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Is there a European Business Cycle?**

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International Business Cycles and the ERM:
Is There a European Business Cycle?

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Abstract

Successful fixed exchange rate systems impose policy disciplines which are likely to lead to conformity in the business cycles of the participating countries. This conjecture is borne out in the present paper by the evidence adduced in it that the business cycle affiliation of ERM member countries has shifted from the United States to Germany since the formation of the ERM. This effect is bolstered by growing links in trade and finance between the European countries. The United Kingdom is conspicuous among these in that its business cycle affiliation did not change.

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Keywords: business cycle, ERM

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Introduction

The purpose of this paper is to investigate the effects of the Exchange-Rate Mechanism (ERM) of the European Monetary System (EMS) on the international business cycle in terms of the linkage and synchronization of cyclical fluctuation between countries. More specifically, by using the US cycle and the German cycle as two bench-mark cycles and the pre-ERM period and the ERM period as two subperiods, and by dividing the sample of 12 countries into two groups - the ERM-group and non-ERM group - the paper attempts to examine whether systematic differences in business cycle behaviour within the two groups of countries across the two period can be observed. The inclusion of the non-ERM countries enables us to distinguish ERM-specific phenomena from the general development of the international business cycle and thus allows us to establish whether there is a "European" business cycle.

The investigation of linkage in business cycles and the way in which economic disturbances are transmitted across countries has a long history. Earlier literature includes the paper by Mitchell (1927) who found that the correlation of business cycles across countries was positive and tended to rise over time due to the openness of financial markets. Recent contributions to this literature, particularly those that investigate the question whether the transmission of foreign economic shocks depends on the exchange rate regime, include papers by Gerlach (1988), Baxter and Stockman (1989), and Ahmed *et al* (1993), among others. Dividing exchange rate experience into fixed and floating rate regimes, identified respectively with the Bretton Woods period and after, these studies examine whether the international business cycle has changed between the two periods.[1]

Gerlach (1988) examines the cross-correlations of monthly industrial production series under the two regimes (1963:2-1973:2 and 1973:3-1986:3) and finds that the variances of monthly growth rates are typically higher in the flexible exchange rate period; but output movements have been correlated across countries under both regimes. He also suggests that there is evidence of a world business cycle.

Baxter and Stockman (1989) use the industrial production data of a sample of 49 countries

1. Because the adoption of an exchange regime is itself endogenous, and because the widespread abandonment of the Bretton Woods system coincided with the first oil shock, Baxter and Stockman (1989) additionally examine two other episodes of change in exchange rate regime where the problem of two-way causation is less acute.

to compare the behaviour of business cycles under the two exchange rate regimes (1960:1-1970:4 and 1973:1-1985:4). They find little evidence of systematic differences in the behaviour of macroeconomic aggregates. They also find that the cross correlations decrease in the flexible rate period and argue that business cycles became more country-specific in the post-1973 period.

Ahmed *et al* (1993) use a structural macroeconometric model to study the source of international economic fluctuations. Apart from other results, they find that the interactions between output, relative prices, and the ratios of fiscal and monetary variables in the United States and the rest of the world were much the same in the pre-1973 fixed-exchange-rate period as in the post-1973 flexible-exchange-rate period. Thus they argue that there is no evidence of differences in the transmission properties of economic disturbances across exchange-rate regimes.

In this paper we take the ERM countries as constituting a fixed exchange rate bloc. The ERM has been characterised as a hegemonic system centred on Germany as the anchor country. In such a case, standard economic theory makes it clear that in choosing to target its exchange rate against the currency of a dominant country with which trade and financial links are probably in any case important, a small open economy will be obliged to import the disturbances hitting the dominant country and will indeed be using its policy instruments to enforce this (for a theoretical characterization, see Canzoneri, 1982). Of course this does not rule out that the country may also import shocks from elsewhere or experience its own idiosyncratic shocks; moreover, referring now specifically to the case of ERM membership, it must be noted that whilst Germany is considerably the largest economy in the ERM, the economies of France and Italy (respectively, the fourth and fifth largest in the G-7 ranking) are hardly "small". Moreover, the ERM has contained a number of "escape" clauses. Exchange rates have not been rigidly fixed but have fluctuated within a band; central parity realignments have occurred; and, up to the late 1980s, member countries could buy a degree of freedom by deploying exchange controls on capital flows. Nevertheless the hypothesis that the formation of the ERM may have bred a "European business cycle" centred on Germany is worth exploring. Indeed, the synchronization of business cycles in the ERM may have become one of the key conditions for the efficient coordination of monetary policy in Europe, as noted for example by Christodoulakis *et al*. (1995) in their recent study of this matter[2]. However, where these authors analyse and compare the cyclical behaviour of a large number of aggregate variables for the EC countries over the period 1960-1990, the focus of our own study is on the change over time in the business cycle affiliation of the set of ERM countries. The papers by Karras (1994) and by Fiorito and Kollintzas (1994) are also complementary to the concerns of the present study. The former paper is concerned with the sources of business cycle fluctuations in the economies of France, Germany and the UK over the period 1960-1988; the latter tests real business cycle propositions on the data for the G-7 countries.

The paper reports some statistical regularities in business cycles for a sample of 12 countries. It appears that 1) the degree of linkage between business cycles within the ERM has strengthened and that business cycle phases have become more synchronous through time; 2) the linkages in business cycles between the ERM countries and the US have weakened during the ERM period; 3) these phenomena do not occur for the non-ERM countries.

The paper contains five sections. The first section gives a brief description of the two most commonly used detrending methods: the phase-average-trend (PAT) method and the filter proposed by Hodrick and Prescott (1980). In sections 2 to 5, we report evidence for the ERM countries in terms of the synchronization, the phase shift and the linkage between their business cycles. This evidence is provided on the basis of comparisons made across countries and across periods employing data derived using the PAT method. The robustness of the results for alternative detrending methods is also assessed. The paper is completed by a summary of the main results and conclusions.

1. Detrending Methods

The data used in the current study are the OECD seasonally adjusted figures on monthly industrial production spanning the period from January 1961 to December 1993[3] for a sample of 12 countries. They are the US, Canada, Japan, the UK, Germany, France, Italy, Netherlands, Belgium, Spain, Portugal and Ireland. The whole period is divided into two

2. It is arguable that it was because the business cycle in the UK was insufficiently "European" that the UK was obliged to leave the ERM in 1992; the delinking of the British from the German business cycles is cited in Artis *et al* (1995) in this connection.

3. The series for Portugal runs from January 1968 to October 1993.

subperiods: the pre-ERM period (1961:1-1979:3) and the ERM period (1979:4-1993:12). Since the main purpose of the paper is to investigate the ERM effect on the international business cycle, most ERM countries are included[4]. While the US cycle serves as the benchmark cycle, the inclusion of data for other non-ERM countries such as Canada, Japan and the UK, helps us to distinguish ERM-specific phenomena from general tendencies in the business cycle.

The definition of the business cycle employed in the current paper is that of the growth cycle, representing cyclical movements around the long-run growth trend of an economy. The decomposition of observed series into a trend movement and cyclical component is one of the key issues in business cycle research. The central issue is what is meant by the cyclical component and how to choose the appropriate filter to use to isolate it. Statistical properties, such as the cross-correlation between two series, will be sensitive to the filter chosen. In this paper we simply adopt the position assumed by Englund *et al* (1992) that as we are agnostic about the proper way to do such detrending, a reasonable way to proceed is to use several of the more commonly used filters in business cycle research and to conduct a sensitivity analysis over the results. The three most widely used techniques are the phase-average-trend estimation procedure proposed by Boschan and Ebanks (1978), the filter proposed by Hodrick and Prescott (1980) and linear trending (a special case of the HP filter).

The phase-average-trend (PAT) estimation procedure provides a fairly flexible growth trend that is substantially free of the shorter-term cyclical movements in the series. This method was designed specifically to separate long-term trends from medium-term cycles, with the latter defined according to the criteria programmed in the Bry-Boschan computer routine for selecting cyclical turning points. Briefly, the basic steps in the PAT procedure involve 1) selecting the turning points using the Bry and Boschan (1971) routine; 2) splitting the series into phases, defined as the number of months between successive turning points; 3) calculating the phase-average, defined as the means of the observations in each phase; 4) computing a three-term moving average by using these phase-averages; and, 5) finally, obtaining the trend. A detailed description of the PAT procedure can be found in Boschan

4. For reference purposes we label as ERM countries all those which are now in the ERM together with Italy. This includes both the original members and the latecomers, Spain (which joined in June 1989) and Portugal (which joined only in April 1992) and excludes the UK (which joined in October 1990 but left in September 1992). Italy was an original memebr of the ERM but left in September 1992. Denmark is excluded for data reasons (the available series is too short).

and Ebanks (1978). The principal statements of results in the text are obtained by using the cyclical series supplied by the OECD, which employs a modified version of the PAT procedure (see Nilsson (1987)).

The Hodrick-Prescott filter (HP filter) decomposes the raw series into a stochastic growth component and a cyclical one. The HP filter can be specified as:

$$\min_{g_t} \sum_{t=1}^{N} (y_t - g_t)^2 + \lambda \sum_{t=2}^{N-1} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2$$

where y_t denotes the raw series, g_t the growth component and $(y_t - g_t)$ the cyclical component. The first part measures the fitness and the second is a measure of smoothness. The parameter, λ, interpreted as the signal-to-noise ratio, determines the weight of fitness relative to that of smoothness. As λ goes to infinity the HP filter collapses to a linear trend. For quarterly data, Hodrick and Prescott (1980) set $\lambda = 1600$, arguing that a 5% deviation from trend per quarter is moderately large as it represents one-eighth of a one percent change in the growth rate in a quarter.

These methods are widely used and easy to implement; they are, however, not free from criticism. For the PAT procedure, the estimation of peaks and troughs is a crucial step, since the method first splits the series into phases which are defined as the number of months between successive turning points. The Bry-Boschan routine specifies a minimum duration of five months for a phase and fifteen months for a cycle. The rules adopted may be sensitive to the turning points selected, particularly for those called 'minor turning points'. Although there is no need to define the turning points in the HP filter, the filter may seriously alter the measures of comovements between series (see, for example, King and Rebelo (1993)). Nevertheless, the robustness /sensitivity of the results from different filters is assessed in a formal way in the current paper and there is no evidence that the main conclusions are sensitive to the choice of filter.

All the cyclical components used in our paper are measured by a cyclical index: $1.0 + (X_t - \text{trend}_t)/\text{trend}_t$, where X_t is the raw series. Figures 1 and 2 graph the US and French business cycles, in which these components are detrended by the filters discussed above. At the top of each figure is the series detrended by the OECD using the modified PAT procedure. In the middle, there are two cyclical indices detrended by the HP filter when $\lambda = 500000$ and $\lambda = 50000$ respectively. The large values for λ may be justified on two grounds: 1) that

Figure 1. The US Business Cycle

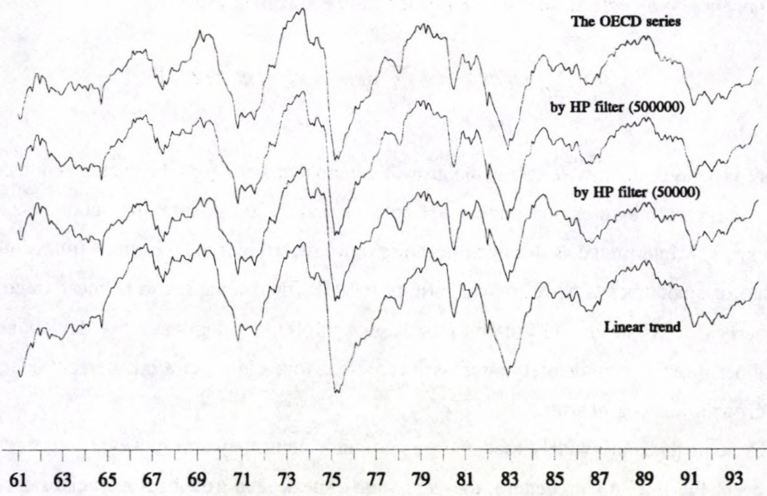
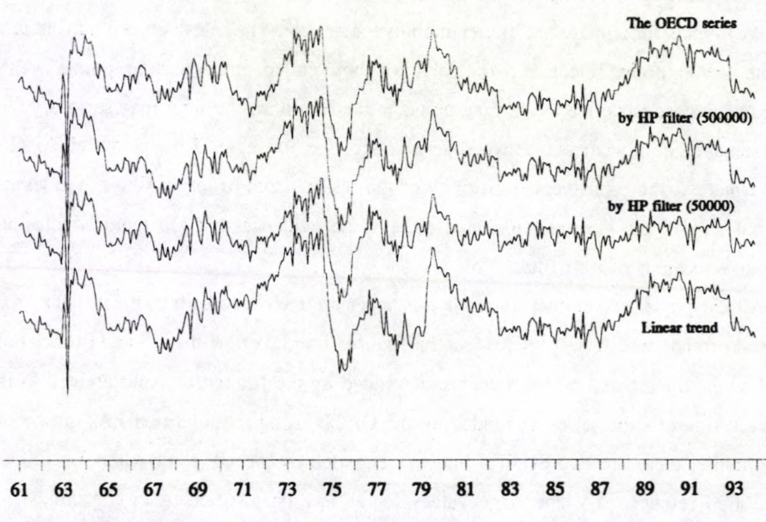


Figure 2. The French Business Cycle



monthly industrial production is a volatile series; 2) that the trend of industrial production can be assumed to be basically upwards. Finally, we also graph the cyclical components derived as deviations from a linear trend. Since the growth rates of industrial production in almost all the industrial countries slowed down during the '80s and '90s, a separate linear trend is applied to the different periods (the pre-ERM and the ERM period). The four series have very similar cyclical movements; in particular, the OECD series and the series detrended by HP filter($\lambda=500000$) are very similar. A noticeable dissimilarity may also be observed for the series detrended by the HP filter($\lambda=50000$), particularly for the French cycle during the later part of the period. The correlations across countries, across periods and across different detrending methods are reported in Tables A1 to A4 in the Appendix. The statistics reported in these tables provide basic information on three features. The degree of synchronization between any two cycles is measured by the contemporaneous cross-correlation. The phase shift is measured by the lead /lag at which the maximum correlation is obtained, while the maximum correlation is used to measure the degree of linkage between two cycles. These three aspects are closely related. However, for convenience, they will be discussed separately in the following sections.

2. Synchronization

A general finding is that the business cycles in the major countries have become more synchronized as a result of increased international trade, openness of financial markets and global capital flows (see, for example, Zarnowitz (1985)); however, Baxter and Stockman (1989) have on the contrary observed decreases in the contemporaneous cross correlation of business cycles and argue that business cycles have become more country-specific in the post-1973 period.

The degree of synchronization between two cycles is measured by the cross-correlation at displacement 0. An excerpt from the full set of results reported in appendix Tables A1 to A4 is given in Table 1. This table reports with a + (-) sign whether the correlation with the German cycle is larger (smaller) than that with the US cycle for a given detrending method. For example, for the series detrended by the OECD, the France-Germany correlation (0.53) is smaller than the France-US correlation (0.67) during the pre-ERM period and this is indicated by the negative sign (-). It is immediately clear that there is very little difference in the signs attached to the comparisons as between the different detrending methods employed and for convenience we may now concentrate on the results achieved using the OECD-adjusted series. Thus Figures 3 and 4 show for this method, respectively, the cross-correlations with the German and the US cycles before and after the creation of the ERM. By construction, observations close to the diagonal indicate a similar degree of synchronization with both benchmark cycles (the higher, the further to the NE the observation is located), whilst displacement from the diagonal can be interpreted as a difference of synchronization between the two benchmark cycles. There are a number of interesting regularities which may be described as follows:

Table 1. Contemporaneous Cross-Correlation

	Detrended by OECD		HP filter ($\lambda=500000$)		HP filter ($\lambda=50000$)		Linear trend	
	US	Germany	US	Germany	US	Germany	US	Germany
Pre-ERM period								
Germany	.45	--	.30	--	.44	--	.19	--
Canada	.85	.48 (-)	.80	.34 (-)	.86	.50 (-)	.73	.37 (-)
Japan	.45	.49 (+)	.29	.57 (+)	.54	.52 (-)	.17	.73 (+)
UK	.70	.63 (-)	.64	.53 (-)	.61	.58 (-)	.72	.49 (-)
France	.67	.53 (-)	.46	.58 (+)	.57	.55 (-)	.29	.68 (+)
Italy	.34	.08 (-)	.41	.07 (-)	.39	.15 (-)	.48	.18 (-)
Netherlands	.29	.76 (+)	.05	.62 (+)	.30	.62 (+)	-.02	.73 (+)
Belgium	.62	.66 (+)	.43	.64 (+)	.59	.66 (+)	.31	.72 (+)
Spain	.63	.38 (-)	.47	.33 (-)	.63	.38 (-)	-.12	.37 (+)
Portugal	.53	.47 (-)	.60	.33 (-)	.59	.28 (-)	.55	.33 (-)
Ireland	.58	.48 (-)	.50	.47 (-)	.54	.38 (-)	.03	.33 (-)
ERM period								
Germany	.32	--	.25	--	.16	--	.34	--
Canada	.90	.24 (-)	.93	.20 (-)	.91	.17 (-)	.91	.21 (-)
Japan	.46	.72 (+)	.35	.78 (+)	.41	.62 (+)	.44	.73 (+)
UK	.65	.36 (-)	.58	.28 (-)	.34	.08 (-)	.69	.44 (-)
France	.34	.78 (+)	.38	.77 (+)	.32	.59 (+)	.41	.85 (+)
Italy	.48	.65 (+)	.41	.57 (+)	.31	.33 (+)	.47	.67 (+)
Netherlands	.54	.78 (+)	.49	.74 (+)	.39	.59 (+)	.59	.82 (+)
Belgium	.44	.73 (+)	.34	.70 (+)	.22	.50 (+)	.45	.79 (+)
Spain	.39	.59 (+)	.28	.51 (+)	.12	.24 (+)	.43	.58 (+)
Portugal	.07	.57 (+)	-.13	.53 (+)	-.22	.29 (+)	-.01	.55 (+)
Ireland	.38	.40 (+)	.49	.31 (-)	.50	.17 (-)	.37	.58 (+)

In the pre-ERM period: With the exception of Canada, Netherlands and Italy, all the countries are located near or slightly below the 45° line in Figure 3, suggesting that business cycles in these countries are in phase slightly more often with the US cycle than with the

Figure 3. Correlation in the Pre-ERM Period

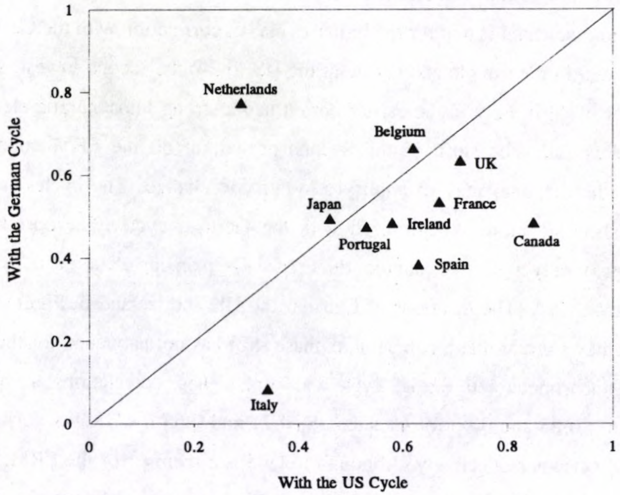
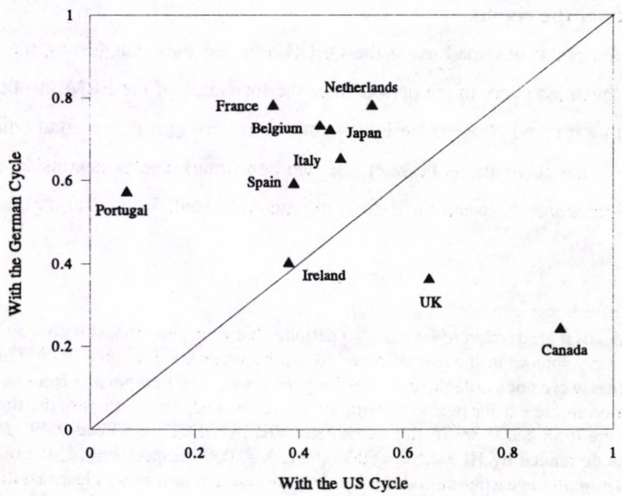


Figure 4. Correlation in the ERM Period



German cycle. A high degree of synchronization in the Canada-US cycles (0.85) and Netherlands-Germany cycles (0.77) is shown in Figure 3 by the displacement from the diagonal in the different directions of these two observations. This is not surprising given that the two pairs of economies have traditionally been closely linked over time. The least degree of synchronization indicated is that for the Italian cycle; its correlation with the German cycle (0.08) is the lowest in the sample and that with the US (0.34) the second lowest, suggesting that the business cycle in Italy in the earlier period had a strong idiosyncratic element.

In the ERM period: The shift, in this second period, of all the ERM countries to a position above the diagonal may exemplify a systematic change. The cycles in all these countries have become more synchronized with the German cycle. The correlations are moreover comparatively high: for example, the France-German correlation is 0.78 compared to 0.34 for France-USA. The locations of Canada, the UK and Ireland in Figure 4 are also of interest, for they suggest that a comparable phase shift has not happened for these cycles. They are still synchronous with the US cycle and in fact, these correlations are quite stable across the period: 0.85 and 0.90 for Canada-US, 0.71 and 0.65 for UK-US during the pre-ERM and ERM periods respectively. Although Ireland is a member of the ERM, a clearcut shift in phase with the US has not been found. On the contrary, the Japanese cycle is in phase more often with the German cycle than with the US one in the latter period.[5]

2.1 Sensitivity of the results

The predominant result obtained using the OECD-adjusted data, suggesting the emergence of a European business cycle in the period since the formation of the ERM, is not dependent on the detrending method chosen. Here we demonstrate, using a χ^2 test, that when the sign of the change in the correlations between the two benchmark cycles is considered, there is no significant difference between the detrending methods used. Formally, the methods used

5. The Irish industrial production series shows a definite change in smoothness before and after 1975: the series is very smooth in the pre 1975 period and becomes volatile after 1975. This is because monthly figures were not available in the earlier period and were interpolated from quarterly data. The correlation in the earlier period is certainly overestimated. For both periods, the Ireland-US correlations are 0.58 and 0.38 for the series detrended by OECD; 0.50 and 0.49; 0.54 and 0.50 for the series detrended by HP with $\lambda=500000$ and $\lambda=50000$ respectively. If the overestimation of the correlation in the earlier period is taken into consideration, it is not clear that there has been any weakening in the degree of synchronization in the Ireland-US cycles in the later period.

can be described as involving a 2×2 contingency table organized as follows[6]:

		Detrending method B: Change in correlation (+)	Detrending method B: Change in correlation (-)	
Detrending method A	Change in correlation (+)	n_{11}	n_{12}	$n_{1.}$
	Change in correlation (-)	n_{21}	n_{22}	$n_{2.}$
		$n_{.1}$	$n_{.2}$	N

where the change in correlation (+) /(-) is defined as before. The entry in cell(i,j), denoted n_{ij}, represents the frequency of observation for the particular category. For example, n_{11} is the number of observations where method A and method B record the same positive (+) sign; and n_{22} where the two methods record the same negative (-) sign. n_{12} and n_{21} are observations where the two methods produce different signs (respectively, (+) and (-) or (-) and (+) for method A and B). Intuitively, the more $n_{11}+n_{22}$ is observed, the more robust the results are across the two methods. The test statistic can be written as

$$X^2 = \sum_{i=1}^{2} \sum_{j=1}^{2} \frac{(n_{ij} - n_{i.}\, n_{.j} / N)^2}{n_{i.}\, n_{.j} / N}$$

where

$$n_{i.} = \sum_j n_{ij} \qquad N_j = \sum_i n_{ij}$$

and $N = n_{1.} + n_{2.} = n_{.1} + n_{.2}$. The two terms, n_{ij} and $n_{i.} n_{.j}/N$, denote observed and expected frequencies respectively. This is a χ^2 test for independence. Not rejecting the null means that the results from the two methods are independent, otherwise the results are related. The number of observations which have the same /opposite change in correlations together with the significance level[7] are reported in Table 2, in which the OECD detrending method is treated as method A in the contingency table format.

6. Details can be found in Yates (1984).

7. The problem of small sample and of small expected frequencies can be relevant in our case. The significance levels for small n in the 2×2 contingency table may be found in Daniel (1978) and they are reported in Table 2.

Table 2. The Comparison I

	HP filter (λ=500000)	HP filter (λ=50000)	Linear trend
Pre-ERM period			
Same direction	9	9	8
Opposite direction	1	1	2
ERM period			
Same direction	9	9	10
Opposite direction	1	1	0
Total			
Same direction	18	18	18
Opposite direction	2	2	2
Significance level of the test	.005*	.005*	.005*

'*' indicates significant at least at that level.

The hypothesis of independence is rejected in all cases, suggesting that the main patterns remain unchanged across filters. In fact, the conclusions, that the business cycles in the ERM countries become more synchronous with the German cycle, and less synchronised with the US cycle during the ERM period, are remarkably consistent across the different filters. These filters produce almost identical results in terms of change in correlation.

To summarise, the business cycles become more group-specific in the ERM period than before. It is in this sense that we may now be able to refer to a "European business cycle". The business cycles of the ERM countries become more synchronised in the ERM period, while this phenomenon has not occurred between the non-ERM countries and the US. For the reasons suggested earlier, this should not be surprising, given that disturbances and policy are transmitted more quickly through the channel of the exchange rate mechanism within the ERM countries. It is also suggested that the prediction that business cycles in the major countries are likely to be more synchronised due to the openness of financial markets may need further investigation. It is true that activities in the financial markets have become more highly integrated worldwide and that stock market indices are widely used as leading indicators of the real economy. However, the poor performance in predicting real economic activity and the wide range of the lead time between the leading indicators and the real business cycle do not suggest that the business cycles worldwide have become more synchronised[8].

4. Lead /lag relationships

Contemporaneous correlation measures provide useful information for measuring the degree of synchronization between two cycles. Although we find evidence that systematic differences of synchronization in business cycles may have been occurred across periods, it is uncertain how the phases shift. We can provide an explicit measure of phase shift by finding the lead /lag at which the maximum correlation is obtained[9]. Table 3 gives these lead /lag relationships. Again we first focus on the results from the series detrended by the OECD and a number of interesting regularities are described as follows:

8. In predicting the latest troughs for the G-7 using a sequential probability model, Artis *et al* (1995) show that what is observed is the opposite: the leading indices became more synchronised worldwide, but the real business cycles have shifted in phase significantly. For example, the first trough calls for the US, Canada, UK, France and Italy emerge almost simultaneously and again the second trough call for Japan, Germany, France and Italy also emerges around same time. The latest troughs in the G-7, however, are at least two years and a half apart. It is also found in the paper that turning point prediction for the European countries has become more difficult than before and less accurate than for the non-European G-7 members. This may suggest that the behaviour of the business cycle in the 1980s and 90s has changed.

9. 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 $\pm i$ ($i \leq 24$). In this paper, the maximum value of $|\rho_{\pm i}|$ is chosen for $i(i \leq 12)$, and the range is extended up to 24 months ($i \leq 24$) if the maximum correlation chosen has the same sign.

Table 3. Lead /Lag Relationship

	OECD series		HP filter (λ=500000)		HP filter (λ=50000)		Linear trend	
	US	Germany	US	Germany	US	Germany	US	Germany
Pre-ERM period								
Germany	0		0		0		-2	
Canada	0	0	0	-1	0	-1	0	-1
Japan	-2	+1	-2	0	-1	0	-12	0
UK	-1	0	0	0	0	0	-1	0
France	0	0	0	0	0	0	-2	-2
Italy	-4	**+14**	-4	**+14**	0	**+15**	-4	+24
Netherlands	-2	0	**-16**	0	**-16**	0	**+19**	0
Belgium	-1	0	-1	-2	-1	0	-2	-2
Spain	-2	-5	-2	-5	-2	-5	**+20**	-8
Portugal	-2	-3	-4	-4	-4	-3	-4	-4
Ireland	0	+3	-2	+3	-2	+3	**+24**	+2
ERM period								
Germany	-8		-8		-7		-8	
Canada	+1	+13	0	+8	0	+7	0	+11
Japan	-7	+1	-7	+1	-4	+1	-7	+1
UK	0	+20	0	+22	0	+22	0	+18
France	-7	0	-3	0	-3	0	-4	0
Italy	-6	0	-6	0	-4	0	-8	0
Netherlands	-7	0	-5	0	-3	0	-5	0
Belgium	-3	0	-3	0	-3	0	-5	0
Spain	-18	+6	-18	+6	-22	+6	-18	+6
Portugal	-24	0	**-24**	0	**+4**	+3	-24	0
Ireland	-2	+6	-2	+8	-2	+19	-2	0

Note 1. The figures indicate the number of months that the business cycle in the US or Germany leads (-) /lags(+) the cycle in the other countries.

Note 2. When the German-US correlation is calculated, the '+' /'-' indicates the US cycle leads /lags the German cycle.

Note 3. Emboldened figures indicate a negative correlation.

Pre-ERM period: With the exception of Italy, the maximum correlations with the US cycle are located within a range of only two months; the range with respect to the German cycle is only slightly larger. This is clear evidence that the business cycles as a whole are in this period synchronous worldwide. One of the main reasons may be the incidence of the two oil shocks in this period: one in 1973 and the other in 1979. These shocks were international in character and spread across countries. On the other hand, one might expect that business cycles would become less synchronous in the absence of common shocks of this type.

In the ERM period: The business cycles in terms of their phases may be classified into groups: the ERM group and the non-ERM group. The cycles in the ERM group (with the exception of Ireland) are in phase with the German cycle and out of phase with the US cycle. In fact, the maximum correlations are located at exactly 0 displacement except for the case of Spain (+6); while the range with respect to the US cycle runs from -3 to -24 months. While the cycles in the ERM group are synchronous, there exist cycles, those in the US, Canada, the UK and perhaps Ireland, which represent another international business cycle. The US cycle always leads those cycles by -2 to +1 months both in the per-ERM and ERM period. This phenomenon may be regarded as providing further support for the ERM effect on the business cycles - the ERM only affects the behaviour of business cycles in the ERM countries.

Another phenomenon we can observe is that the lead /lag relationship between the cycles in the ERM countries and the US cycle becomes unclear. This may be viewed in Table 4, which reproduces a part of Table A1. Table 4 provides information for the ERM period on the cross-correlation at different leads and lags between the ERM countries cycles and the two benchmark cycles. The distribution of correlations with the US cycle in the ERM period has a "thick tail" which suggests that the US cycle may lead the ERM cycles by much longer than the figures indicated in Table 3 which were based only on the maximum correlation. For example, the US cycle leads the French cycle by -7 months at which the maximum correlation is obtained, but the actual lead time could range from -3 to -24 months within which the correlations have a very similar level. This phenomenon exists for all the ERM countries except Ireland, but does not occur for the cycles between Germany and the rest of the ERM countries.

Table 4 Cross-Correlation at the Different Leads /Lags

	Leads / Lags						
	-24	-18	-12	-9	-6	-3	0
ERM Period							
Germany-US	.40	.45	.46	.48	.46	.41	.32
France-US	.41	.40	.40	.41	.41	.41	.34
France-Germany	.10	.20	.38	.49	.59	.69	.78
Italy-US	.42	.52	.62	.65	.66	.62	.48
Italy-Germany	-.01	.12	.30	.42	.52	.59	.65
Netherlands-US	.28	.43	.54	.61	.62	.62	.54
Netherlands-Germany	-.17	-.01	.27	.41	.54	.67	.78
Belgium-US	.26	.32	.39	.45	.50	.51	.44
Belgium-Germany	-.28	-.20	.01	.21	.39	.57	.73
Spain-US	.38	.45	.43	.42	.40	.41	.39
Spain-Germany	-.19	-.09	.10	.21	.33	.47	.59
Portugal-US	.44	.42	.34	.27	.21	.14	.07
Portugal-Germany	-.25	-.16	.03	.19	.32	.46	.57
Ireland-US	-.01	.00	.05	.17	.30	.38	.38
Ireland-Germany	.06	.09	.15	.19	.24	.32	.40

Baxter and Stockman (1989) observe that business cycles in the post-1973 period have been more country-specific and argue that this is because the source of shock may have changed whilst government policies may have differed in a way that affects the international character of business cycles. Gerlach (1988) suggests there is evidence of a world business cycle. Our findings are "mid-way" between these views in that we find that the business cycle has become more group-specific, with disparities emerging between the groups rather than within them - or at least, not within the "European" (ERM) group, where disparities have narrowed considerably. Of course, our observation period is somewhat different from that employed in these earlier studies, benefitting in particular from the inclusion of observations drawn from the period of the "hard ERM" and the idiosyncratic German shock associated with that country's unification and the associated fiscal and monetary policies.

5. Maximum correlation

Despite the fact that the phase in business cycles has been shifted across periods, it is uncertain whether the linkages of the business cycles have been changed. The linkage between the two cycles is measured by the maximum cross-correlation coefficients, which are reported in Tables A1 to A4 and reorganized in Table 5. Again, a graphical view of these correlations lends clarity to their interpretation. Figures 5 and 6 thus show maximum correlations with each of the two benchmark cycles across the subperiods. It is worth noting that comparisons provided in Tables 5 and 6 are across the subperiods and not across the two benchmark cycles, so that the impact of common shocks occurring in the earlier period may be isolated. Some interesting patterns may be observed and they are categorized into the following three groups: the group near, below and above the 45° line.

Canada, the UK and Germany: These countries are located near the diagonal in Figure 5 and this indicates that there is no evidence of systematic differences across periods. The correlations of the Canadian cycle with the US one are the highest and the UK correlations are almost the second highest in both periods. The German-US correlations in the pre-ERM period and during the ERM period are very similar, suggesting in that sense that the regularities in the two cycles may not have changed significantly between the two periods; on the other hand, for both periods they are quite low, indicating a relatively high degree of independence in each cycle.

Table 5. Maximum Cross-Correlation

	Detrended by OECD		HP filter (λ=500000)		HP filter (λ=50000)		Linear trend	
	Pre-ERM	ERM	Pre-ERM	ERM	Pre-ERM	ERM	Pre-ERM	ERM
With the US cycle								
Canada	.85	.90 (+)	.80	.93 (+)	.86	.91 (+)	.73	.91 (+)
Japan	.48	.60 (+)	.30	.51 (+)	.54	.56 (+)	.31	.59 (+)
UK	.71	.65 (-)	.64	.58 (-)	.61	.34 (-)	.73	.69 (-)
Germany	.45	.48 (+)	.30	.42 (+)	.44	.30 (-)	.19	.50 (+)
France	.67	.42 (-)	.46	.45 (-)	.57	.37 (-)	.30	.49 (+)
Italy	.34	.67 (+)	.41	.60 (+)	.39	.46 (+)	.49	.67 (+)
Netherlands	.31	.62 (+)	-.50	.58 (+)	-.48	.49 (+)	-.44	.66 (+)
Belgium	.63	.51 (-)	.44	.42 (-)	.60	.31 (-)	.32	.52 (+)
Spain	.66	.45 (-)	.50	.37 (-)	.66	.15 (-)	-.60	.48 (+)
Portugal	.56	.44 (-)	.65	.42 (-)	.64	-.29 (-)	.59	.47 (-)
Ireland	.58	.38 (-)	.51	.50 (-)	.55	.52 (-)	-.46	.37 (+)
With the German cycle								
US	.45	.48 (+)	.30	.48 (+)	.44	.30 (-)	.19	.50 (+)
Canada	.48	.49 (+)	.35	.42 (+)	.50	.36 (-)	.38	.45 (+)
Japan	.49	.73 (+)	.57	.78 (+)	.52	.65 (+)	.73	.74 (+)
UK	.63	.65 (+)	.53	.59 (+)	.58	.48 (-)	.49	.62 (+)
France	.53	.78 (+)	.58	.77 (+)	.55	.59 (+)	.68	.85 (+)
Italy	-.20	.65 (+)	-.20	.57 (+)	-.27	.33 (+)	.30	.67 (+)
Netherlands	.77	.78 (+)	.62	.74 (+)	.62	.59 (-)	.73	.82 (+)
Belgium	.66	.73 (+)	.65	.70 (+)	.66	.50 (-)	.73	.79 (+)
Spain	.46	.63 (+)	.45	.54 (+)	.50	.27 (-)	.48	.62 (+)
Portugal	.49	.57 (+)	.39	.53 (+)	.32	.30 (-)	.38	.55 (+)
Ireland	.51	.43 (-)	.49	.36 (-)	.40	.33 (-)	.34	.58 (+)

Japan and Italy: The business cycles in Japan and Italy increase their linkages not only with the US, but with the German cycle as well. The observations for these two countries lie well above the diagonal in both Figures.

The ERM countries: With the exception of the Netherlands and Italy, they are grouped below the diagonal in Figure 5 and above it in Figure 6. The average correlation with the US is around 0.65 in the pre-ERM period, but falls to around 0.45 during the latter period. Linkages with the German cycle are strengthened though time - the correlations with the German cycle are significantly higher in the ERM period than before. This phenomenon is not observed for the non-ERM countries, suggesting that there is evidence of the ERM effect

Figure 5. Correlation with the US Cycle

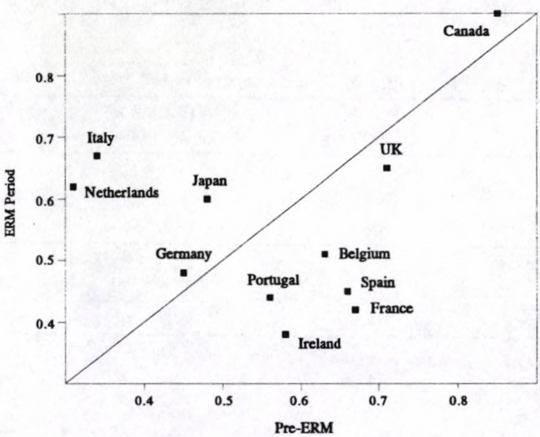
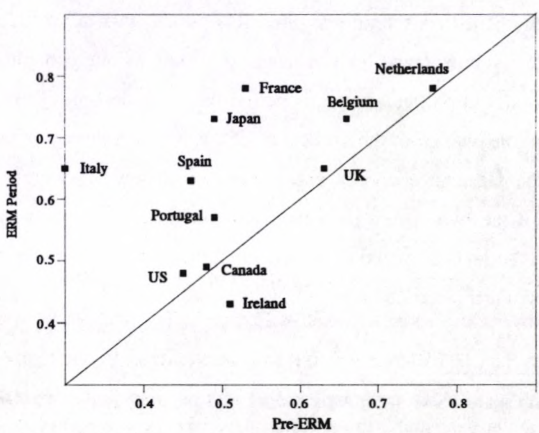


Figure 6. Correlation with the German Cycle



on the business cycles: the business cycles not only become more synchronous, but more closely linked within the ERM countries during the ERM period.

A comparison made across the filters in Table 6 shows that the PAT procedure and the HP filter (λ=500000) produce identical results. The results from the PAT and the HP (λ=50000) are associated at least at the 0.03 significance level, whilst the significance level of the association between the PAT procedure and linear trend is slightly above the 0.05 level of significance.

Table 6. The Comparison II

	HP filter (λ=500000)	HP filter (λ=50000)	Linear trend
With the US cycle			
Same direction	11	10	7
Opposite direction	0	1	4
With the German cycle			
Same direction	10	4	9
Opposite direction	0	6	1
Total			
Same direction	21	14	16
Opposite direction	0	7	5
Significance level of the test	.001*	.030*	.050+

'*' significant at least at that level; '+' not significant at that level.

Whilst there seems to be good evidence that the linkages of the ERM countries with the German cycle strengthened considerably in the ERM period, it is important also to note that the character of the cycle changed for Germany - and thus for the economies linked to it - as well in this period. In particular, in this period the cycle becomes less clear-cut (where there is no comparable change in the cyclicality of the North American economies); it is in this period that the German economy experiences its longest upswings since 1960 (the average duration of the two upswings in the ERM period rises to 45 months from the 33 months average in the preceding two decades) whilst the difference in growth rates between the upturn and downturn phases of the cycle falls[10].

10. These observations are drawn from Artis *et al* (1995) and are based on the OECD cyclical data series used in the present study. In the earlier paper the focus was on cyclical predictablility. The changes described were among the factors that made it less easy to predict the cycle in the 1980s than in earlier periods.

6. Conclusions

How far is an exchange rate regime likely to affect the character of economic fluctuations in the participating economies? Standard international monetary economics suggests that a successful nominal exchange rate peg will entail the transmission of shocks from one economy to another; the peg removes a means of buffering external shocks and may require policy measures to be taken which have precisely the effect of facilitating the import of such shocks. In a hegemonic system this suggests that the smaller economies may be exposed to the business cycle generated in the leader country, whilst both may suffer from common shocks generated elsewhere. These insights underlie the literature on optimum currency areas, and have been much in evidence in the debate over the putative formation of the European Monetary Union (e.g see Tavlas (1993)).

Despite the theoretical presumption, tests of the effect of exchange rate regimes on the character of economic fluctuations have not hitherto been entirely supportive of it - perhaps partly because of the identification problem involved in the sample separation required and partly because of the difficulties that are involved in controlling for other factors that would affect the nature of economic fluctuations. These must include factors such as trade and financial integration, increases in which are generally held to predispose in favour of the emergence of linkage between countries in the evolution of their business cycles, independently of the exchange rate regime.

In this paper we examine the question whether the formation of the functioning of the Exchange Rate Mechanism (ERM) of the European Monetary System has produced a strengthening of the linkages between the participating economies, resulting in a dilution of the effect of the US business cycle on these economies in favour of a stronger effect from the business cycle of Germany. Our data period starts in 1961 and expires at the end of 1993; the series employed are monthly data for industrial production and three different methods of detrending to isolate a (growth-) cyclical component are employed. Whilst the results are shown to be insensitive to the filtering method selected our presentation relies heavily on the use of the OECD-adjusted data, where the adjustment is a version of the phase-average-trend (PAT) method used by the NBER. Dividing the sample period between a pre- and a post-ERM period, and relying upon standard measures such as contemporaneous and maximum cross correlations, it is clearly observable that the synchronicity and linkage between the ERM economies and Germany has grown strongly between the two periods whilst the linkages with the US cycle have diminished for these countries. The UK, a member of the ERM only for a short period (October 1990 - August 1992), is shown not to have significantly changed its "business cycle affiliation" - possibly a partial explanation of its withdrawal from the ERM. Ireland, also, is a partial exception to the general rule. However, in the main, the data rather clearly indicate the emergence of a group-specific "European" cycle in the ERM period, somewhat independent of the US cycle. The nominal exchange rate peg of the ERM agreement and the degree to which these arrangements were credible in the period examined appear to be the obvious candidate for the explanation - although, of course, the adherence to the ERM arrangements has been accompanied by a growth in linkages in trade and finance between the ERM countries. This growth in turn can be characterized as at least partly independent of ERM membership (certainly so, in the case of Spain and Portugal which only joined the ERM comparatively late in the sample period) and it would have had reinforcing effects.

Appendix. Cross-correlations

In Table A1 to A4, the cross-correlations at different leads /lags from the series detrended by the OECD, the HP filters and linear trend are reported. These statistics are the correlation coefficients of the cycle in each country with the two benchmark cycles at the leads /lags indicated. The emboldened figures are the contemporaneous correlations. The lead (-) /lag(+) means that the cycle in the benchmark country (the US or Germany) leads /lags the cycle in other country. For example, in Table A1, in the pre-ERM period, the France-US contemporaneous correlation is 0.67; and becomes -0.43 when the US cycle leads the French cycle by 24 months. When the Germany-US correlation is calculated the US cycle serves as a benchmark cycle.

Table A1 Cross-Correlations for the Series Detrended by OECD

	Leads / Lags												
	-24	-18	-12	-9	-6	-3	**0**	3	6	9	12	18	24
Pre-ERM period													
Germany-US	-.38	-.24	.02	.17	.30	.41	**.45**	.40	.26	.09	-.06	-.29	-.35
Canada-US	-.45	-.25	.12	.37	.60	.77	**.85**	.74	.54	.29	.03	-.40	-.65
Canada-Germany	-.34	-.33	-.07	.10	.28	.42	**.48**	.44	.31	.14	-.02	-.33	-.47
Japan-US	-.28	-.05	.22	.34	.43	.47	**.45**	.36	.20	.01	-.18	-.40	-.46
Japan-Germany	-.35	-.39	-.14	.04	.22	.39	**.49**	.49	.43	.30	.16	-.07	-.16
UK-US	-.43	-.10	.28	.47	.60	.69	**.70**	.57	.38	.16	.02	-.30	-.50
UK-Germany	-.49	-.33	-.05	.16	.38	.55	**.63**	.56	.41	.26	.09	-.19	-.43
France-US	-.43	-.25	.08	.30	.49	.63	**.67**	.57	.34	.13	-.06	-.29	-.36
France-Germany	-.34	-.36	-.13	.06	.25	.45	**.53**	.51	.38	.25	.10	-.10	-.19
Italy-US	-.15	-.03	.17	.25	.30	.34	**.34**	.26	.10	-.09	-.19	-.31	-.22
Italy-Germany	-.05	-.09	-.07	-.02	.02	.07	**.08**	-.01	-.10	-.14	-.18	-.12	.14
Netherlands-US	-.20	-.13	.03	.13	.24	.31	**.29**	.18	-.01	-.16	-.26	-.32	-.21
Netherlands-Germany	-.45	-.25	.05	.30	.48	.65	**.76**	.63	.43	.25	.04	-.20	-.25
Belgium-US	-.38	-.15	.17	.35	.52	.61	**.62**	.47	.21	-.05	-.25	-.46	-.46
Belgium-Germany	-.40	-.30	.02	.24	.44	.62	**.66**	.58	.41	.22	.03	-.26	-.39
Spain-US	-.37	-.08	.36	.48	.58	.65	**.63**	.49	.22	-.06	-.28	-.46	-.46
Spain-Germany	-.30	-.10	.21	.33	.42	.44	**.38**	.25	.06	-.15	-.33	-.55	-.47
Portugal-US	-.45	-.17	.19	.37	.49	.56	**.53**	.49	.40	.26	.06	-.27	-.40
Portugal-Germany	-.18	-.01	.26	.32	.41	.49	**.47**	.41	.26	.13	-.04	-.32	-.46
Ireland-US	-.40	-.19	.09	.25	.42	.56	**.58**	.53	.41	.24	.09	-.21	-.41
Ireland-Germany	-.41	-.40	-.16	.02	.21	.40	**.48**	.50	.47	.35	.24	.00	-.12
ERM Period													
Germany-US	.40	.45	.46	.48	.46	.41	**.32**	.18	.03	-.10	-.21	-.28	-.32
Canada-US	-.18	.07	.33	.49	.65	.80	**.90**	.86	.74	.59	.43	.17	.01
Canada-Germany	-.45	-.37	-.27	-.17	-.05	.09	**.24**	.35	.44	.47	.48	.47	.46
Japan-US	.21	.36	.53	.59	.59	.57	**.46**	.30	.16	.03	-.08	-.24	-.33
Japan-Germany	-.42	-.34	-.04	.18	.40	.58	**.72**	.70	.67	.60	.50	.30	.07
UK-US	.11	.25	.35	.43	.51	.59	**.65**	.60	.53	.47	.38	.33	.14
UK-Germany	-.34	-.35	-.29	-.17	-.02	.16	**.36**	.43	.51	.57	.59	.64	.60
France-US	.41	.40	.40	.41	.41	.41	**.34**	.22	.09	-.04	-.16	-.24	-.36
France-Germany	.10	.20	.38	.49	.59	.69	**.78**	.71	.65	.55	.45	.31	.18
Italy-US	.42	.52	.62	.65	.66	.62	**.48**	.31	.18	.04	-.07	-.28	-.45
Italy-Germany	-.01	.12	.30	.42	.52	.59	**.65**	.62	.52	.44	.39	.29	.19
Netherlands-US	.28	.43	.54	.61	.62	.62	**.54**	.40	.25	.10	-.02	-.14	-.22
Netherlands-Germany	-.17	-.01	.27	.41	.54	.67	**.78**	.74	.69	.62	.53	.35	.21
Belgium-US	.26	.32	.39	.45	.50	.51	**.44**	.34	.21	.12	.02	-.06	-.19
Belgium-Germany	-.28	-.20	.01	.21	.39	.57	**.73**	.69	.62	.53	.44	.35	.24
Spain-US	.38	.45	.43	.42	.40	.41	**.39**	.32	.27	.21	.13	.00	-.16
Spain-Germany	-.19	-.09	.10	.21	.33	.47	**.59**	.60	.63	.59	.50	.44	.34
Portugal-US	.44	.42	.34	.27	.21	.14	**.07**	-.03	-.08	-.10	-.09	-.11	-.19
Portugal-Germany	-.25	-.16	.03	.19	.32	.46	**.57**	.55	.49	.41	.36	.22	.05
Ireland-US	-.01	.00	.05	.17	.30	.38	**.38**	.30	.19	.06	-.05	-.21	-.32
Ireland-Germany	.06	.09	.15	.19	.24	.32	**.40**	.43	.43	.40	.37	.35	.27

Table A2 Cross-Correlations for the Series Detrended by HP Filter (λ=500000)

	Leads / Lags												
	-24	-18	-12	-9	-6	-3	**0**	3	6	9	12	18	24
Pre-ERM period													
Germany-US	-.34	-.32	-.16	-.02	.12	.24	**.30**	.28	.18	.05	-.06	-.22	-.26
Canada-US	-.46	-.22	.15	.39	.60	.75	**.80**	.69	.50	.26	.02	-.37	-.60
Canada-Germany	-.13	-.16	.01	.12	.24	.33	**.34**	.26	.11	-.08	-.24	-.46	-.50
Japan-US	-.13	-.03	.13	.21	.26	.30	**.29**	.23	.11	-.04	-.20	-.41	-.47
Japan-Germany	-.15	-.09	.13	.26	.39	.51	**.57**	.53	.46	.34	.22	.05	-.02
UK-US	-.43	-.14	.19	.36	.50	.60	**.64**	.53	.36	.17	.06	-.22	-.43
UK-Germany	-.36	-.23	.01	.18	.36	.49	**.53**	.44	.28	.14	-.01	-.23	-.43
France-US	-.37	-.27	-.05	.13	.29	.41	**.46**	.39	.20	.04	-.09	-.25	-.30
France-Germany	-.09	-.08	.11	.26	.40	.55	**.58**	.52	.35	.19	.03	-.15	-.22
Italy-US	-.09	.04	.24	.33	.40	.41	**.41**	.31	.12	-.09	-.21	-.35	-.26
Italy-Germany	-.13	-.16	-.13	-.07	-.02	.05	**.07**	.00	-.10	-.14	-.19	-.11	.17
Netherlands-US	.02	.07	.17	.15	.14	.12	**.05**	-.05	-.21	-.34	-.44	-.48	-.38
Netherlands-Germany	.01	.20	.39	.51	.56	.60	**.62**	.47	.31	.17	.01	-.14	-.20
Belgium-US	-.31	-.16	.07	.21	.36	.44	**.43**	.31	.09	-.12	-.27	-.40	-.37
Belgium-Germany	-.15	-.06	.20	.37	.52	.65	**.64**	.53	.35	.15	-.03	-.26	-.35
Spain-US	-.35	-.10	.27	.37	.45	.50	**.47**	.37	.15	-.08	-.28	-.46	-.48
Spain-Germany	-.05	.10	.33	.40	.44	.42	**.33**	.16	-.04	-.24	-.40	-.53	-.40
Portugal-US	-.40	-.08	.29	.48	.59	.64	**.60**	.54	.44	.27	.04	-.34	-.50
Portugal-Germany	.00	.15	.33	.34	.35	.38	**.33**	.28	.14	.03	-.11	-.31	-.37
Ireland-US	-.22	-.05	.18	.29	.40	.50	**.50**	.43	.28	.11	-.06	-.34	-.50
Ireland-Germany	-.30	-.24	-.02	.12	.27	.42	**.47**	.49	.45	.33	.22	.04	-.03
ERM period													
Germany-US	.34	.38	.39	.41	.40	.35	**.25**	.12	-.02	-.12	-.21	-.22	-.23
Canada-US	-.26	-.02	.24	.43	.63	.81	**.93**	.85	.68	.47	.23	-.05	-.19
Canada-Germany	-.30	-.24	-.20	-.15	-.06	.07	**.20**	.32	.39	.41	.39	.34	.31
Japan-US	.15	.25	.43	.50	.51	.48	**.35**	.17	.03	-.10	-.22	-.32	-.37
Japan-Germany	-.28	-.21	.08	.28	.49	.66	**.78**	.75	.71	.62	.51	.27	-.01
UK-US	.03	.13	.22	.31	.41	.50	**.58**	.52	.44	.37	.28	.29	.13
UK-Germany	-.22	-.28	-.29	-.22	-.08	.08	**.28**	.35	.43	.49	.51	.57	.55
France-US	.32	.33	.36	.40	.43	.45	**.38**	.25	.11	-.04	-.14	-.16	-.28
France-Germany	-.12	-.06	.14	.30	.46	.62	**.77**	.69	.62	.51	.41	.29	.17
Italy-US	.33	.42	.53	.58	.60	.56	**.41**	.23	.09	-.03	-.13	-.29	-.44
Italy-Germany	-.02	.08	.23	.35	.44	.51	**.57**	.52	.40	.31	.27	.19	.11
Netherlands-US	.18	.34	.46	.56	.58	.58	**.49**	.33	.16	.00	-.13	-.18	-.20
Netherlands-Germany	-.26	-.13	.17	.33	.46	.61	**.74**	.68	.62	.53	.42	.24	.10
Belgium-US	.20	.22	.28	.35	.41	.42	**.34**	.24	.12	.05	-.02	-.04	-.15
Belgium-Germany	-.22	-.15	.02	.21	.38	.54	**.70**	.65	.56	.46	.37	.31	.22
Spain-US	.32	.37	.30	.29	.26	.29	**.28**	.21	.15	.12	.07	-.02	-.17
Spain-Germany	-.20	-.15	.01	.12	.23	.39	**.51**	.51	.54	.48	.36	.31	.22
Portugal-US	.42	.34	.20	.12	.03	-.04	**-.13**	-.22	-.24	-.22	-.16	-.10	-.16
Portugal-Germany	-.13	-.05	0.12	.25	.34	.44	**.53**	.50	.43	.33	.28	.14	-.02
Ireland-US	-.15	-.09	.02	.19	.37	.48	**.49**	.40	.26	.10	-.02	-.21	-.31
Ireland-Germany	-.08	-.07	-.02	.02	.09	.20	**.31**	.35	.36	.32	.30	.31	.24

Table A3 Cross-Correlations for the Series Detrended by HP Filter (λ=50000)

	Leads / Lags												
	-24	-18	-12	-9	-6	-3	**0**	3	6	9	12	18	24
Pre-ERM period													
Germany-US	-.37	-.34	-.14	.03	.21	.36	**.44**	.40	.26	.09	-.07	-.27	-.31
Canada-US	-.44	-.25	.12	.38	.62	.79	**.86**	.74	.53	.26	-.01	-.43	-.65
Canada-Germany	-.33	-.34	-.08	.10	.29	.45	**.50**	.43	.26	.05	-.13	-.38	-.41
Japan-US	-.31	-.15	.14	.29	.41	.51	**.54**	.46	.29	.08	-.13	-.35	-.39
Japan-Germany	-.36	-.37	-.11	.08	.26	.43	**.52**	.49	.39	.23	.05	-.18	-.20
UK-US	-.41	-.15	.17	.34	.48	.57	**.61**	.48	.29	.10	.00	-.28	-.48
UK-Germany	-.42	-.28	-.03	.18	.39	.54	**.58**	.48	.30	.14	-.01	-.22	-.44
France-US	-.33	-.25	-.02	.18	.38	.52	**.57**	.49	.26	.06	-.09	-.26	-.29
France-Germany	-.33	-.35	-.11	.09	.29	.49	**.55**	.49	.31	.13	-.04	-.17	-.14
Italy-US	-.14	-.04	.17	.27	.36	.37	**.39**	.31	.11	-.11	-.22	-.34	-.18
Italy-Germany	-.16	-.18	-.12	-.04	.03	.12	**.15**	.05	-.09	-.15	-.23	-.19	.13
Netherlands-US	.00	.11	.31	.33	.35	.36	**.30**	.15	-.09	-.29	-.41	-.45	-.31
Netherlands-Germany	-.32	-.06	.21	.40	.49	.56	**.62**	.43	.21	.03	-.18	-.31	-.29
Belgium-US	-.30	-.15	.12	.29	.49	.59	**.59**	.43	.17	-.08	-.27	-.43	-.39
Belgium-Germany	-.42	-.34	-.01	.22	.43	.63	**.66**	.53	.32	.11	-.09	-.28	-.29
Spain-US	-.40	-.11	.36	.48	.58	.65	**.63**	.50	.22	-.08	-.29	-.44	-.43
Spain-Germany	-.30	-.07	.28	.39	.47	.47	**.38**	.21	-.02	-.24	-.43	-.55	-.36
Portugal-US	-.44	-.11	.27	.46	.58	.64	**.59**	.53	.44	.27	.03	-.33	-.43
Portugal-Germany	-.27	-.07	.18	.21	.26	.32	**.28**	.27	.14	.03	-.10	-.26	-.27
Ireland-US	-.26	-.09	.16	.27	.41	.54	**.54**	.47	.32	.12	-.04	-.31	-.47
Ireland-Germany	-.31	-.31	-.12	.03	.20	.35	**.38**	.40	.36	.20	.07	-.13	-.16
ERM period													
Germany-US	.19	.19	.21	.28	.30	.26	**.16**	.03	-.13	-.22	-.28	-.19	-.11
Canada-US	-.32	-.18	.04	.26	.51	.75	**.91**	.80	.53	.23	-.08	-.41	-.43
Canada-Germany	-.11	-.10	-.17	-.17	-.11	.03	**.17**	.30	.35	.31	.22	.08	.07
Japan-US	-.20	-.06	.28	.44	.52	.55	**.41**	.18	.01	-.13	-.25	-.31	-.31
Japan-Germany	-.37	-.39	-.13	.06	.30	.49	**.62**	.62	.61	.51	.39	.20	-.07
UK-US	-.09	-.02	-.02	.05	.14	.25	**.34**	.28	.19	.14	.08	.28	.23
UK-Germany	-.07	-.21	-.41	-.40	-.30	-.14	**.08**	.11	.18	.23	.24	.37	.44
France-US	.02	.00	.08	.19	.29	.37	**.32**	.20	.05	-.10	-.18	-.03	-.08
France-Germany	-.22	-.28	-.13	.02	.18	.38	**.59**	.46	.38	.27	.19	.20	.20
Italy-US	.02	.06	.24	.34	.44	.45	**.31**	.11	.00	-.09	-.13	-.22	-.33
Italy-Germany	-.04	.00	.07	.14	.21	.27	**.33**	.28	.08	-.02	-.02	.03	.01
Netherlands-US	-.01	.13	.28	.42	.47	.49	**.39**	.19	-.02	-.19	-.32	-.27	-.19
Netherlands-Germany	-.20	-.14	.12	.22	.31	.46	**.59**	.52	.42	.32	.17	.06	-.05
Belgium-US	-.01	-.02	.06	.16	.28	.31	**.22**	.13	.02	-.02	-.06	.04	-.02
Belgium-Germany	-.22	-.20	-.15	.01	.16	.33	**.50**	.44	.30	.19	.11	.19	.18
Spain-US	.11	.12	-.01	.00	-.02	.06	**.12**	.06	.05	.06	.06	.03	-.11
Spain-Germany	-.17	-.21	-.14	-.11	-.05	.13	**.24**	.22	.28	.20	.06	.12	.09
Portugal-US	.23	.13	.02	-.05	-.12	-.16	**-.22**	-.28	-.24	-.14	.00	.15	.06
Portugal-Germany	-.23	-.18	-.01	.09	.12	.20	**.29**	.30	.25	.16	.17	.14	.03
Ireland-US	-.32	-.23	-.09	.14	.36	.50	**.50**	.41	.27	.10	-.01	-.18	-.23
Ireland-Germany	-.22	-.23	-.20	-.17	-.10	.03	**.17**	.22	.26	.19	.20	.28	.28

Table A4 Cross-Correlations for the Linearly Trended Series

	Leads /Lags												
	-24	-18	-12	-9	-6	-3	**0**	3	6	9	12	18	24
Pre-ERM period													
Germany-US	.03	.00	.06	.11	.16	.19	**.19**	.15	.07	-.03	-.12	-.25	-.30
Canada-US	-.09	.07	.32	.47	.61	.70	**.73**	.63	.48	.30	.12	-.20	-.40
Canada-Germany	.03	.02	.15	.23	.31	.37	**.37**	.33	.22	.09	-.03	-.22	-.27
Japan-US	.29	.31	.32	.30	.28	.24	**.17**	.10	.01	-.11	-.23	-.40	-.48
Japan-Germany	.10	.21	.40	.51	.60	.68	**.73**	.71	.66	.58	.49	.34	.24
UK-US	-.01	.23	.48	.59	.67	.72	**.72**	.63	.49	.35	.25	.02	-.17
UK-Germany	-.27	-.14	.06	.21	.35	.45	**.49**	.46	.38	.30	.22	.07	-.06
France-US	-.09	-.05	.07	.16	.24	.29	**.29**	.22	.08	-.04	-.14	-.27	-.33
France-Germany	.18	.22	.37	.49	.58	.67	**.68**	.62	.50	.36	.23	.03	-.08
Italy-US	.16	.25	.39	.44	.48	.48	**.48**	.39	.23	.05	-.05	-.20	-.18
Italy-Germany	-.07	-.07	-.02	.04	.09	.16	**.18**	.15	.10	.08	.05	.09	.30
Netherlands-US	.38	.33	.29	.22	.15	.07	**-.02**	-.11	-.21	-.30	-.37	-.44	-.43
Netherlands-Germany	.34	.49	.62	.69	.72	.73	**.73**	.64	.54	.45	.34	.19	.07
Belgium-US	-.02	.05	.17	.24	.31	.32	**.31**	.21	.05	-.09	-.21	-.33	-.34
Belgium-Germany	.14	.24	.43	.56	.65	.73	**.72**	.63	.50	.35	.20	-.01	-.14
Spain-US	-.07	-.03	.07	.04	.01	-.04	**-.12**	-.16	-.27	-.40	-.50	-.59	-.57
Spain-Germany	.23	.32	.44	.47	.47	.44	**.37**	.22	.07	-.09	-.22	-.35	-.34
Portugal-US	-.39	-.09	.25	.42	.54	.58	**.55**	.50	.41	.25	.05	-.29	-.43
Portugal-Germany	.06	.20	.34	.35	.36	.38	**.33**	.28	.17	.06	-.05	-.20	-.26
Ireland-US	-.19	-.11	-.03	.01	.05	.07	**.03**	.01	-.05	-.15	-.24	-.39	-.46
Ireland-Germany	-.21	-.15	.00	.09	.20	.29	**.33**	.33	.31	.23	.16	.05	.00
ERM period													
Germany-US	.44	.48	.48	.49	.48	.42	**.34**	.19	.04	-.08	-.19	-.26	-.33
Canada-US	-.19	.07	.33	.50	.66	.81	**.91**	.86	.73	.57	.39	.15	.00
Canada-Germany	-.51	-.43	-.32	-.22	-.09	.06	**.21**	.32	.40	.44	.45	.45	.45
Japan-US	.25	.37	.52	.58	.58	.56	**.44**	.29	.16	.05	-.06	-.20	-.28
Japan-Germany	-.34	-.24	.06	.25	.45	.61	**.73**	.73	.72	.67	.59	.42	.20
UK-US	.13	.26	.37	.46	.55	.63	**.69**	.62	.53	.45	.34	.29	.09
UK-Germany	-.32	-.31	-.22	-.10	.06	.24	**.44**	.50	.56	.60	.60	.62	.57
France-US	.43	.45	.46	.48	.48	.48	**.41**	.27	.12	-.04	-.16	-.24	-.39
France-Germany	.06	.17	.37	.50	.63	.75	**.85**	.78	.71	.61	.50	.35	.19
Italy-US	.44	.53	.63	.66	.67	.62	**.47**	.30	.17	.04	-.07	-.26	-.42
Italy-Germany	-.01	.14	.33	.45	.55	.62	**.67**	.64	.55	.48	.44	.34	.24
Netherlands-US	.29	.45	.56	.64	.66	.66	**.59**	.43	.26	.10	-.04	-.15	-.26
Netherlands-Germany	-.18	-.02	.26	.42	.55	.70	**.82**	.78	.72	.65	.55	.37	.21
Belgium-US	.32	.36	.43	.48	.52	.52	**.45**	.34	.21	.11	.01	-.07	-.22
Belgium-Germany	-.15	-.05	.15	.33	.49	.65	**.79**	.75	.68	.60	.51	.41	.28
Spain-US	.38	.48	.46	.46	.44	.45	**.43**	.35	.27	.21	.13	.00	-.17
Spain-Germany	-.28	-.18	.02	.16	.29	.45	**.58**	.59	.62	.57	.49	.43	.33
Portugal-US	.47	.42	.30	.23	.15	.08	**-.01**	-.10	-.14	-.14	-.11	-.11	-.17
Portugal-Germany	-.14	-.05	.12	.26	.36	.46	**.55**	.54	.49	.42	.37	.25	.10
Ireland-US	.12	.13	.16	.23	.31	.37	**.37**	.25	.12	-.03	-.17	-.30	-.45
Ireland-Germany	.29	.35	.41	.43	.47	.52	**.58**	.54	.48	.39	.29	.16	.02

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