength of business cycle synchronization. The data involve twelve E.U. countries and two groups of countries G3 and G9 that represent E.U.'s largest and smaller countries respectively in terms of real GDP share. G3's cycle is used as the benchmark for measuring the strength of the synchronization.

The contribution of the paper is the use of a sample that extends to 2010Q2 covering more than twelve years after the monetary union and the use of three alternative methodologies of measuring the cycle synchronization. Another contribution is the use of the proposed Cycle Synchronization Index (CSI) that differs from the concordance index proposed by Harding and Pagan (2002) in that it is applied to the detrended real GDP series. The detrending is done with a HP filter and the sensitivity of the resulting cycles is explored with the use a various λ parameters for the HP filter and also the use of the BK filter with various leads/lags structures. Then, a binomial distribution is used to formally test whether the CSIs are stronger after the monetary union.

The rest of the paper is organized as follows: Section 2 discusses the data used, Section 3 describes the three methodologies employed to measure the strength of the cycle synchronization and in Section 4 I present the empirical results. Finally, in Section 5 I summarize the conclusions.

2. The Data

The data used in the paper are drawn from the OECD database. I use quarterly real GDP seasonally adjusted[6]. The data span the period from 1989Q1 to 2010Q2 for a total of 86 observations. They include twelve counties, Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal and Spain. These are the countries[7] that on January 1st 1999 joined Stage Three of the Economic and Monetary Union adopting the euro as their common currency and ceding monetary policy to the European Central Bank. In the

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[6] OECD subject B1_GE, measure VOBARSA.

[7] Greece joined Stage Three of the EMU on January 1st 2001 but the euro replaced the national currency on January 1st 2002 the same data with the other eleven countries.

empirical part of this paper I also use two groups of countries: G3 that includes France, Germany and Italy, the three largest countries in terms of GDP[8] share and G9 that includes the rest nine countries. The data are next transformed into natural logarithms. A summary of descriptive statistics is presented in Table 1.

The aim of the paper is to investigate whether after the introduction of the common currency the synchronization of the business cycles is stronger. Cycle synchronization is considered as an important ingredient of successful monetary policy within a currency area. Thus, in an effort to extract the cyclical component of the GDP, we apply a Hodrick-Prescott (1997) (HP) filter that is commonly used in the literature dealing with business cycles[9] to decompose a series' short-term fluctuations from the trend dynamics. The HP filter produces a smooth non-linear trend that is more sensitive to long-term fluctuations of the time series rather than the short-term ones. Furthermore, I have addressed the issue described in the literature of possible biasedness of the cycle obtained by the HP filter by investigating the robustness of the results to alternative decompositions of the GDP time-series. In doing so, we first extract the cyclical component of the EU GDP using alternative specifications for the HP λ parameter (i.e. instead of the standard λ = 1600 we use 1000 and 2200). We also employed the Baxter and King (1995) filter (BK) and extract the cycle using alternatively eight, twelve and sixteen leads/lags. In Figure 1, I present the cycles extracted as above with alternative λs and leads/lags with the HP and BK filters respectively for the case of Germany. As the qualitative results of the extracted cyclical components for both the alternative λ specifications for the HP filter and the BK filter are quite similar for all countries to the ones obtained by the standard HP filter, for the rest of the paper, I continue the analysis with the cycles extracted with the standard HP filter with λ = 1600. In Figure 2, I present the extracted cycles from the fourteen GDP time series.

3. The Methodology

In the effort to investigate the degree of synchronization of economic cycles for the fourteen countries and groups of countries, I will compare each extracted cycle to the cycle of the G3. The justification for such comparison is that since France, Germany and Italy produce more than two thirds of the total GDP, it is important for the "small" countries that participate in the same monetary union to

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[8] For 2010Q2 their share in the total 12-country GDP is 67.85%.

[9] Cogley, T. and J. M. Nason., (1995), Effects of the Hodrick-Prescott Filter on Trend and Difference Stationary Time Series: Implications for Business Cycle Research, Journal of Economic Dynamics and Control.

have their cycles synchronized with the G3. Synchronized cycles is one of the criteria of an optimal currency area according to Mundell (1961), since asymmetric shocks within a monetary union make it difficult for the central bank to conduct monetary policy that is appropriate to all member countries and especially the smaller ones. We investigate the issue of synchronization both in the full sample from 1989Q1 to 2010Q2 and also in the two sub-samples before and after the monetary union that occurred in 1999Q1 (for Greece in 2001Q1).

3.1 Linear Regressions

The first method employed here to examine the degree of synchronization of economic cycles is a linear regression. We regress the extracted cyclical component of the logarithms of the seasonally adjusted real GDP of each country and G9 against the cyclical component of G3:

$$\ln(c_{i,t}) = a_i + \beta_i \ln(c_{G3,t}) + \sum_{k=1}^{j} \gamma_i \ln(c_{i,t-k}) + \varepsilon_{i,t} \quad (1)$$

$c_{i,t}$ represents the corresponding country's extracted cyclical component, and $c_{G3,t}$ is the extracted cyclical component of G3. In Equation 1, the value of *j* is selected such that $\varepsilon_{i,t}$ is not serially correlated according to the Q(16) test statistic of Ljung-Box (1978). In the effort to investigate whether in the period after the monetary union and the introduction of the euro the degree of cycle synchronization has strengthened we also estimate the following regression for all countries:

$$\ln(c_{i,t}) = a_i + \beta_i \ln(c_{G3,t}) + \delta_i \ln(c_{G3,t}) D_{MU} + \sum_{k=1}^{j} \gamma_i \ln(c_{i,t-k}) + \varepsilon_{i,t} \quad (2)$$

where D_{MU} is a slope dummy variable that takes the value one with the monetary union and the introduction of the euro in 1999Q1 onwards and for all countries, with the exception of Greece[10] where this date is 2001Q1, and zero elsewhere. In Table 2, Panel A, we present the results from the estimation of Equation 1 for the twelve countries and G9. In Panel B, we display the results from a Chow break point test using an F, log likelihood and Wald statistic with an assumed break point at 1999Q1 for all regressions with the exception again of Greece where the break point is set at 2001Q1. In Table 3 we present the estimated slope dummies from Equation 2.

[10] For the rest of the paper for Greece we use 2001Q1 as the introduction period of the common currency in all estimations and tests although not explicitly stated from here on.

3.2 Cross-Correlations

The next methodology employed is the comparison of the cross-correlation coefficients. We calculate the cross-correlations as:

$$\rho_{i,G3} = \frac{\sigma_{i,G3}}{\sigma_i \sigma_{G3}} \qquad (3)$$

Where σ_i and σ_{G3} are country *i*'s and *G3*'s standard deviations of the extracted cyclical component and σ_{iG3} represents their covariance. We calculate the cross-correlations for the full sample 1989Q1-2010Q2 and for the two sub-samples before the monetary union 1989Q1-1998Q4 and after the introduction of the common currency in 1999Q1-2010Q2. These are presented in Panel A of Table 4. To assess whether these cross-correlations increased in the two sub-samples implying a stronger synchronization after the implementation of the monetary union in 1999Q1, in Panel B of Table 4 I test whether the coefficients have different strengths in the two sub-samples. I perform a two-tailed test of the null hypothesis $H_0: \rho^1_{i,G3} = \rho^2_{i,G3}$ and a one-tailed test of the null hypothesis $H_0: \rho^1_{i,G3} < \rho^2_{i,G3}$ and the results are reported in the first and second column of Panel B respectively.

3.3 Cycle Synchronization Index

The third methodology employed in this paper in assessing the degree of business cycle synchronization is the proposed Cycle Synchronization Index (CSI). With the CSI, we measure the sign concordance of the cyclical component series of each country and the G3. For every quarter that one country's cycle has the same sign with G3, positive or negative, the two cycles for that quarter are said to be synchronized. They are both either above or below their long-run trend and the uniform monetary policy implemented by the ECB is efficient. The higher the cycle sign concordance of a country with G3 the stronger the degree of business cycle synchronization. The CSI is calculated as follows:

$$CSI_{i,G3} = \frac{\sum_{j=1}^{n} k_j}{n} \qquad (4)$$

$$k_j = \begin{cases} 1 \ if \ \ sign(c_{i,j}) = sign(c_{G3,j}) \\ 0 \ if \ \ sign(c_{i,j}) \neq sign(c_{G3,j}) \end{cases}$$

where $CSI_{i,G3}$ is the cycle synchronization index of country *i* with the group of the largest economies G3 and $c_{i,j}$, $c_{G3,j}$ represent the cyclical components at quarter *j* of country i and G3 respectively. Thus, $0 \leq CSI_{i,G3} \leq 1$ and it can be perceived as the percentage of the quarters for which the business cycles between each country and G3 are synchronized. We also calculate the CSI for the sub-samples before and after the introduction of the common currency 1989Q1-1998Q4 and 1999Q1-2010Q2 respectively. To formally assess the significance of the changes in the CSIs in the two sub-samples we perform a test of differences using a binomial distribution. These results are summarized in the first three columns of Table 5.

4. Empirical Results

4.1 Regression Results

In Table 2 we present the results from the regressions of each country's cycle series to the cycle of G3. We observe that for all countries all cycles are positively related to that of the G3 and they are statistically significant to probabilities less than 0.01. Germany (not surprisingly), Ireland and Luxemburg demonstrate the highest degree of synchronization with β = 1.070, 0.875 and 0.648 respectively, but the corresponding R^2 for the last two are 0.658 and 0.582 respectively. The lowest degree of synchronization is found for Austria, Finland and Greece with β = 0.282, 0.338 and 0.414 respectively. The corresponding R^2 is high 0.929 and 0.837 for the first two countries but only 0.182 for Greece. These results are qualitatively consistent with Agresti and Mojon (2003). According to the Chow break point test presented in the last three columns of Table 2, we find evidence[11] of a break point on the date of the adoption of the euro for the case of Finland, Greece, Ireland, Italy, Luxemburg, Netherlands and Spain. In Table 3, we present the coefficient estimates of the slope dummy from Equation 2. As we can see the slope dummy is statistically significant only for the case of Finland and the Netherlands with a positive estimated coefficient implying that only for these two countries synchronization is significantly stronger after the introduction of the common currency.

4.2 Correlations Results

In Table 4, we present the results from the calculation of the cross-correlation coefficients. In column one we report the results for the whole sample 1989Q1 to 2010Q2. In columns two and three we report the cross-correlation coefficients for the two sub-samples, the period prior to the adoption of the euro, 1989Q1 to 1998Q4 and the common currency period, 1999Q1 to 2010Q2. All cross-correlation coefficients appear higher in the second sub-sample, implying a stronger degree of cycle synchronization after the adoption of the euro and the formation of

[11] In various p-levels depending on the test statistic of reference.

the common currency area. In column four of Table 4 we formally test, using a two-tailed test for each country, the null hypothesis that the two cross-correlation coefficients are equal. Similarly, in column five we test using a one-tailed test the null hypothesis that the cross-correlations of the second sub-sample are stronger than the ones in the first sub-sample. In the two-tailed test we reject the null hypothesis at significance level 1% for Finland, France, Germany, Italy and Luxemburg, at the 5% level for Ireland and the G9 and at the 10% level for Belgium and Spain. The null hypothesis cannot be rejected only for the cases of Austria and Portugal. In the one-tailed test the results are similar and we reject the null at the 1% level for Finland, France, Germany, Ireland, Italy, Luxemburg and the Netherlands, at the 5% level for Spain and G9 and at the 10% level for Austria and Greece. We cannot reject the null only for the case of Portugal. Thus, the correlation coefficient results provide strong evidence in support of a stronger cycle synchronization in the euro era.

4.3 Cycle Synchronization Index Results

In Table 5, we summarize the results of the CSI calculations: column one reports the CSI for the whole sample 1989Q1-2010Q2 while in columns two and three we calculate the CSI for the two sub-samples 1989Q1 – 1998Q4 and 1999Q1 – 2010Q2, pre and post euro respectively. In the last column we report for each country the difference in the CSI between the two sub-samples. This provides evidence on the strengthening or loosening of synchronization after the creation of the common currency area and the introduction of the euro. As expected, in the full sample calculation of the CSI, Germany, France and Italy display the strongest degree of synchronization with indexes 0.930, 0.895 and 0.884 respectively. The worst CSIs are found for Greece, Finland and Luxemburg with 0.547, 0.674 and 0.709 respectively, these results are consistent with Agresti and Mojon (2003). The calculation of the CSIs for the pre- and post-euro era reveals whether the degree of synchronization of each country with G3, no matter if it was high or low before the monetary union, has actually strengthened. In the last column of Table 5 we report the difference in the CSIs between the two periods and we can see that the CSIs are higher in the euro era for all countries of our sample with the exception of Belgium, France and Greece where the differences are -0.046, -0.009 and -0.036 respectively. This result supports the strengthened synchronization in the post-euro period. These results are also depicted in Figure 3. Though, to formally assess the significance of the improvement in the CSIs in the two sub-samples, I perform a test of differences using a binomial distribution. I find that the CSI differences in the two sub-samples are significantly different implying a strengthening of the cycle synchronization for the cases of Finland at the 99% level and Luxemburg at the 95% level. The finding that, in ten out of the thirteen countries (and G9) tested, synchronization was stronger in the later period in terms of the CSIs, but only for the case of Finland and

Luxemburg we find the CSI differences statistically significant may indicate either that the power of the test is not high enough to get more rejections or that synchronization actually did not change after 1999Q1.

5. Conclusions

In this paper, we have employed three methodologies in the effort to assess whether the degree of business cycle synchronization within the European Union has strengthened or weakened after the introduction of the common currency in 1999. This is an interesting question as business cycle synchronization is considered an important ingredient of a successful monetary policy within a common currency area. The regression results show a positive and statistical significant relation of all countries' cycles to that of the G3. The corresponding Chow break-point-tests provide strong evidence of a break point on the date of the adoption of the euro as the common currency for the case of Finland, Greece, Ireland, Italy, Luxemburg, Netherlands and Spain. The slope dummy on the other hand appears significant only for Finland and the Netherlands. The cross-correlation of each country's cycle to the G3 provides evidence of stronger cycle synchronization[12] for all countries after the introduction of the euro, as all correlations are higher in the post-euro era and the differences are statistically significant for all countries with the exception of Portugal. The evidence from the proposed Cycle Synchronization Index (CSI) shows that cycle synchronization is stronger after the monetary union in all countries, with the exception of Belgium, France and Greece where synchronization appears slightly weakened. A formal test of the difference in the pre and post euro indices is significant only for Finland and Luxemburg. This may be the result of either the low power of the test due to the limited number of available observations or of no actual differences in the CSIs. Overall, the empirical analyses presented in this paper, provide evidence that the cycle synchronization within eurozone's economies has certainly not weaken and there is adequate empirical evidence that it became stronger in the post euro period. Especially the cycle of G9, the group of the smaller economies for which a non synchronous to G3 cycle will mean an ineffective and possibly destabilizing monetary policy, appears to be adequately synchronized across all three methodologies in the full ple, but the results show a statistically significant stronger synchronization in the common currency era only in the correlation coefficients methodology and in one case of the Chow-break-point tests. Certainly, though, the evidence shows that G9 synchronization did not weaken in the common currency period.

[12] Either at the 1%, 5% or10% significance.

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Table 1. Sample Discriptive Statistics

Statistic	Austria	Belgium	Finland	France	Germany	Greece	Ireland
Mean	12.197	12.395	11.742	14.142	14.495	11.824	11.414
Median	12.220	12.415	11.749	14.153	14.514	11.800	11.499
Maximum	12.419	12.588	12.035	14.321	14.650	12.121	11.952
Minimum	11.951	12.176	11.472	13.948	14.269	11.523	10.758
Std. Dev.	0.138	0.127	0.180	0.120	0.098	0.190	0.393
Skewness	-0.042	-0.067	0.043	-0.026	-0.455	0.241	-0.209
Kurtosis	1.722	1.616	1.593	1.486	2.328	1.540	1.497
Jarque-Bera	5.881	6.924	7.120	8.223	4.589	8.469	8.717
Probability	0.053	0.031	0.028	0.016	0.101	0.014	0.013

	Italy	Luxemburg	Netherlands	Portugal	Spain	G9	G3
Mean	13.952	9.913	12.870	11.667	13.318	14.473	15.321
Median	13.961	9.932	12.916	11.722	13.319	14.492	15.335
Maximum	14.072	10.321	13.106	11.838	13.605	14.736	15.474
Minimum	13.803	9.430	12.575	11.401	13.027	14.193	15.125
Std. Dev.	0.082	0.272	0.162	0.140	0.189	0.176	0.100
Skewness	-0.218	-0.060	-0.240	-0.388	0.071	-0.027	-0.225
Kurtosis	1.631	1.652	1.661	1.562	1.502	1.524	1.761
Jarque-Bera	7.392	6.559	7.248	9.569	8.114	7.822	6.234
Probability	0.025	0.038	0.027	0.008	0.017	0.020	0.044

Table 2. Regressions Results with G3 as the independent variable

Country	AR Lags	A. regression results			B. Chow Break Point Test 1999Q1					
		adj. R^2	Coeff. β	Prob.	F-Stat		Log L		Wald	
Austria	4	0.929	0.282	0.000	0.915		0.887		0.918	
Belgium	2	0.817	0.580	0.000	0.295		0.251		0.285	
Finland	2	0.837	0.338	0.002	0.000	***	0.000	***	0.000	***
France	3	0.917	0.546	0.000	0.203		0.153		0.189	
Germany	3	0.934	1.070	0.000	0.532		0.469		0.528	
Greece[1]	1	0.182	0.414	0.007	0.003	***	0.002	***	0.002	***
Ireland	1	0.658	0.875	0.000	0.004	***	0.003	***	0.003	***
Italy	4	0.918	0.548	0.000	0.087	*	0.051	*	0.072	*
Luxemburg	1	0.582	0.648	0.001	0.011	**	0.008	***	0.008	***
Netherlands	1	0.867	0.466	0.000	0.013	**	0.009	***	0.009	***
Portugal	1	0.686	0.436	0.000	0.514		0.485		0.511	
Spain	1	0.811	0.463	0.000	0.013	**	0.009	***	0.009	***
G9	3	0.885	0.461	0.000	0.124		0.086	*	0.109	

Notes: For Greece the cut-off date is 2001:Q1. One, two and three asterisks denote rejection of the null at the 10%, 5% and 1% respectively.

Table 3. Slope Dummy Estimation Results

		Slope Dummy		
Country	AR Lags	Coefficient	Prob.	
Austria	4	0.073	0.341	
Belgium	2	-0.043	0.680	
Finland	2	0.631	0.003	***
France	3	-0.027	0.679	
Germany	3	-0.117	0.161	
Greece*	1	-0.008	0.979	
Ireland	1	0.380	0.206	
Italy	4	0.108	0.161	
Luxemburg	1	0.434	0.161	
Netherlands	1	0.324	0.001	***
Portugal	1	-0.222	0.168	
Spain	1	0.062	0.612	
G9	3	0.147	0.126	

Notes: For Greece the cut-off date is 2001:Q1. One, two and three

Table 4. Correlation Coefficients with G3

	A. Cross-Correlation Coefficients			B. Correlation Coef. Tests of Difference			
	1989Q1 - 2010Q2	1989Q1 - 1998Q4	1999Q1 - 2010Q2	Ho: $\rho^1_{i,G3} = \rho^2_{i,G3}$		Ho: $\rho^1_{i,G3} \geq \rho^2_{i,G3}$	
Country	$\rho_{i,G3}$	$\rho^1_{i,G3}$	$\rho^2_{i,G3}$	Prob. 2-tailed		Prob. 1-tailed	
Austria	0.861	0.802	0.885	0.193		0.097	*
Belgium	0.877	0.804	0.913	0.052	*	0.026	**
Finland	0.664	0.122	0.921	0.000	***	0.000	***
France	0.926	0.860	0.960	0.004	***	0.002	***
Germany	0.965	0.927	0.988	0.000	***	0.000	***
Greece*	0.354	0.267	0.556	0.117		0.058	*
Ireland	0.774	0.583	0.839	0.014	**	0.007	***
Italy	0.923	0.776	0.976	0.000	***	0.000	***
Luxemburg	0.691	0.365	0.832	0.000	***	0.000	***
Netherlands	0.856	0.747	0.906	0.016	**	0.008	***
Portugal	0.748	0.727	0.801	0.425		0.212	
Spain	0.845	0.805	0.902	0.099	*	0.049	**
G9	0.903	0.828	0.929	0.036	**	0.018	**

Notes: For Greece the cut-off date is 2001:Q1. One, two and three asterisks denote rejection of the null at the 10%, 5% and 1% respectively.

Table 5. Cycle Synchronization Indexes with G3

Country	(A) Full Sample 1989Q1 - 2010Q2	(B) Pre Euro 1989Q1 - 1998Q4	(C) Post Euro 1999Q1 - 2010Q2	(D) Difference (D) = (C) - (B)	
Austria	0.802	0.800	0.804	0.004	
Belgium	0.826	0.850	0.804	-0.046	
Finland	0.674	0.525	0.804	0.279	***
France	0.895	0.900	0.891	-0.009	
Germany	0.930	0.900	0.957	0.057	
Greece*	0.547	0.563	0.526	-0.036	
Ireland	0.744	0.700	0.783	0.083	
Italy	0.884	0.825	0.935	0.110	
Luxemburg	0.709	0.600	0.804	0.204	**
Netherlands	0.826	0.800	0.848	0.048	
Portugal	0.791	0.750	0.826	0.076	
Spain	0.814	0.800	0.826	0.026	
G9	0.814	0.775	0.848	0.073	

Notes: For Greece the cut-off date is 2001:Q1.

Figure 1. Sinsitivity of Alternative Cycle Extraction for Germany

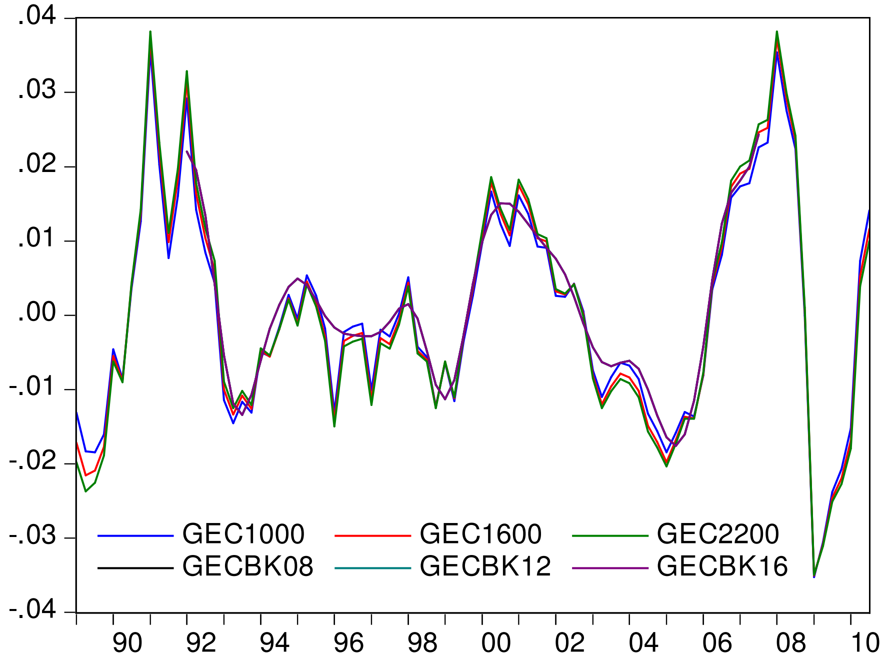

Figure 2. Extracted GDP Cycles

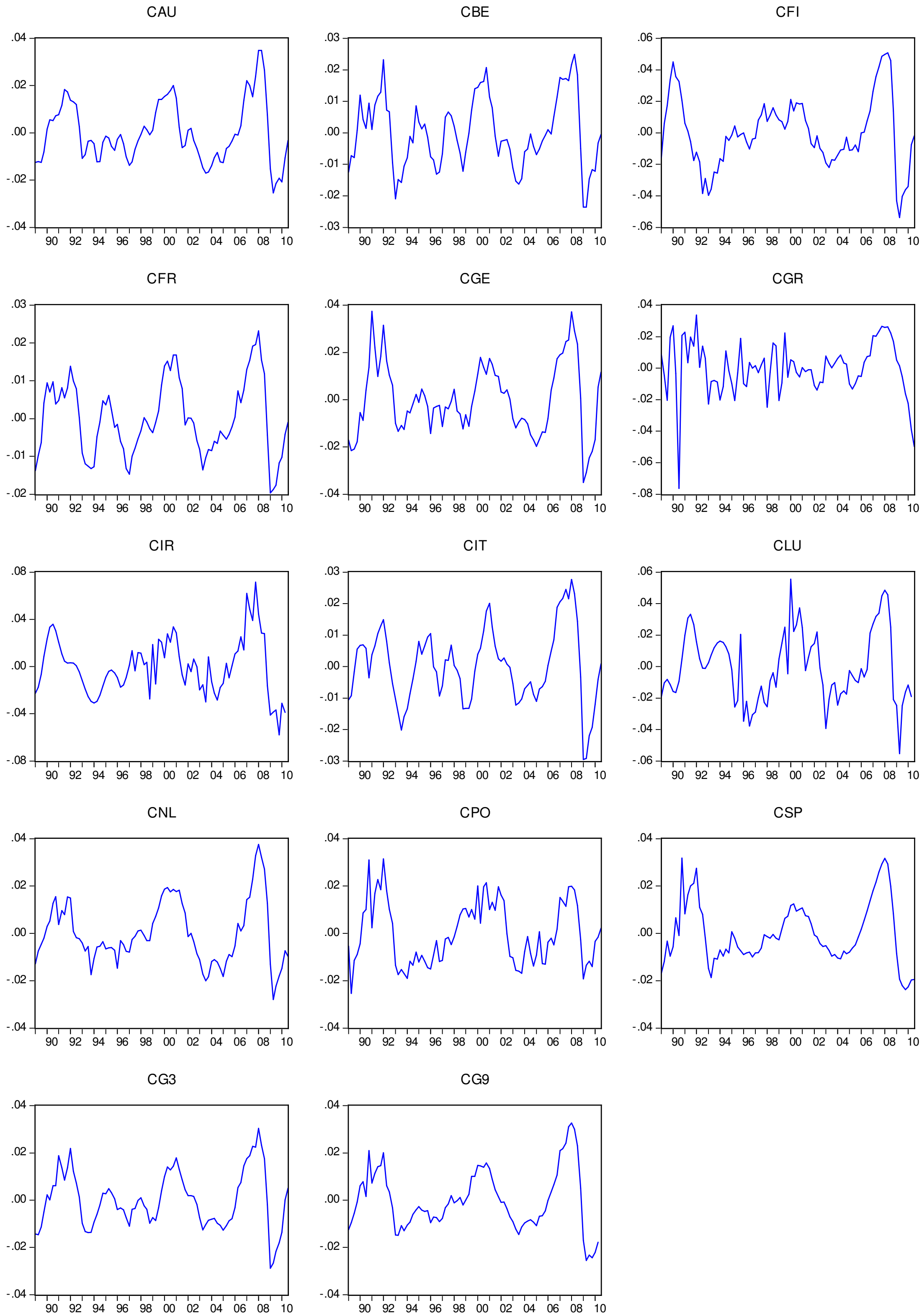

Figure 3. Cycle Synchronization Indices in the Pre and Post Euro Sub-Samples