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Some facts about the cyclical convergence in the euro zone

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Some facts about the cyclical convergence in the euro zone.[1]

Frederico Belo

Abstract

In the context of a single currency and a common monetary policy defined by the European Central Bank for the euro area as a whole, it is important to evaluate the degree of business cycle resemblance among the participant countries.

We resort to the association and synchronization concepts to define cyclical convergence. Using a time domain approach, we purport to use several parametric and non-parametric statistics to investigate whether the cycles of these countries have converged to the euro area business cycle during the sample period.

The results obtained are in line with those from previous studies and suggest that Italy, Spain, Austria, the Netherlands, Portugal and Greece have cyclically converged to the euro area business cycle. Regarding the United Kingdom, the evidence suggests the existence of a strong degree of association with the euro zone, exhibiting however a lead cycle in the more recent period.

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1. Introduction

One of the key elements on the ongoing debate about monetary unions is the degree of business cycle resemblance among the member states. This paper contributes to this debate by providing a descriptive analysis of the cyclical evolution of the output of the European Union countries between 1960 and 1999. As the creation of the European monetary union probably represents a regime shift[2] no attempt is made at forecasting cyclical fluctuations. Nonetheless, historical elements can be very useful as a benchmark in the analysis and interpretation of current results.

We resort to the association and synchronization concepts to define cyclical convergence. Using a time domain approach, we purport to use several parametric and non-parametric statistics to investigate whether the cycles of these countries have converged to the euro area business cycle during the sample period.

The results of this paper are much in line with those from previous studies. Some recent research provides support to the view that there was an increase in the similarity between the business cycles of the European Union countries. Arthis and Zhang (1995) studied the cyclical movements in the industrial production and focused on the role of the Exchange Rate Mechanism in inducing common business cycles among the participating countries. They have found that over time, the business cycle affiliation of most of these countries had shifted from the United States to Germany. Angeloni and Dedola (1999) studied a larger set of variables to conclude for an increase in the cyclical correlation of output, prices and stock indexes between euro countries. In our study, the results obtained suggest that Italy, Spain, Austria, the Netherlands, Portugal and Greece have cyclically converged to the euro area business cycle.

We proceed as follows. In section 2 we describe the data used. Section 3 briefly discusses the use of the Hodrick-Prescott filter to extract the cyclical components of the data. Section 4 analyses the evolution of the degree of association between country and euro area business cycle. Section 5 analyses the evolution of the degree of synchronization. Section 6 evaluates the existence of cyclical convergence. Section 7 analyses the cross-correlation between countries' business cycles. Section 8 compares the main results with other previous studies. Finally, section 9 concludes.

[2] The extrapolation of past results to forecast future behaviour would be subjected to the Lucas critique (Lucas (1976)).

2. Data

The data used in the current study is based on European Commission-Ameco database figures on annual product spanning the period from 1960 to 1999 for a sample of 17 countries plus the euro area as a whole. The countries are: the 11 countries of the euro zone (Germany,[3] France, Italy, Spain, the Netherlands, Belgium, Austria, Finland, Portugal, Ireland, Luxembourg) and the area as a whole; the 4 countries of the European Union outside the euro area (the United Kingdom, Denmark, Sweden, Greece[4]) and the United States and Japan, used as external references.

Our choice of annual data was constrained by the requirement of getting series as long as possible for a large number of countries in order to provide a reasonable number of complete business cycles by country (approximately 5). Nonetheless, we recognise that 40 years is a relatively small sample in a business cycle study, particularly when we divide the sample period and so the main conclusions must take this limitation into consideration.

3. Detrending Method

To analyse the cyclical evolution we must first provide an operational definition for business cycle. In this study, we follow Lucas (1977) in defining business cycles as deviations of aggregate real output from trend.[5]

In order to decompose the observed series into trend movement and cyclical component we used the Hodrick-Prescott (HP) filter with a smoothing parameter λ=100, the method and parameter more widely used in business cycles studies when the data frequency is annual.[6] This filter, described by Hodrick-Prescott (1980) defines a trend $\{Y_t^*\}$ from a series $\{Y_t\}$ as the solution to the following minimisation problem:

$$\min_{\{Y_t^*\}} \sum_{t=1}^{T} (Y_t - Y_t^*)^2 + \lambda \sum_{t=2}^{T-1} \left[\left(Y_{t+1}^* - Y_t^* \right) - \left(Y_t^* - Y_{t-1}^* \right) \right]^2$$

[3] In the German case, the sample refers to West Germany until 1991 and after, to unified Germany. The same applies to the euro zone. In both cases, the level was corrected through the output growth rate.
[4] Greece has become an euro area member on 1 January 2001.
[5] This is the "growth" definition and the one that is most frequently employed in the empirical literature on business cycles. Alternatively, there is the "classic" definition, proposed by Burns and Mitchell (1946), which refers to peaks and troughs in the level of the series. In this case, a recession is usually defined as a period of at least two consecutive years of negative growth. For a discussion of alternative definitions see Kydland and Prescott (1990).
[6] Conceptually, the smoothing parameter λ should depend on the duration of the business cycle in each country since implicitly this parameter limits the maximum duration of the cycle. Hence, the optimal λ figure should have been probably different in each

This filter emphasises the medium and high frequency movements in the data, those that most people associate with business cycles.[7] The difference between the trend and the series cannot be too large, as captured by the first term, and there is a restriction concerning the degree of smoothness of the trend, as captured by the second term. The relative importance of these effects depends on the λ parameter, which typically varies with the frequency of the data. A higher λ value implies a smoother trend and a more volatile cyclical component. In the extreme cases, when $\lambda=0$ the trend is equal to the original series and when $\lambda=\infty$ the trend will be linear.

Despite its generalised use, the HP filter has some limitations. The most relevant of these is the endpoint distortion. The HP filter as a two-sided-moving-average filter, gives a distorted picture at the beginning and at the end of the sample when there are not values at one side to count for. One way to minimise this problem is to forecast values so to extend the sample but for the purpose of this work, we did not find necessary to do such correction.

Other limitations of the HP filter include the treatment of structural breaks in the sample,[8] which tend to be smoothed by the filter, the problem of choosing the smoothing parameter and the induction of spurious cycles, although this last critique is not consensual.[9]

Notwithstanding, according to Baxter and King (1999), the HP filter has good theoretical properties because it is a good approximation to the filter that would ideally eliminate a low frequency interval, although this interval depends on the smoothing parameter figure. If this parameter is chosen consistently with the interval of frequencies that we want to eliminate, then the results produced by the HP filter will be similar to those from the filters suggested by Baxter and King, which are constructed as an approximation to the ideal filter.[10]

The series were all expressed in logarithms and so the cyclical component was obtained through the difference between the original series and its trend, as obtained by the HP filter. It should be noted that the results reported in this study refer only to the cyclical component.

4. Degree of cyclical association

In this section, we will evaluate the degree of association between the business cycles of the countries included in our sample and the euro area.[11]

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country and so we must have present that by choosing the same parameter for every country we could be introducing some distortion in the results.

[7] In fact, it is possible to show that the HP filter can be seen as a *"high pass filter"* which, by definition, retains high frequency components and attenuates fluctuations at low frequencies. See Baxter and King (1999).

[8] Using, for example, a linear trend, this problem can be minimised by correctly identifying the break point in the sample.

[9] See, for example, Kaiser and Maravall (1999), Cogley and Nason (1995) and Harvey and Jaeger (1993).

[10] For discussions of the properties of these and other filters, see Hodrick and Prescott (1997), King and Rebelo (1993), Kydland and Prescott (1990) and Baxter and King (1999).

[11] It should be noted that, when comparing the cyclical movements in each country with respect to the euro zone business cycle there is the possibility of a non-exogeneity problem between the variables, particularly in the major economies like Germany, France or Italy. The results for these countries should also take this fact into consideration when evaluated. Nonetheless, the results remain valid since the monetary policy is defined to the euro area as a whole (the sum of each country) and it is with respect to this cycle that we should look for cyclical asymmetries.

Since we are interested not only in the degree of cyclical association but also in its evolution, the sample was divided in two sub-periods, from 1960 to 1978 and from 1979 to 1999, which also coincides with the creation of the European Monetary System in 1979.[12]

4.1 Simple correlation, concordance and Spearman's rank correlation

The simple correlation coefficient is the statistics normally used when we intend to measure the degree of association between business cycles. However, since it only measures the degree of linear association, we will also compute the concordance statistics, initially proposed by Harding and Pagan (1999) and the Spearman's rank correlation coefficient.

The concordance is a non-parametric statistics that measures the proportion of time that the cycles of two series spend in the same phase.[13] Let $S_{i,t}$ be a series taking on the value unity when the cycle in country i is positive and 0 when it is negative and defining $S_{EU11,t}$ in the same way for the euro zone cycle, the degree of concordance in a sample of N years is:

$$C_{i,EU11} = N^{-1}\left\{\sum_{t=1}^{N}\left[(S_{i,t}.S_{EU11,t}) + (1-S_{i,t}).(1-S_{EU11,t})\right]\right\}$$

It should be noted that $\left[(S_{i,t}.S_{EU11,t}) + (1-S_{i,t}).(1-S_{EU11,t})\right]$ is a binary variable that assumes the value unity when the two series are in the same phase of the cycle and 0 if they are not. As a proportion, the concordance statistics varies between 0 and 1. However, a positive relationship between the phase in two series implies a degree of concordance higher than 0.5, as this is the expected value of the concordance when we have two independent and identically distributed series, symmetrically around 0.[14]

As a measure of co-movement between two series, the concordance statistics main advantage in comparison with the correlation coefficient is that it can be applied to both stationary and non-stationary series, since it is not affected by single events in time series which are irrelevant for inferences of co-movement.[15] For example, consider two independent

[12] The EMS was created in 1979 and included Germany, France, Belgium, Luxembourg, Denmark, the Netherlands, Italy, Ireland, and the United Kingdom. With the exception of the United Kingdom, all these countries participated in the Exchange Rate Mechanism (ERM) the most significant feature of the EMS. According to the ERM, the countries exchange rates were only allowed to fluctuate between a pre-specified range. Spain has only joined the ERM in 1989 and Portugal in 1992. The United Kingdom joined the ERM in 1990 and suspended its membership in 1992. Italy also left in 1992.

[13] Although originally applied to the classic definition of business cycle, in this study the concordance statistics will be applied to the cycle, measured by the difference between output and trend.

[14] If we consider two independent and identically distributed series, the probability of these two series to be in the same phase of the cycle is equal to the probability of being in a different phase so the concordance distribution will be symmetric with mean equal to 0.5.

[15] This analysis borrows heavily from McDermott and Scott (1999).

random walks with zero drift. In this case, we expect the concordance statistics to be 0.5 and the correlation coefficient to be approximately 0. However, if we include a step function halfway through both series, the concordance statistics is not affected but the correlation coefficient is, even though the two series are still random. So, in non-stationary series, McDermott and Scott (1999) conclude that the correlation coefficient cannot be easily interpreted: "a high number may be the result of significant co-movement through time", or the result of, as in this example, "a single large event that is common to the two series". However, in our study, since we will apply the concordance statistics to the cycle, which is level stationary by construction, this problem will not be present.

Another advantage of the concordance statistics is that, in contrast to the correlation coefficient, it can be used to detect both linear and non-linear type association between two variables. Plotting the cycle in country i against the cycle in country j, the concordance statistics will be given by the proportion of observations that are in the same quadrant, independently of the particular type of relationship between the two variables (linear or non-linear).

An alternative measure of the degree of association between series that is also robust to non-linear relationships is the Spearman's rank correlation coefficient. As its name suggests, rather than use the cycle itself, it is based on the ranks of the observations. Having ordered the values of the cycle in each country, the Spearman's rank correlation coefficient is just the correlation coefficient calculated for the ranks of the two series and is computed as:

$$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-2)} \quad \text{and} \quad \sum_{i=1}^{n} d_i^2 = \sum_{i=1}^{n} \left[R(X_i) - R(Y_i) \right]^2$$

where n is the number of observations, $R(X_i)$ = the rank of the cycle in country X and $R(Y_i)$ = the rank of the cycle in country Y, for year i.

Table 1 presents the results for the simple correlation coefficient, the concordance statistics and the Spearman's rank correlation. The conclusions are remarkably consistent across the different methods, especially between the simple correlation coefficient and the Spearman's statistics. This also suggests that the cycle among countries exhibits in fact a linear relationship and so we can focus our analysis mainly in the correlation coefficient results.

Regarding the results for the euro zone, the most interesting feature is the high degree of contemporaneous correlation in the majority of the countries with respect to the euro area, particularly in France, Belgium, Germany, Portugal, Austria and the Netherlands. In contrast, Finland and Ireland exhibit a weak association with the euro zone business cycle.

Table 1 – Correlation, concordance and Spearman's rank correlation with the euro zone[16]

	Correlation			Concordance			Spearman's		
	1960-99	**1960-78**	**1979-99**	**1960-99**	**1960-78**	**1979-99**	**1960-99**	**1960-78**	**1979-99**
Germany	0,84	0,86	0,83	0.78	0.84	0.71	0.82	0.84	0.79
France	0,92	0,93	0,91	0.88	0.84	0.90	0.91	0.93	0.88
Italy	0,71	0,56	0,87	0.70	0.58	0.81	0.72	0.52	0.87
Spain	0,72	0,56	0,83	0.75	0.68	0.81	0.70	0.41*	0.84
The Netherlands	0,76	0,62	0,85	0.90	0.84	0.95	0.78	0.68	0.85
Belgium	0,89	0,84	0,93	0.85	0.79	0.90	0.89	0.76	0.91
Austria	0,77	0,71	0,85	0.73	0.74	0.71	0.73	0.58	0.80
Finland	0,35	0,60	0,23*	0.58	0.58	0.57	0.27*	0.51	0.12*
Portugal	0,80	0,72	0,86	0.73	0.53	0.90	0.72	0.44*	0.88
Ireland	0,35	0,19*	0,44	0.70	0.53	0.86	0.34	0.06*	0.49
Luxembourg	0,71	0,82	0,63	0.63	0.58	0.67	0.67	0.71	0.65
United Kingdom	0,40	0,57	0,32*	0.60	0.58	0.62	0.32	0.34*	0.27*
Denmark	0,09*	0,63	-0,25*	0.55	0.79	0.33	0.09*	0.70	-0.27*
Sweden	0,40	0,38*	0,40	0.70	0.63	0.76	0.42	0.37*	0.41*
Greece	0,61	0,50	0,77	0.83	0.63	1.00	0.65	0.48	0.79
United States	0,23	0,10*	0,32*	0.48	0.37	0.57	0.18*	0.09*	0.29*
Japan	0,64	0,63	0,70	0.60	0.58	0.62	0.60	0.65	0.61

Note: (*) The correlation coefficient is not statistically significant with a level of significance of 10%.

Considering the periods before and after 1979, we find that in general, there is an increase in the degree of contemporaneous association between the euro zone countries and the euro area business cycle. This fact is illustrated in **figure 1**. In this figure, if a country is over the 45º line, this mean that the correlation coefficient with the euro area stood at the same level in both periods and if it is on the right (left) of the 45º line, the correlation coefficient has increased (diminished) between the two sub-periods. The increase in the contemporaneous correlation is particularly evident in the cases of Italy, Spain and the Netherlands. Finland and Luxembourg are the only euro zone countries where we observe a significant decrease in the contemporaneous correlation with the euro zone business cycle.[17] In fact, the correlation coefficient for Finland is not statistically significant in the late period of the sample.

We have also computed the contemporaneous correlation using the United States as the benchmark economy. In sharp contrast to the euro zone, the results presented in **appendix 3**

[16] The significance test was applied in the simple correlation and Spearman's rank correlation statistics. In the simple correlation, the confidence interval is given by $\pm \frac{t^{(df)}_{\alpha/2}}{\sqrt{T}}$, with (n-2) degrees of freedom (df). For the Spearman's rank correlation coefficient, the appropriate sampling distribution is the Student's t, with df=n-2, which will be compared with the statistics $t = r.\sqrt{\frac{n-2}{1-r^2}}$, where r is the Spearman's coefficient (Yule and Kendall (1953)).

[17] In Germany and France there also is a slight but not significant decrease in the contemporaneous correlation with the euro area.

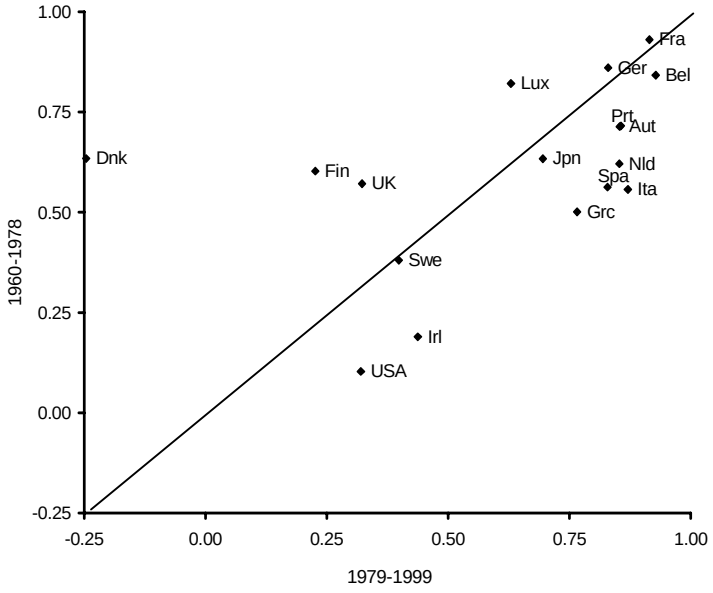
now exhibit a weak association between United States and the euro zone countries business cycles. In fact, considering the whole sample period, the correlation coefficient is not statistically significant for the euro countries, except for the Netherlands.

In the non-euro area countries, the results for Greece suggest a relatively strong association with the euro area business cycle, especially in the late period of the sample. The Spearman's and concordance statistics reinforce this conclusion and it is interesting to note that the concordance assumes the value unity in the late sub-period.

Regarding the results for the United Kingdom, the evidence suggests a weak contemporaneous correlation with the euro area business cycle, particularly in the late period of the sample, where the coefficient is not statistically significant. On the contrary, the contemporaneous correlation with the United States has steadily increased, exhibiting in the late period of the sample a stronger contemporaneous association with the United States than with the euro area business cycle (**table 1** and **appendix 3** and **4**).

Finally, Denmark and Sweden, also exhibit a weak association with the euro area business cycle.

Figure 1- Contemporaneous correlation with the euro area



The results presented in this section do not change qualitatively if we use the first differences filter or λ=10 on the HP filter (**appendix 6**).

4.2 Multiple correlation

An alternative approach to the non-parametric statistics analysed so far, will be to estimate a model where the relationship between country i and the euro zone cycle is described by the following equation:

$$X_t^i = \beta_1 X_t^{EU11} + \beta_2 X_{t-2}^{EU11} + \beta_3 X_{t-1}^{EU11} + \beta_4 X_{t+1}^{EU11} + \beta_5 X_{t+2}^{EU11} + \varepsilon_{it}$$

where X^i is the cycle in country i and X^{EU11} is the cycle in the euro area.

The main advantage of this approach is that it will give an accurate measure of the degree of linear association between country i and euro area business cycle in the presence of leading or lagging relationships between the cycles.

Defining R as the square root of the coefficient of determination in country i equation, the value of R is then the correlation coefficient between X^i and $\hat{X}^i$, where $\hat{X}^i$ are the fitted values of X^i. In other words, R can be seen as the multiple correlation coefficient between country i and euro area business cycle.

The results are presented in **table 2.** It is clear that for the euro zone countries, there is once again a high consistency degree between these results and the previous ones. In fact, the countries that exhibit a stronger association with the euro area business cycle during the whole sample period are the same, namely France, Belgium, Germany, Austria, the Netherlands and Portugal. Finland and Ireland remain the countries with the lowest degree of association with the euro zone business cycle.

Considering the multiple correlation coefficient in both sub-periods, we find that in general, the results from the previous section also remain valid, particularly the general increase in last period association with the euro area for the euro zone countries. This increase was particularly sharp and significant in Spain and Italy, as well as in Portugal. On the opposite end, in Finland, Luxembourg and Ireland (although in the latter not observed in the previous analysis) there was a decrease in the degree of association with the euro zone business cycle.

For the non-euro zone countries and in contrast to what was observed in the previous statistics, there was a sharp increase in the multiple correlation coefficient between the two sub-periods, particularly in the United Kingdom and Sweden. In the United Kingdom, it is also interesting to note that this country has the highest degree of multiple correlation with the euro zone business cycle. The contradictory results between the contemporaneous correlation and the multiple correlation suggest that these countries have in fact increased their association with the euro area business cycle but the synchronisation, which will be analysed in the next section, has changed between the two sub-periods.

At last, for Greece, the multiple correlation coefficient suggests a relatively strong association with the euro zone business cycle during the whole sample period.

Table 2 – Multiple correlation

	1962-1997	1962-1978	1979-1997
Germany	0.89	0.89	0.93
France	0.93	0.95	0.93
Italy	0.79	0.74	0.92
Spain	0.76	0.67	0.94
The Netherlands	0.83	0.80	0.87
Belgium	0.92	0.95	0.93
Austria	0.86	0.86	0.93
Finland	0.51	0.87	0.79
Portugal	0.82	0.75	0.89
Ireland	0.54	0.66	0.62
Luxembourg	0.72	0.93	0.78
United Kingdom	0.75	0.75	0.98
Denmark	0.75	0.79	0.87
Sweden	0.55	0.66	0.94
Greece	0.76	0.82	0.84
United States	0.62	0.54	0.80
Japan	0.74	0.80	0.84

5. Synchronisation

In order to determine the existence of cyclical convergence with respect to the euro zone, it is necessary not only to analyse the evolution of the degree of association between each country and the euro area business cycle but also the degree of synchronisation.

The degree of synchronisation will be measured by the number of leading or lagging periods at which the maximum correlation is obtained so that, country i will be synchronised with the euro zone business cycle if the maximum correlation is obtained contemporaneously.[18]

According to the results presented in **table 3**, we can say that for the whole sample period, the euro zone countries are highly synchronised with the euro area business cycle. This synchronisation is illustrated in **figure 2**, where we confront the German, France and

[18] For a given pair of cycles, X and Y, $\rho_{\pm i}(x_{t\pm i}, y_t)$ denotes the correlation between X and Y at displacement $\pm i (i \leq 2)$. The maximum correlation coefficient is then the maximum value for $\rho_{\pm i}$.

Belgium cycles with the euro area business cycle. In the late period of the sample, only Finland and Luxembourg seem to exhibit a lead cycle.[19]

Considering the whole period, non-euro area countries are in general not synchronised with the euro area business cycle, with the exception of Greece and Japan.

Between the two sub-periods and as predicted in the previous section, we observe that the United Kingdom, United States and Denmark have become less synchronised with the euro area business cycle. As illustrated in **figure 2** for the United Kingdom, these countries exhibit a lead of about 2 years in the second period of the sample. In contrast, Greece business cycle has become more synchronised with the euro zone business cycle.[20]

Table 3 – Maximum correlation with the euro zone

	1960-1999	i	1960-1978	i	1979-1999	i
Germany	0,84	0	0,86	0	0,85	1 [a]
France	0,92	0	0,93	0	0,91	0
Italy	0,71	0	0,56	0	0,87	0
Spain	0,72	0	0,56	0	0,89	-1 [a]
The Netherlands	0,76	0	0,62	0	0,85	0
Belgium	0,89	0	0,84	0	0,93	0
Austria	0,77	0	0,71	0	0,85	0
Finland	0,36	-1 [a]	0,60	1 [a]	0,54	-1
Portugal	0,80	0	0,72	0	0,86	0
Ireland	0,40	-1 [a]	0,49	-1	0,44	0
Luxembourg	0,71	0	0,82	0	0,71	-1
United Kingdom	0,63	-1	0,57	0	0,90	-2
Denmark	0,23	-1	0,63	0	0,39	-2
Sweden	0,40	-1 [a]	0,48	1	0,70	-1
Greece	0,61	0	0,68	-1	0,77	0
United States	0,37	-1	0,10	0	0,67	-2
Japan	0,65	0	0,75	-1	0,70	0

Notes:

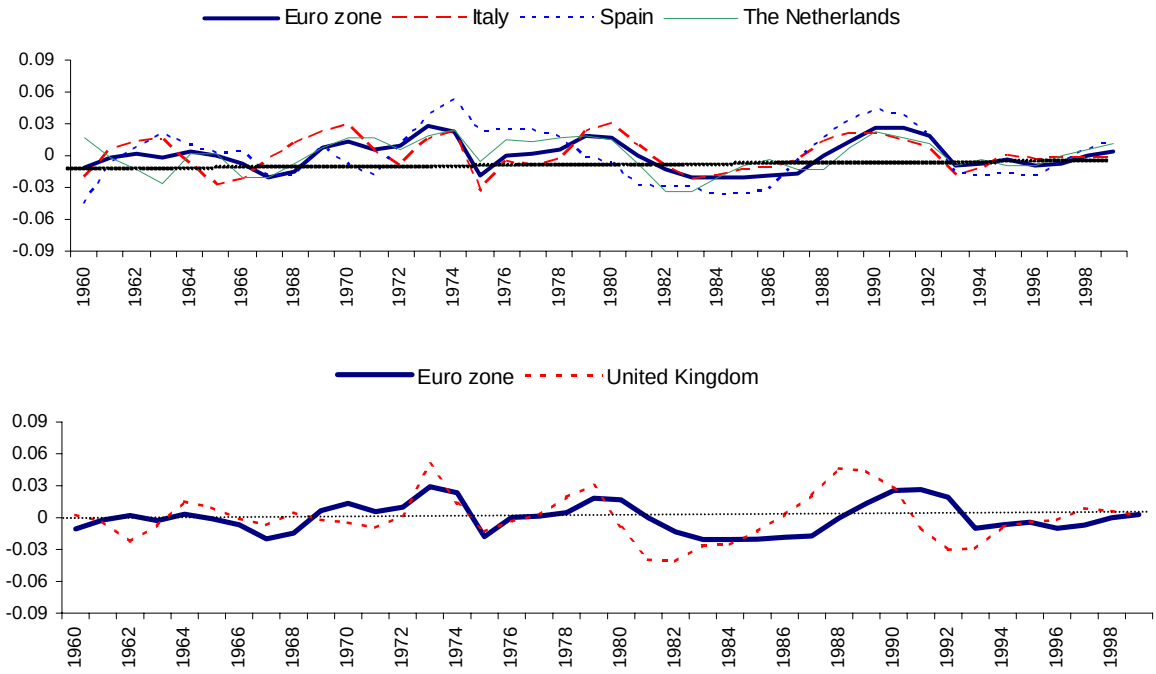
(i) displacement where the correlation is maximum, with i=-2, -1, 0, 1, 2. A positive value (negative) for i mean that the country has a lead (lag) cycle with respect to the euro area cycle.

(a) maximum correlation is similar to contemporaneous correlation (absolute difference ≤ 0,06).

[19] In Germany and Spain the maximum correlation coefficient is also not contemporaneous. However, since the absolute difference of the maximum and contemporaneous correlation is small (≤ 0.06) we can consider the cycles to be contemporaneous.

[20] In order to look for precedence relationships between business cycles, we have also performed the Granger causality test (Granger (1969)). The results did not change qualitatively our analysis and are available from the author upon request.

Figure 2: Business cycle



6. Cyclical convergence

Evidence of cyclical convergence implies an increase in both the degree of association and synchronisation between the country and the euro area business cycles and so we will look at the contemporaneous correlation, concordance and maximum correlation coefficients from a dynamic perspective. Moreover, we will estimate and evaluate the cyclical component that is specific to each country, that is, the part in country i cycle that is not explained by the euro area business cycle.

The previous analysis suggests that, in terms of cyclical convergence, it is possible to distinguish three groups of countries.

A first group includes Germany, France and Belgium, where the results suggest a high degree of association and synchronisation with the euro zone business cycle in the whole sample period. However, it should be noted that, in the case of Germany, the idiosyncratic shock caused by the unification and the associated fiscal and monetary policies have probably led to a slight decrease in the degree of association and synchronisation with the euro zone business cycle in recent years. This fact can be observed in the correlation and concordance coefficient for a rolling sample of 12 years (**appendix 1** and **2**) and in the evolution of the displacement where the maximum correlation is obtained (**appendix 5**), which exhibits a slight lag in the post-unification period.

A second group includes Italy, Spain, Austria, the Netherlands and Portugal, where we observe a sharp increase in the degree of association with the euro zone cycle. In **appendix 1** and **2** it is possible to observe that this increase in Austria, the Netherlands and Portugal has occurred in the beginning of the sample, earlier and sharper than in Italy and Spain. However, in both cases, the significant increase in the degree of association and synchronisation with the euro zone business cycle suggests that these countries exhibit an evolution that is compatible with the cyclical convergence hypothesis.

A last group includes Finland, Ireland and Luxembourg, where the evidence does not allow us to conclude for the existence of cyclical convergence. This conclusion draws from the fact that during the sample period these countries decreased their degree of association with the euro zone business cycle[21] and have not become more synchronised with the euro zone business cycle.

In the non-euro zone countries, although the degree of association with the euro zone business cycle has increased, particularly in the United Kingdom,[22] the cycles have become less synchronised and so we cannot state that these countries had cyclically converged to the euro zone business cycle. The only exception seems to be Greece, where there was both an increase in association and synchronisation.

An alternative approach to the cyclical convergence issue would be to analyse the specific cyclical component in each country and so we have estimated the following equations:[23]

$$X_t^i = \beta_1 X_{t-1}^i + \beta_2 X_{t-2}^i + \beta_3 X_t^{EU11} + \beta_4 X_{t-1}^{EU11} + \beta_5 X_{t-2}^{EU11} + \varepsilon_{it}$$

where X_{t+j}^i is the country i cycle and X_{t+j}^{UE11} is the euro zone cycle lagged j years.

The estimation residual ε_i can be interpreted as the part of country i cycle that is not explained by the euro zone business cycle nor by the past behaviour of the country cycle. So, the residual might be seen as the idiosyncratic component of country i fluctuations.

In **table 4** we present the results for the weight of the variability of the specific component in the total variability of the cycle.[24] As expected, this weight decreases in the majority of the euro area countries, suggesting an increase in integration with the euro area business cycle,

[21] In Ireland, although the contemporaneous correlation and concordance increase, the maximum and multiple correlation suggests a decrease in the association with the euro zone business cycle.
[22] In Denmark and Japan the results for the maximum and multiple correlation suggest a different evolution, so we considered the multiple correlation coefficient to be representative of an increase in the degree of linear association.
[23] This approach is similar to a previous one by Barbosa et al. (1998) for the Portuguese business cycle. In Germany, France and Italy the equations were estimated with and without the contemporaneous cycle of the euro area in order to minimise the problem of non-exogeneity of the explanatory variable. The estimation procedure included two steps: first, all the equations were estimated for each country and for the whole period. Then the variables not statistically significant at 10% level were eliminated. The equations were then re-estimated with the significant variables for each sub-period (1962-78 and 1979-99) and for the whole period.

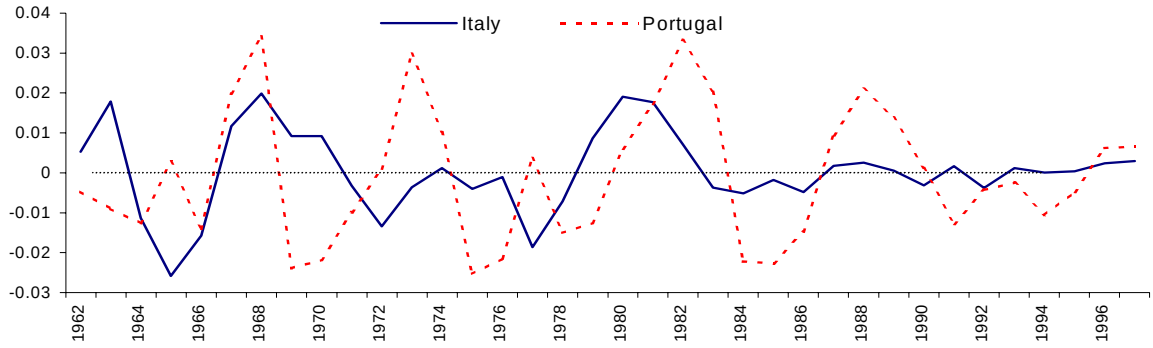
even for Finland and Ireland. Only in Luxembourg does the weight of the specific component increase.[25]

In order to test if the changes in country i specific component variability are significant or not, we have applied the Goldfeld-Quandt test.[26] If country i exhibits a higher degree of association with the euro zone business cycle one should expect a decrease in the specific component variability and so the rejection of the homoscedasticity hypothesis. If this rejection was due to a decrease in the specific component variability, then it would suggest that country i had converged to the euro zone business cycle during the sample period, since the majority of their fluctuations would be explained by those of the euro area.

According to the results presented in **table 4**, we may conclude for a significant decrease in the variability of the specific component in Germany, Italy, Spain, the Netherlands, Austria and Portugal supporting the previous conclusion of cyclical convergence of these countries with respect to the euro zone business cycle. As **figure 3** illustrate, this decrease was particularly sharp in Italy and Portugal.

In the other countries, the results do not suggest a significant change in the variability of the specific component. In France and Belgium this was due to the fact that the variability of the specific component stood low during the whole sample period. In Finland, Ireland and Luxembourg the variability stood high, reinforcing the conclusion that these countries had not converged to the euro zone business cycles during the period in analysis.

Figure 3: Specific component of the cycle



[24] The weight is given by $\frac{\sigma_{\varepsilon_{it}}}{\sigma_{x_{it}}}$, where $\sigma_{\varepsilon_{it}}$ is the standard deviation of the specific cyclical component and $\sigma_{x_{it}}$ the total standard deviation of the cycle in country i for the t sub-period.

[25] It should be noted that in France (with the contemporaneous euro zone cycle) and Belgium there is also an increase in the weight of the specific component, although this increase was not significant.

[26] This test uses the $\frac{RSS_1 / df}{RSS_2 / df}$ statistics, where RSS_i is the residuals squared sum in i period, that follows a F distribution with (n-c)/2-k degrees of freedom (df). The homoscedasticity hypothesis is tested. In our case, to increase the power of the test, we have ignored the residuals for the 79-83 period (c=4).

Table 4 – Weight of the variability of the specific component in the total variability of the cycle and Goldfeld-Quandt test

			GQ Test [a)]
	1962-78	**1979-99**	**F Statistic**
Germany	0.38	0.29	2.18 *
France	0.28	0.30	1.00
Italy	0.55	0.21	16.05 ***
Spain	0.56	0.32	3.16 **
The Netherlands	0.56	0.33	4.07 **
Belgium	0.35	0.37	1.71
Austria	0.54	0.43	3.34 **
Finland	0.52	0.32	1.46
Portugal	0.56	0.25	5.91 ***
Ireland	0.70	0.57	1.35
Luxembourg	0.43	0.75	1.64
	Estimation without the contemporaneous euro zone cycle		
Germany	0.70	0.51	2.64 *
France	0.84	0.68	1.15
Italy	0.84	0.55	4.63 ***

Notes:

(a) Between the sub-periods 1962-1978 and 1983-1999.

(***) Significant at 1% level, (**) Significant at 5% level and (*) Significant at 10% level

7. Bilateral correlation

Although the monetary policy is defined for the euro area as a whole, it is also interesting to study the degree of association and synchronisation between countries cycles, so we can have a better understanding of the cyclical evolution during the sample period. In particular, one should understand whether a country increase in association and synchronisation with the euro area is due to cyclical convergence with respect to the euro area or is determined by cyclical convergence with a third country that has converged to the euro zone cycle.

In order to study the cross-correlation, we have computed the maximum cross-country correlation for each sub-period. The results presented in **appendix 7** reveal a high correlation (in general contemporaneous) between business cycles in Germany, France and Belgium in both periods. In the last sample period, Italy, Spain, Portugal and the Netherlands joined this group of highly correlated countries. In particular, it should be pointed out the high bilateral correlation between Germany and Austria, France and Austria, France and Belgium and France and Portugal, exhibiting a correlation coefficient of 0.9 or above.

In the other European union countries, there is a high degree of association between the United Kingdom and Portugal cycles. However, in the late period of the sample and as noted in respect with the euro zone, the United Kingdom exhibits a lead cycle of about 2 years. In the 1979-1999 period, the United Kingdom also exhibits a high degree of cyclical association with Italy, France, Spain, the Netherlands and Belgium. Lastly, it is interesting to note that there is a high contemporaneous correlation between Sweden and Finland cycles, not seen in the case of Finland with any other euro zone country.

These results seem to suggest that, at least in recent years, there is not a clear distinction between south countries and the core countries in terms of cyclical evolution. They also suggest that before and after 1979 there was a strengthening of the cyclical association among euro zone countries, not only with the euro area as a whole, but also between countries.

8. Comparison with previous studies

The results obtained in this study are much in line with those of previous studies. For the purpose of comparison we will discuss three of these studies.

Arthis and Zhang (1995) focus on the role of the Exchange Rate Mechanism (ERM) in inducing common business cycles among participating countries. In their study, they use standard measures such as the contemporaneous and maximum cross correlation to study the cyclical movements in the industrial production variable for the 1961-1993 period. The sample was broken in the period before and after the start of the Exchange Rate Mechanism (ERM) in 1979, which is similar to our division. Using the German and United States as the benchmark economies, they found that over time the business cycle affiliation of most of countries participating in the ERM of the European Monetary System has shifted from the United States to Germany, attributing this to an increase in exchange rate stability.[27] The only exceptions are the United Kingdom and Ireland. Regarding the United Kingdom, a member of the ERM only for a short period (October 1990-August 1992), it was not found a significant change in its business cycle affiliation during the sample period. In Ireland, the evidence also suggests that its association with the US cycle has remained strong, despite her continued membership of the ERM.

Angeloni and Dedola (1999) studied a larger set of variables (output, consumption, investment, industrial production, CPI, GDP deflator and stock indexes) for the 1970:1-1997:3 period. The main conclusion of their study is, as in our study, an increase in the cyclical correlation in output, prices and stock indexes between euro countries. Using the

[27] Inklaar and Haan (2001) shade some doubt on these results. They argue that the two periods distinguished by Arthis and Zhang are not uniform with respect to exchange rate volatility and so they have compared the business cycle synchronisation for four sub-periods. Examining the relationship between exchange rate volatility and business cycle synchronisation, they found no evidence of a systematic relationship between them.

Bayoumi and Eichengreen's (1993) approach of structural VAR methodology to identify the underlying demand and supply shocks, they conclude that the increase in correlation does not appear to be attributable to shifts in the correlation pattern of these shocks but conceivably to a stronger influence of the international transmission process, operating through trade links, financial market prices, expectations and to a greater coherence of monetary policies.

At last, Azevedo (2001) presents a descriptive analysis in the frequency domain of the business cycles for the same countries and database as our study. Using the spectral analysis, he concludes that Sweden, Finland, the United Kingdom and the United States lead the euro area by more than one year. The Netherlands, Italy, Japan and Spain are also leading countries but with a lead of no more than one year, which was not observed in our study. For Greece and Ireland no reliable conclusions are stated. Finally, he concludes that the remaining countries exhibit a high degree of correlation with the euro area business cycles with a lag of no more than three-quarters, with the exception of Austria.

9. Conclusions

This paper provides a descriptive analysis of the cyclical evolution of the European Union countries between 1960 and 1999. In particular, we investigate whether the cycle of these countries converged to the euro area business cycle.

Considering the whole sample period, the various parametric and non parametric statistics used in this paper, suggested that the set of countries with the highest degree of association with the euro zone business cycle are France, Belgium, Germany, Austria, the Netherlands and Portugal. In contrast, Finland and Ireland are the euro zone countries that exhibit the lowest degree of association with the euro zone business cycle.

During the sample period, in terms of cyclical convergence, we distinguished three groups of countries. A first group included Germany, France and Belgium, where the results suggested a high degree of association and synchronisation with the euro zone business cycle in the whole sample period. A second group included Italy, Spain, Austria, the Netherlands and Portugal, where it was observed a significant increase in both the association and synchronisation with the euro zone cycle, suggesting that these countries converged to the euro area business cycle. A last group included Finland, Ireland and Luxembourg, where no evidence of cyclical convergence with the euro area was found.

In the non-euro area countries, there was an increase in the degree of cyclical association, particularly for the United Kingdom, but not in synchronisation, so we cannot state that these countries have cyclically converged to the euro zone business cycle. The only exception seems to be Greece, where there was also an increase in synchronisation.

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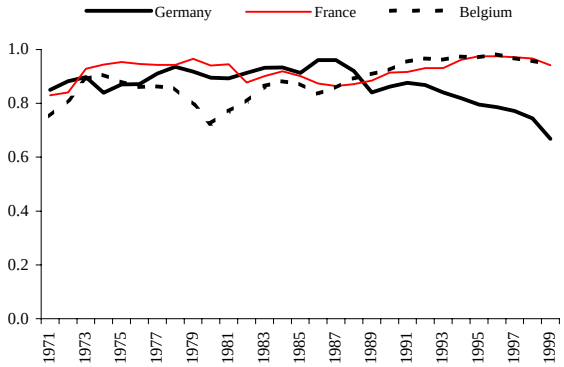
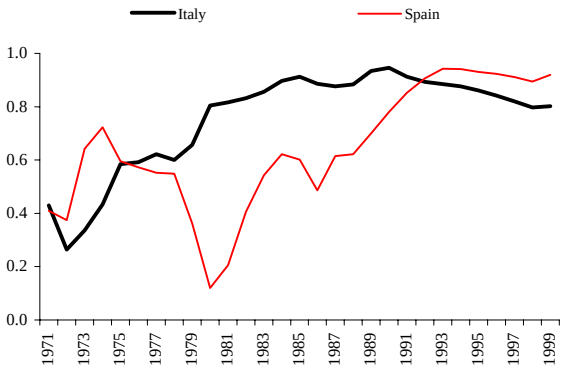
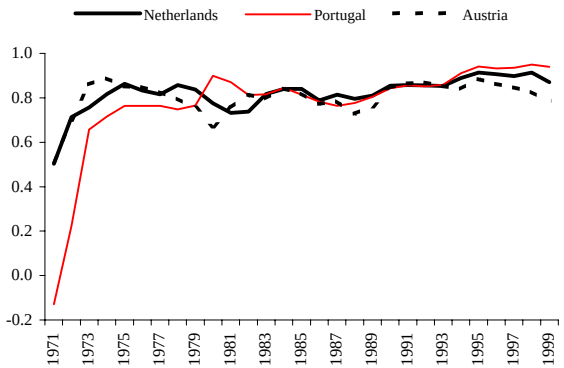
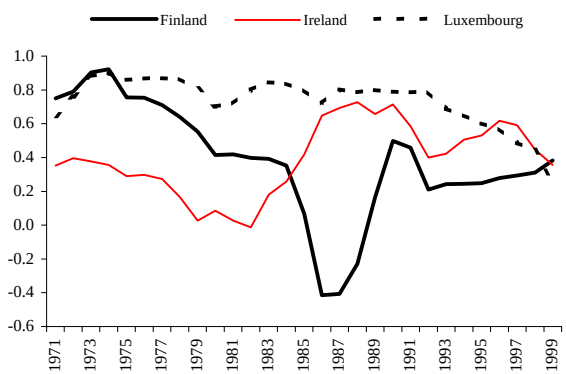
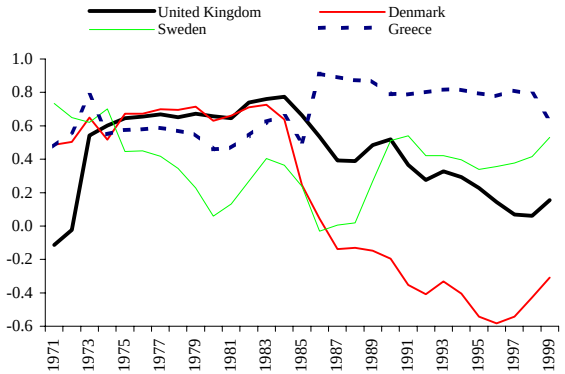
Appendix 1: Contemporaneous correlation for a rolling sample of 12 years

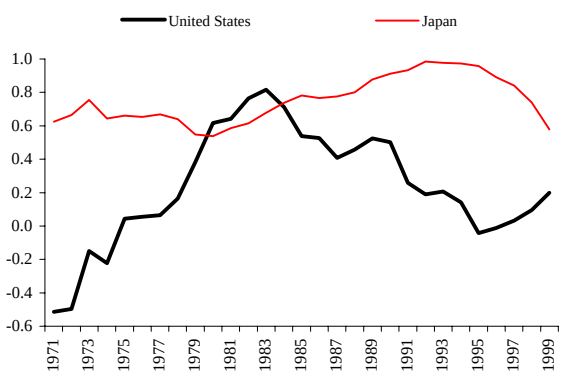




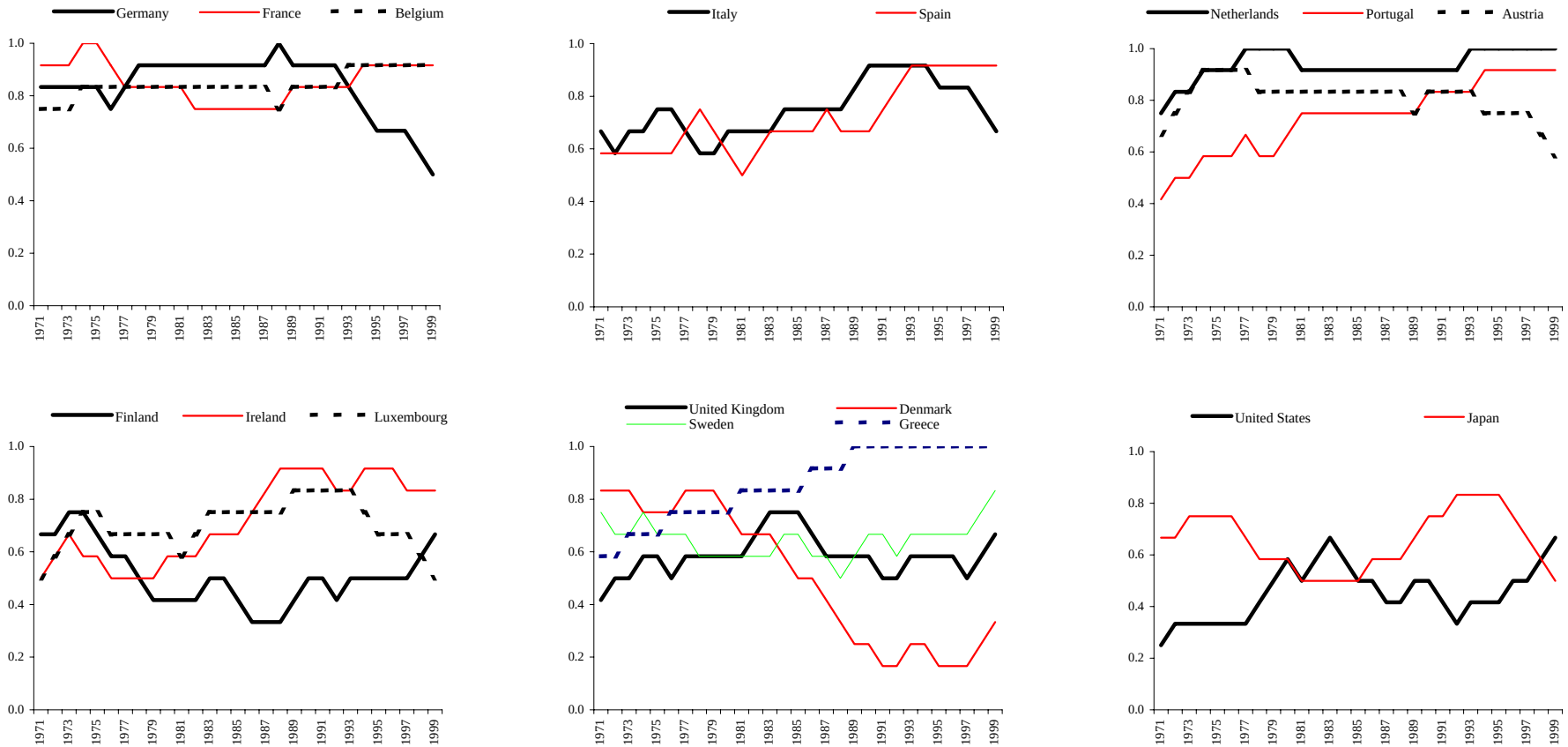








Appendix 2: Contemporaneous concordance for a rolling sample of 12 years



Appendix 3 – Contemporaneous correlation with the United States

	1960-1999	1960-1978	1979-1999
Euro zone	0.23*	0.10*	0.32*
Germany	0.12*	0.22*	0.04*
France	0.19*	0.17*	0.20*
Italy	0.26*	0.02*	0.52
Spain	0.22*	-0.03*	0.42
The Netherlands	0.31	-0.04*	0.59
Belgium	0.07*	-0.13*	0.24*
Austria	-0.15*	-0.23*	-0.08*
Finland	0.23*	-0.32*	0.58
Portugal	0.18*	0.33*	0.07*
Ireland	0.14*	-0.11*	0.29*
Luxembourg	0.22*	0.06*	0.40
United Kingdom	0.69	0.56	0.79
Denmark	0.53	0.45	0.59
Sweden	0.28	-0.39*	0.72
Greece	0.32	0.22*	0.46
Japan	0.05*	0.04*	0.05*

Note: (*) The correlation coefficient is not statistically significant with a level of significance of 10%.

Appendix 4 – Maximum correlation with the United States

	1960-1999	i	1960-1978	i	1979-1999	i
Euro zone	0,37	1	0,10	0	0,67	2
Germany	0,12	0	0,22	0	0,42	2
France	0,35	1	0,17	0	0,68	2
Italy	0,58	1	0,34	1	0,79	1
Spain	0,27	1[a]	-0,03	0	0,61	1
Netherlands	0,35	1[a]	-0,04	2[a]	0,65	1
Belgium	0,22	1	-0,13	0	0,58	2
Austria	0,07	2	-0,22	-2[a]	0,50	2
Finland	0,32	1	-0,01	1	0,58	0
Portugal	0,37	2	0,33	0	0,82	2
Ireland	0,25	1	-0,11	-1[a]	0,41	1
Luxembourg	0,22	0	0,06	0	0,40	1[a]
United Kingdom	0,69	0	0,56	0	0,79	0
Denmark	0,54	0	0,45	0	0,76	-1
Sweden	0,38	1	0,28	2	0,72	0
Greece	0,32	0	0,23	-1[a]	0,61	1
Japan	0,33	2	0,24	2	0,46	2

Notes:

(i) displacement where the correlation is maximum, with i=-2, -1, 0, 1, 2. A positive value (negative) for i means that the country has a lead (lag) cycle with respect to United States cycle.

(a) maximum correlation is similar to contemporaneous correlation (absolute difference ≤ 0,06).

Appendix 5: Displacement for the maximum correlation coefficient for a rolling sample of 12 years

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1a	1	1	1	1	1	1	1
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1a	0	0	0	0	0	0	0	0	0	0	0	0
Italy	-2	-2	-2	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1a	-1a	-1a	-1a	-1a	-1a	-1a	-1a
Spain	0	0	0	0	1a	0	0	0	0	0	0	0	0	0	-2	-2	-2	-1	-1	-1	-1	-1	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1a	0	0	0	0	0	0	0	0	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1a	0	0	0	0	0	0	0	0	0	0	0	0
Austria	0	1a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1a	1a	0	0	1	1	1	1a	1a	1a	1a	1a
Finland	0	0	0	0	1a	1a	1a	1a	1	1	1	1	1	2	1	2	1	0	0	-2	-1	-2	-2	-2	-2	-2	-2	-2	-2
Portugal	-1	-1	-1a	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1a	0	0	0	0	0	0	0	0	0	0	0
Ireland	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	1	1	1	1	1	1	1	1a	0	-1a	0	-1a	-1	-1	-1
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1a	-1a	-1	-1	-1	-1	-1a	-1a	0	0	0	2
United Kingdom	2	2	0	0	0	0	0	0	0	0	0	0	0	-1	-2	-1	-1	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
Denmark	0	0	0	0	-1a	0	0	0	0	0	0	-1a	-1a	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
Sweden	0	0	0	0	1	1	1	1	2	2	2	2	2	2	0	-1	-1	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-1	-1
Greece	0	1a	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USA	2	2	2	2	0	0	0	-1	-1	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2
Japan	-1	-1	-1a	-1	-1	-1	-1	-1a	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: (i) displacement where the correlation is maximum, with i=-2, -1, 0, 1, 2.A positive value (negative) for i means that the country has a lead (lag) cycle with respect to euro area business cycle.
(a) maximum correlation is similar to contemporaneous correlation (absolute difference less than 0,06).

Appendix 6:

In order to do a sensitivity analysis to the results derived from the Hodrick-Prescot (HP) with λ=100, we have computed the correlation coefficients between the cyclical components obtained by using λ=10 in the HP filter and also from the first differences filter, with respect to the euro area and United States cycles, for the 1960-1999 period. It should be noted that we have chosen to test the parameter λ=10 in the HP filter following Baxter and King (1999) where they suggest that a λ=10 parameter, for annual data, is theoretically better than λ=100 parameter for annual data.

Contemporaneous correlation with the euro zone and United States

	Euro zone			United States		
	HP 100	**HP 10**	**1st Dif**	**HP 100**	**HP 10**	**1st Dif**
Euro zone	1,00	1,00	1,00	0,23	0,34	0,40
Germany	0,84	0,83	0,84	0,12	0,34	0,41
France	0,92	0,88	0,93	0,19	0,23	0,34
Italy	0,71	0,70	0,84	0,26	0,23	0,30
Spain	0,72	0,65	0,83	0,21	0,16	0,32
The Netherlands	0,76	0,68	0,78	0,30	0,42	0,42
Belgium	0,89	0,86	0,89	0,07	0,16	0,25
Austria	0,77	0,73	0,78	-0,15	0,04	0,08
Finland	0,35	0,52	0,48	0,22	0,13	0,20
Portugal	0,80	0,69	0,77	0,18	0,29	0,32
Ireland	0,35	0,47	0,02	0,14	0,16	0,10
Luxembourg	0,71	0,61	0,32	0,22	0,44	0,31
United Kingdom	0,40	0,39	0,40	0,69	0,68	0,59
Denmark	0,09	0,34	0,57	0,53	0,49	0,48
Sweden	0,40	0,45	0,63	0,28	0,03	0,21
Greece	0,61	0,52	0,65	0,32	0,40	0,34
United States	0,23	0,34	0,40	1,00	1,00	1,00
Japan	0,64	0,59	0,74	0,05	0,14	0,24

These results suggest that although the correlation coefficients are sensible to the filter used, the qualitative conclusions based on them do not change significantly across methods. This conclusion draws from the following facts:

- The three countries with a higher correlation with the euro area are the same, namely, France, Belgium and Germany.
- The set of countries with a higher correlation with the euro area is nearly the same.
- The two countries that exhibit a higher correlation degree with the United States are also the same, namely, United Kingdom and Denmark.
- The set of countries with a higher correlation with the United States is also nearly the same.

Appendix 7

MAXIMUM CROSS-COUNTRY CORRELATION[(a)]

1960-1978

	Ger	Fra	Ita	Spa	Nld	Bel	Aut	Fin	Prt	Irl	Lux	UK	Dnk	Swe	Grc	USA	Jpn
Ger	**1**																
	0																
Fra	**0.83**	**1**															
	0	0															
Ita	0.40	0.43	**1**														
	-2	0	0														
Spa	0.30	0.44	0.07	**1**													
	0	2*	0	0													
Nld	0.62	0.62	0.25	0.41	**1**												
	0	0	2*	-2*	0												
Bel	0.69	**0.82**	0.37	**0.72**	0.67	**1**											
	0	0	2	0	0	0											
Aut	0.65	**0.80**	0.21	0.69	0.64	**0.82**	**1**										
	0	0	2*	-2*	0	0	0										
Fin	0.60	0.69	0.54	0.49	0.36	0.71	0.64	**1**									
	1	1*	2	-2*	1*	0	0	0									
Prt	0.58	**0.76**	0.43	0.60	0.50	0.64	0.65	0.59	**1**								
	0	0	0	-1	0	0	0	-1	0								
Irl	0.56	0.38	0.39	0.31	0.31	0.53	0.34	0.42	0.17	**1**							
	-1	-1	1	-1*	-1*	-1	-2	-1	1	0							
Lux	0.69	0.82	0.25	0.76	0.63	0.89	**0.74**	0.72	0.68	0.46	**1**						
	0	0	2*	0	0	0	0	0	0	1	0						
UK	0.55	0.58	0.10	0.44	0.47	0.55	0.42	0.41	**0.75**	0.38	0.67	**1**					
	0	0	0	0	0	0	0	-1	0	1	0	0					
Dnk	0.75	0.58	0.25	0.23	0.50	0.44	0.41	0.37	0.54	0.23	0.45	0.51	**1**				
	0	0	-1	-1	0	0	0	-1	0	1	0	0	0				
Swe	0.28	0.44	0.65	0.34	0.34	0.54	0.37	**0.74**	0.65	0.47	0.58	0.28	0.20	**1**			
	0	1	2	1	0	0	-1*	0	2	1	1	1	2	0			
Grc	**0.71**	0.75	0.36	0.40	0.47	0.63	0.70	0.52	0.74	0.42	0.63	0.62	0.58	0.09	**1**		
	0	-1	2	-1	0	-1	-1	-1	-1	1	-1	0	0	-2*	0		
USA	0.22	0.17	0.34	-0.03	-0.04	-0.13	-0.22	-0.01	0.33	-0.11	0.06	0.56	0.45	0.28	0.23	**1**	
	0	0	-1	0	2*	0	2*	-1	0	1*	0	0	0	-2*	1*	0	
Jpn	0.55	**0.76**	0.61	0.43	0.60	0.62	0.66	0.75	0.61	0.23	0.63	0.32	0.48	0.56	0.53	0.24	**1**
	-1*	-1	0	-2	-1	-1	-1	-2	-1	0	-1	0	0	-2*	0	2	0

1979-1999

	Ger	Fra	Ita	Spa	Nld	Bel	Aut	Fin	Prt	Irl	Lux	UK	Dnk	Swe	Grc	USA	Jpn
Ger	**1**																
	0																
Fra	**0.77**	**1**															
	-1	0															
Ita	0.60	0.77	**1**														
	0	0	0														
Spa	0.88	0.84	0.72	**1**													
	-2	-1*	0	0													
Nld	0.82	0.66	0.79	0.73	**1**												
	-1*	0	0	1*	0												
Bel	0.72	**0.90**	0.86	**0.77**	0.73	**1**											
	0	0	0	0	0	0											
Aut	0.91	**0.88**	0.66	0.84	0.71	**0.76**	**1**										
	0	1	1	2	0	0	0										
Fin	0.28	0.53	0.46	0.63	0.29	0.45	0.31	**1**									
	-2	-1	0	-1	-1	-1	-2	0									
Prt	0.60	**0.90**	0.87	0.76	0.67	0.86	0.73	0.50	**1**								
	0	0	1	1*	1	0	-1*	2	0								
Irl	0.36	0.50	0.61	0.23	0.36	0.55	0.45	0.54	0.49	**1**							
	-1	0	0	0	0	0	-1*	1*	0	0							
Lux	0.74	0.59	0.55	0.69	0.71	0.60	**0.72**	0.16	0.58	0.13	**1**						
	-1	-1*	-1*	1*	-1*	-1*	-1	2	-1	-1	0						
UK	0.65	0.83	0.90	0.83	0.78	0.83	0.65	0.67	**0.86**	0.53	0.57	**1**					
	-2	-2	-1	-1	-1	-2	-2	0	-2	-2	-1	0					
Dnk	-0.01	0.36	0.60	0.55	0.37	0.35	-0.07	0.66	0.49	0.33	0.25	0.68	**1**				
	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-1*	0				
Swe	0.35	0.59	0.60	0.76	0.51	0.55	0.38	**0.86**	0.57	0.36	0.34	0.82	0.69	**1**			
	-2	-2	0	-1	-1	-1	-2	0	-2	-1*	-2	1*	1	0			
Grc	**0.71**	0.68	0.82	0.57	0.79	0.74	0.66	0.42	0.59	0.63	0.47	0.71	0.39	0.52	**1**		
	0	0	0	1	0	0	0	2	0	0	0	2	2	1	0		
USA	0.42	0.68	0.79	0.61	0.65	0.58	0.50	0.58	0.82	0.41	0.40	0.79	0.76	0.72	0.61	**1**	
	-2	-2	-1	-2	-1	-2	-2	0	-2	-1	-1*	0	1	0	-1	0	
Jpn	0.75	**0.73**	0.63	0.83	0.72	0.73	0.75	0.45	0.71	0.32	0.59	0.71	0.23	0.65	0.54	0.46	**1**
	-1	0	1*	1*	0	0	-1*	2	0	0	0	2	2	1	0	2	0

Notes:

(a) The value below the maximum correlation coefficient is the displacement for the maximum correlation, with i=-2, -1, 0, 1, 2. A positive value (negative) for i means that line country has a lead (lag) cycle with respect to column country. The shadded cells mean that the correlation coefficient is higher or equal to 0.7 and the **bold** values mean that this happens in both periods.

(*) Maximum correlation is similar to contemporaneous correlation (absolute difference less than 0,06).

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