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

Periklis Gogas
Department of International Economic Relations and Development,
Democritus University of Thrace, Komotini 69100, Greece.
pgkogkas@ierd.duth.gr

February 13, 2013

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

February 13, 2013

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 sub-groups of countries are extracted for the period 1989Q1-2010Q2. The cycle of *G3*, the group of the three largest European economies (Germany, France and Italy) is then used as a benchmark series for the comparisons. 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 has become stronger in the common currency period.

Keywords: Business Cycle, Synchronization, Eurozone.

Acknowledgements:

I wish to thank Costas Leon from the DCT University Center, Switzerland, for valuable comments that improved this paper. I also thank two anonymous referees that provided me with very constructive and extended comments and criticism on the first and second draft of this paper that greatly improved the final manuscript. Of course any remaining errors are solely mine.

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 within such a diverse group of countries. The important question was whether the business cycles of these countries are or can become adequately synchronized so that across-the-board monetary policy will be effective to all countries in the group. Asynchronous business cycles render monetary policy 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 contraction may require an expansionary monetary policy to stimulate growth. Krugman (1991) believes that EMU countries' business cycles will become less synchronized as commercial integration will lead to a specialization process in national economies. Emerson et al. (1992) on the other hand, conclude that a common currency, increased trade and financial integration leading to better cycle synchronization. De Grauwe (2000) points that wage and labour mobility rigidities within the E.U. combined with the lack of national monetary policy can increase the cost of participation 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. Thus, the issue of whether E.U.'s business cycles are synchronized is very important to both academics and policy makers.

Several studies in the empirical literature deal with this issue. Their approach is diverse in three respects: a) the way business cycles are extracted, b) how cycle synchronization is measured and c) which countries are included in the sample and which are used as the reference cycle. Several methods are used in the literature to extract the cycle from the *GDP*. 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. Other studies also, in an effort to improve the robustness of their results to the extraction methodology, employ more than one cycle extraction method; see Altavilla (2004), Perez et al. (2007) and Darvas and Szapary (2008) that use both the HP and the BK filter, Montoya and de Haan (2008) employ the HP and the Christiano–Fitzgerald (2003) filter. A very promising[2] approach is the time-frequency analysis. A prominent

[1] Greece joined the monetary union in 2001.

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

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.

Measuring the strength of cycle synchronization most studies use a correlation coefficient, but there are some other 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) apply a non-parametric concordance index that utilizes a binary indicator of cycle phases.

The empirical evidence is somewhat conflicting. Artis and Zhang (1997) and (1999) find that ERM[3] 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 concludes that cycle correlations are getting stronger in the 1970's reaching a maximum of 0.80 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 his results support the existence of a common European macroeconomic cycle. Darvas and Szapary (2008) studying new and old EU members find evidence in support of increased synchronization after the participation in the EMU. 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.

The first contribution of the paper is the use of a sample that covers more than twelve years of post-monetary union data and the use of three alternative methodologies measuring the cycle synchronization. The second contribution is the use of the proposed Cycle Synchronization Index (*CSI*). This differs from the concordance index proposed by Harding and Pagan (2002) as it is applied to detrended real *GDP* series. Detrending is performed using a) a HP filter with various values for the parameter λ and b) the BK filter with a wide range of leads/lags. A

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

binomial distribution is used to formally test whether the *CSI*s 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 presents the empirical results. Finally, in Section 5 I summarize and discuss the conclusions.

2. The Data

The data used in the paper are drawn from the OECD database. I use quarterly real *GDP* figures, seasonally adjusted[4]. 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[5] 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 empirical part of the paper I also use two sub-groups of countries: *G3* that includes France, Germany and Italy, the three largest countries in terms of *GDP*[6] share and *G9* that includes the remaining nine countries. The data are next transformed into natural logarithms. A summary of descriptive statistics is presented in Table 1.

Cycle synchronization is considered an important ingredient of successful monetary policy within a currency area. Thus, in an effort to extract the cyclical component of *GDP*, I apply a Hodrick-Prescott (1997) (HP) filter that is commonly used in the literature dealing with business cycles[7] 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, I first extract the cyclical component of the EU *GDP* using alternative specifications for the HP λ parameter (i.e. instead of the standard $\lambda = 1600$ for quarterly data, I use 1000 and 2200). The Baxter and King (1995) filter (BK) is also employed and the cycle is extracted using alternatively eight, twelve and sixteen leads/lags. In Figure 1, I present the cycles extracted as above with alternative λs and

[4] OECD subject B1_GE, measure VOBARSA.

[5] Greece joined Stage Three of the EMU on January 1st 2001 but the euro was adopted as the national currency on January 1st 2002 the same time as in the other eleven countries.

[6] For 2010Q2 their share in the total 12-country *GDP* was 67.85%.

[7] 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.

leads/lags with the HP and BK filters respectively for the case of Germany[8]. As the results of the extracted cyclical components from both the alternative λ specifications for the HP filter and the BK filter variations are qualitative quite similar for all countries to the ones obtained by the standard HP filter, for the rest of the paper, the analysis is conducted using the HP filter with λ = 1600. In Figure 2, I present the extracted cycles for the fourteen *GDP* time series.

3. Methodology and Empirical Results

In the effort to investigate the degree of synchronization of economic cycles for the fourteen countries and groups of countries, I 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 be synchronized with *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 of 1999Q1 (for Greece 2001Q1).

3.1 Linear Regressions

The first method employed here to examine the degree of synchronization of economic cycles is a linear regression. I 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:

[8] The results for the rest of the countries are similar to those of Germany and thus the relevant Figures are not presented here in order to preserve space. Moreover, the empirical results from all three methodologies employed in the next section using a BK cyclical component are qualitatively the same. They are of course available from the author upon request.

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

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[9] where this date is 2001Q1, and zero elsewhere. In Table 2, Panel A, the results from the estimation of Equation 1 for the twelve countries and *G3* are reported. In Panel B, I present 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. The estimated slope dummies from Equation 2 are reported in Table 3.

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 $\sigma_{i,G3}$ 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 $H_0\colon \rho_{i,G3}^1 = \rho_{i,G3}^2$ and a one-tailed test of the null hypothesis $H_0\colon \rho_{i,G3}^1 < \rho_{i,G3}^2$ 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*, the sign concordance of the cyclical component series of each country with the *G3* is calculated. For each quarter that a country's cycle accords in sign with *G3*, 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 ECB monetary policy is efficient.

[9] 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.

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:

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

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

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, we have $0 \leq CSI_{i,G3} \leq 1$ and the *CSI* 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 *CSI*s in the two sub-samples we perform a test of differences using a binomial distribution. These results are summarized in Table 5.

3.4 Regression Results

In Table 2, Panel A, the results from the regressions of each country's cycle series to the cycle of *G3* are presented. 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, and the corresponding R^2 are 0.934, 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 are 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 Panel B of Table 2, we find evidence[10] 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. 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 stronger after the introduction of the common currency.

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

3.5 Correlation Results

In Table 4, the results from the calculation of the cross-correlation coefficients are presented. In column one I report the results for the whole sample 1989Q1 to 2010Q2. In columns two and three I 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 the common currency area. In column four of Table 4 I 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 I test using a one-tailed test the null hypothesis that the cross-correlations of the second sub-sample are stronger than the ones from 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, the Netherlands and *G3* and at the 10% level for Belgium and Spain. The null hypothesis cannot be rejected only for the cases of Austria, Greece 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 Belgium, Spain and *G3* and at the 10% level for Austria and Greece. We cannot reject the null only for the case of Portugal.

3.6 Cycle Synchronization Index Results

In Table 5, the results of the *CSI* calculations are summarized: column (A) reports the *CSI* for the whole sample 1989Q1-2010Q2 while in columns (B) and (C) I calculate the *CSI* for the two sub-samples 1989Q1 – 1998Q4 and 1999Q1 – 2010Q2, pre- and post-euro respectively. In the last column, I report the difference in the *CSI* between the two sub-samples for each country. 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 indices 0.930, 0.895 and 0.884 respectively. The lowest *CSI*s 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 *CSI*s for the pre- and post-euro era reveals whether the degree of synchronization of each country with *G3* has actually strengthened. In the last column of Table 5, we see that the *CSI*s are higher in the euro era for all countries from 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. To formally assess though, the significance of the improvement in the *CSI*s 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. These results are also depicted in Figure 3. The finding that in ten out of the thirteen countries (and *G9*) synchronization became stronger in the second sub-group, but only for the case of Finland and Luxemburg we find the *CSI* differences statistically significant, may indicate that either the power of the test is not high enough to get more rejections or that synchronization actually did not change after 1999Q1 for most countries.

4. Conclusions

In this paper, three methodologies were employed 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 a very 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 statistically 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 *G3* provides evidence of stronger cycle synchronization[11] after the introduction of the euro for all countries: 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 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 the low power of the test due to the limited number of available observations. Overall, the empirical analyses presented in this paper, provide evidence that the cycle synchronization within Eurozone's economies has become stronger in the post euro period and certainly it did not weaken. The cycle of *G9*, the group of the smaller economies, for which an asynchronous to *G3* cycle will mean an ineffective and possibly destabilizing monetary policy, appears to be more synchronized in the common currency era, but the results are statistically significant only in the correlation coefficients methodology and in one instance of the Chow-break-point tests.

In light of the recent debt crisis in the Eurozone and its implications for the E.U., the above results should be interpreted with caution. Evidence of improved cycle synchronization should not be directly interpreted as evidence of overall economic convergence. Although cycle synchronization appears strengthened after the introduction of the euro, the fundamentals of member states such as productivity

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

and competitiveness may have not converged. The recent sovereign debt crisis that threatens Eurozone’s very existence may be the result of this. Several member countries are in the verge of a financial collapse and default: Greece, Ireland, Portugal, Spain and Cyprus are already in trouble and bailout plans have already been implemented for their rescue. There is also speculation that the crisis may soon spread to Italy, Belgium, Slovenia and even France one of the three core Eurozone economies while, on the other hand, Germany is growing enjoying minimum borrowing costs. These differences make the implementation by the ECB of an appropriate monetary policy for all Eurozone member states impossible. Since the introduction of the euro, most of the small peripheral economies are facing fundamental and accumulating competitiveness problems. Being in a currency union and thus unable to compensate for their high labor and other production costs with a currency devaluation they seem to have relied heavily on deficits and debt in an effort to finance growth and their current account imbalances. As productivity differences were not transitory and short-lived these economies became dependent on debt. Our findings show that although monetary policy after the euro is de facto synchronized and business cycles show stronger synchronization of the real economy, the picture is far from complete: fiscal policies (deficits and outstanding debt) must become consistent as well a) for the Eurozone to become a successful common currency area and b) for a true economic integration of the member states. The failure to control the sustainability of deficits and debts led to this critical situation that threatens the existence of the Eurozone.

References

Agresti A.B. and Mojon B. (2003), Some Stylised Facts on the Euro Area Business Cycle, In: Angeloni I, Kashyap A, Mojon B (eds) Monetary policy Transmission in the Euro Area. Cambridge University Press, Cambridge, 15–35.

Altavilla, (2004), Do EMU Members Share the Same Business Cycle?, Journal of Common Market Studies, Vol. 42, No. 5, pp. 869-896.

Artis, M. J. (2006), The U.K. and the Eurozone, Ces-ifo Economic Studies.

Artis, M.J., Krolzig H.M. and Toro J. (2004), The European Business Cycle, Oxford Economic Papers.

Artis, M.J., Z.G. Kontolemis and D.R. Osborn (1997), Business Cycles for G7 and European Countries. Journal of Business.

Artis, M., Marcellino M. and Proietti T. (2004), Dating Business Cycles: A Methodological Contribution with an Application to the Euro Area, Oxford Bulletin of Economics and Statistics.

Artis M. and Zhang W. (1997), International Business Cycles and the ERM: is there a European Business Cycle?, International Journal of Financial Economics, 2(1), 1–16.

Artis, J.M and W. Zhang (1999), Further Evidence on the international Business Cycle and the ERM: Is There A European Business Cycle? Oxford Economic Papers.

Baxter M. and King R. (1999), Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series, Review of Economics and Statistics 81, 575–593.

Bergman M. (2008), Finnish and Swedish business cycles in a global context, International Economics and Economic Policy 5, 103-121.

Burns, A. F. and Mitchell C.W., (1946), Measuring Business Cycles. New York: National Bureau of Economic Research.;ia

Canova F. (1998), Detrending and Business Cycle Facts. Journal of Monetary Economics, 41, 475–512.

Christiano L. and Fitzgerald T.J. (2003), The Band Pass Filter, International Economic Review, 44, 435–465.

Christodoulakis, N., S. P. Dimelis and T. Kollintzas (1995), Comparisons of Business Cycles in the EC: Idiosychracies and regularities, Economica.

Croux C., Forni M. and Reichlin, L. (2001), A Measure for Comovement of Economic Variables: Theory and Empirics, Review of Economics and Statistics 83, 232–241.

Darvas, Z. and Szapáry G., (2008), Business Cycle Synchronization in the Enlarged EU, Open Economies Review, 19(1).

de Haan, Inklaar R. and Jong-A-Pin R. (2008), Will Business Cycles in Euro Area Converge? A Critical Survey of Empirical Research, Journal of Economic Surveys 22(2), 234-273.

de Haan, J., Inklaar, R. and Sleijpen, O. (2002), Have Business Cycles become More Synchronized?, Journal of Common Market Studies, 40(1), 23–42.
Dickerson A., Gibson H. and Tsakalotos E. (1998), Business cycle correspondence in the European Union, Empirica 25(1), 51–77.
Emerson, M., Gros, D., Italianer, A., Pisani-Ferry, J. and Reichenbach, H. (1992), One Market, One Money, Oxford University Press.
Frankel, J.A., Rose A.K. (1998), The Endogeneity of the Optimum Currency Area Criteria, Economic Journal, 108, 1009–1025.
Fidrmuc J. and Korhonen I. (2006), Meta-Analysis of the Business Cycle Correlation Between the Euro Area and the CEECs, Journal of Comparative Economics, 34, 518–537.
Gouveia S. and Correia L. (2008), Business Cycle Synchronization in the Euro Area: the Case of Small Countries, International Economics and Economic Policy, 5, 103-121.
Hallet A.H. and Richter C. (2008), Have the Eurozone Economies Converged on a Common European Cycle?, International Economics and Economic Policy, 5, 71-101.
Harding D, and Pagan A. (2002), Dissecting the Cycle: a Methodological Investigation, Journal of Monetary Economics, 49, 365–381.
Harvey, A.C. and A. Jaeger (1993), Detrending, stylized facts, and the business cycle, Journal of Applied Econometrics.
Hodrick, R., and E.P. Prescott (1997), "Postwar Business Cycles: An Empirical Investigation," Journal of Money, Credit, and Banking.
Inklaar, R. and Haan D. J. (2001), Is There Really a European Business Cycle? A Comment, Oxford Economic Papers.
Koopman, S.J. and Azevedo, J.V. (2003), Measuring Synchronization and Convergence of Business Cycles, Tinbergen Institute Discussion Paper No. 2003-052/4.
Krugman, P. (1991), Geography and Trade, MIT Press.
Leon C. and Georgikopoulos N. (2010), Stochastic Shocks of the European and the Greek Economic Fluctuations, International Journal of Business Policy and Economics 3(1), 89-107.
Ljung, G.M. and Box G.E.P. (1978), On a Measure of Lack of Fit in Time Series Models, Biometrika.
Massmann M. and Mitchell J. (2004), Reconsidering the Evidence: Are Eurozone Business Cycles Converging? Journal of Business Cycle Measurement and Analysis, 1(3), 275–308.
Montoya L.S. and de Haan J. (2008), Business Cycle Synchronization in the Euro Area: the Case of Small Countries, International Economics and Economic Policy, 5, 123-137.
Mundell, R.A. (1961), A Theory of Optimum Currency Areas, American Economic Review.
Perez P., Osborn D. and Sensier M. (2007), Business Cycle Affiliations in the Context of European Integration. Applied Economics, 39(2), 199–214.

Wynne A. M. and J. Koo (2000), Business Cycles under Monetary Union: A Comparison of the EU and US, Economica.

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

		A. Regression Results			B. Chow Break Point Test				(prob.)	
Country	AR Lags	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

Country	AR Lags	Slope Dummy 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*

Country	A. Cross-Correlation Coefficients 1989Q1 - 2010Q2 $\rho_{i,G3}$	1989Q1 - 1998Q4 $\rho^1_{i,G3}$	1999Q1 - 2010Q2 $\rho^2_{i,G3}$	B. Correlation Coef. Tests of Difference Ho: $\rho^1_{i,G3} = \rho^2_{i,G3}$ Prob. 2-tailed		Ho: $\rho^1_{i,G3} \geq \rho^2_{i,G3}$ 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 Indices with *G3*

Country	(A) Full Sample 1989Q1 - 2010Q2	(B) Pre Euro 1989Q1 - 1998Q4	(C) Post Euro 1999Q1 - 2010Q2	(D) (D) = (C) -	
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

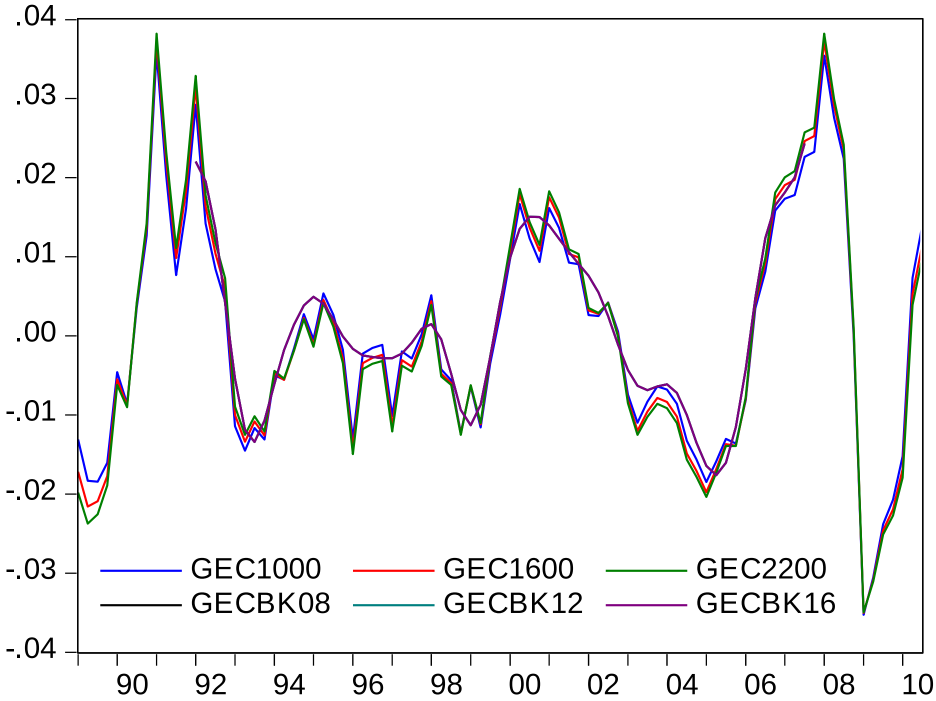

Figure 2. Extracted *GDP* Cycles

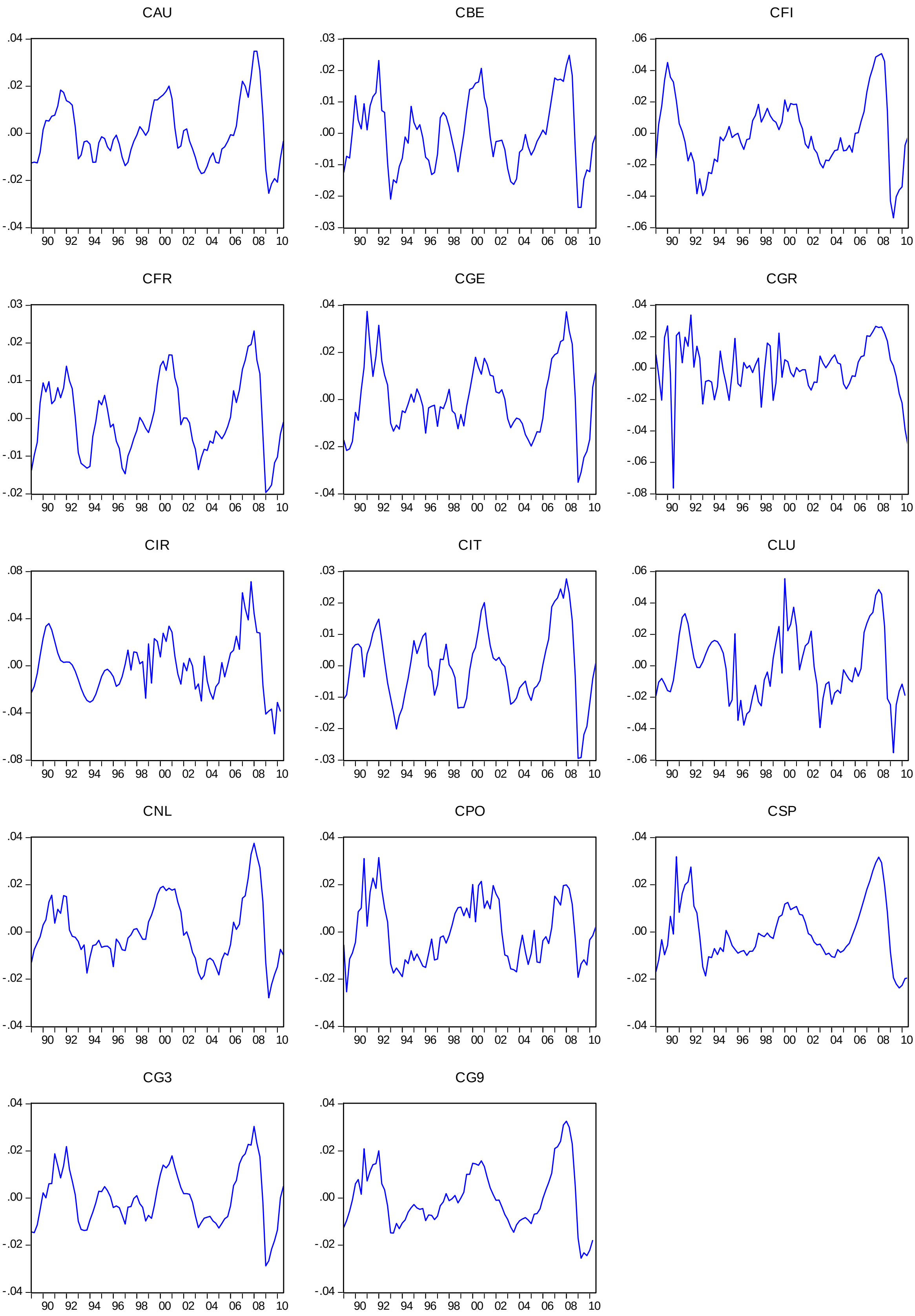

Figure 3. Cycle Synchronization Indices in the Pre and Post Euro Sub-Samples