THE BUSINESS CYCLE IN THE G-7 ECONOMIES

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Abstract

In this paper the Hodrick-Prescott filter is used to decompose real GDP for the G7 countries into cyclical and trend components. The resulting series of cyclical components are then examined for static relationships, using correlations and graphs; long-run relationships using autoregressive-distributed lag models; and short-run relationships, using error-correction models. The main result is that the patterns of cyclical behaviour changed following the oil price shocks in the 1970s. Since 1980, cyclical fluctuations have been smaller as a result of a decline in synchronisation of the cycles in the G7. Two separate cycles seem to be developing since 1990. One is for Germany, Italy and France, whilst the other is for the US, UK and Canada. Within each of these groups there are both long-run and short-run relationships between the cyclical components of GDP.

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1. INTRODUCTION

The remarkable globalisation of the goods, services, and capital markets during the last three decades is creating new concern and debate on policy-making bodies. It provides a rapid channel of transmission of fluctuations between different countries (Zarnowitz, 1985). The present work focuses on the behaviour of the business cycle within the context of the major industrialised economies. In particular, we explore some cyclical regularities and discrepancies shown by the real economic activity of these economies since the sixties.

During recent years, there has been a renewed interest in the study of business cycles within and between different countries. For instance, in Europe, the term "synchronicity" can be associated with the concept of symmetry, which in turn, has been extensively used to justify the convergence aspirations imposed for access to the EMU. In this context, the typical argument refers to the loss of the exchange rate as an instrument of economic policy to muffle the discrepancies in the business cycle caused by asymmetric shocks [see, for example, Bean (1992), and Von Hagen and Newman (1992)]. Without the exchange rate as an instrument of economic policy, it is argued that a more synchronised cycle would ease the process of adjustment. In other words, a more synchronised cycle is a key element to ensure a stable and well functioning EMU. Furthermore, this argument has also been extended outside the borders of the European Union where a greater harmonisation of the business cycle is seen as a means to achieve a more stable environment for exchange rate developments [see Hufbauer and Schoot (1992)]

The study of linkages in business cycles and the international transmission of output shocks has a long history. A pioneer worker in this area is Mitchell (1927), who found positive correlation of business cycles across countries as a result of greater integration of financial markets and international trade. More recently, a number of studies have concentrated on different aspects of this subject. Gerlach (1988), for example, studied the monthly industrial production index and found evidence of a world business cycle and that output movements were correlated across countries under both periods of fixed and flexible exchange rate. Baxter and Stockman (1989) also use industrial production data in a sample of 49 countries and arrive at the conclusion, amongst others, that business cycles became more country-specific in the post 1973 period. Artis and Zhang (1995) have examined the existence of a European business cycle and its link to the international business cycle. Their study concentrates on the index of industrial production of a sample of 15 countries during the period before and after the formation of the ERM. Their major finding is that the linkages between business cycles within the ERM group have strengthened, while, in contrast, the linkages between the cycles of the ERM countries and that of the USA have weakened during the ERM period.

This paper will review the recent historical experience of the G7 countries, viz. Canada, France, Germany, Italy, Japan , the UK and the USA. Using quarterly data on real GDP/GNP over the period 1960:1 – 1998:2, three inter-related issues are examined. We explore (a) how real output has fluctuated; (b) whether the cycles in different countries are linked; and (c) whether the patterns have changed as a result of the European Union (EU). Different estimation methods are used in this paper to obtain measures of the business cycles at three different time horizons: contemporaneous, short-run and long-run.

The paper is organised as follows. Section 2 presents the methods used to estimate the cyclical component of the data and the statistical techniques to measure and analyse the evolution of the aggregate and individual business cycles of the main industrialised countries. The purpose is to arrive at some tentative conclusions about the magnitude, variability, and regularities of the cycles within and between different countries of the G7. Section 3 gives a brief description of the data and reports the evidence from the static analysis using the results of applying the Hodrick-Prescott filter to determine the cyclical component. In section 4 the results for the cycles of the G7 countries in terms of variability and synchronisation are reported. In particular the question to be addressed is whether the business cycle has become more specific to the individual countries of the G7, or more synchronised. These questions will be discussed using the estimates of both short- run and long-run linkages between the G7 countries. The conclusions are presented in section 5.

2. ESTIMATION METHODOLOGY

In this section, we start with a specific definition of business cycles and the statistical methodology to measure them. Then, three methods will be used to examine how business cycles for the G7 countries fluctuate. The first method is static and concentrates on contemporaneous movements of the business cycle in the G7. This method includes a measure of peaks and troughs as well as a measure of aggregate volatility and correlation. Second, a VAR model will be estimated to explore the dynamic properties of the cyclical component of the series. This will provide measures of persistence and co-movement in the system. The third method is adapted from Pesaran et al (1996) to test the existence of a long-run relationship between the cycles and to estimate the corresponding coefficients.

To measure and explore the evolution of the aggregate and individual business cycle of the G7 countries, the methodology used consists of determining the cyclical component of the data, measuring its variability and analysing the degree of synchronisation. Since the GDP of the analysed economies grows, to evaluate its cyclical position it is necessary to decompose the observed series into its trend and cyclical components. In other words, let $\boldsymbol{y}$ and $\boldsymbol{y^n}$ represent the log of observed and potential GDP respectively then GDP's cyclical component can be written as:

$$(1) \qquad y^c = y - y^n .$$

To estimate (1), one difficulty lies in measuring $\boldsymbol{y^n}$ (potential GDP or its long-term trend), which is unobserved. Among the techniques available for doing this, the filter proposed by Hodrick and Prescott (1997) has been chosen because it has been used extensively in the literature on real economic cycles and because it is commonly used by several national and international institutions[1]. This method is appropriate to obtain a smooth but not linear trend[2]. In technical terms, the Hodrick-Prescott (HP) filter decomposes the original series, $\boldsymbol{y}$, into a stochastic growth component, $\boldsymbol{y^n}$, and a cyclical one, $\boldsymbol{y^c}$, by minimising the following expression

$$(2) \quad \sum_{t=1}^{T}(y_t - y_t^n)^2 + l \sum_{t=2}^{T-1}\left[\left(y_{t+1}^n - y^n\right) - \left(y_t^n - y_{t-1}^n\right)\right]^2$$

The parameter λ, in (2), controls the smoothness of the series $\boldsymbol{y^n}$. The larger the value of λ, the smoother the trend path, and when λ = 0, a linear trend results. In our computations, we set λ = 1,600, as has been suggested by Hodrick and Prescott for quarterly data.

Static analysis

A measure of the aggregate variability of the business cycle can be determined by simply computing the variance of $\boldsymbol{y^c}$ for the G7 countries, which by definition is:

$$(3) \qquad Var(y_7^c) = \sum_{i=1}^{7} a_i^2 \, Var(y_i^c) + \sum_{i} \sum_{i,j=1}^{7} a_i a_j \, Cov(y_i^c, y_j^c) \quad where\ i, j = 1, 2, \ldots, 7$$

[1] The Hodrick-Prescott filter has been applied by the European Commission to estimate output gaps, that is the difference between actual and potential GDP in Europe. See European Commission (1995).

[2] The greatest advantage of using the HP filter is its widespread use in recent studies such as Backus and Kehoe (1989), Danthine and Girardin (1989), King and Rebelo (1993), Kydland and Prescott (1990), Christodoulakis, Dimelis and Kollintzas (1995). However, other authors have pointed out the risk of arbitrarily using this filter (see Canova, 1991, Harvey and Jaeger, 1993, Artis and Zhang, 1995, and Cogley and Nason, 1995).

As can be seen, the right hand side of (3) contains two terms: the first one represents the sum of each country's variability, while the second one is a weighted sum of the covariances. This latter term serves to indicate the degree of synchronisation. GDP weights, α_i are measured in terms of purchasing power parity for 1990[3], and the calculation was carried out assuming that on average the duration of the cycle is twenty quarters, that is to say, five years[4]. As a result, a recursive measure of variability is obtained throughout the sample period.

Dynamic analysis

In international business cycle analysis the extent to which output shocks can be transmitted from one country to another can be explored by means of the matrix of contemporaneous correlations of the innovations, Granger non-causality tests for blocks of equations, and impulse responses function of the system (Canova, 1995). Moreover, cointegration could also be an appropriate way of simultaneously modelling long-run persistence and co-movement.

Long-run analysis will be conducted in line with recent developments of time series techniques. Amongst alternative techniques, Johansen (1988) and Pesaran *et al* (1996), are currently widely used in practical applications. One notable difference between these techniques is that the former investigates the long-run relationship in the context of a system of equations, while the second is based on a single reduced form equation. However, the attractiveness of Pesaran methodology lies in two major advantages: First, the existence of a long-run relationship can be tested without any a priori knowledge of the order of integration of the time series, or the possibility of cointegration. This feature makes Pesaran's test particularly attractive since existing unit root tests to identify the order of integration of variables are still highly questionable. The second advantage of this test is that no matter whether the explanatory variables are exogenous or not, the long and short-run parameters, with appropriate asymptotic inferences, can be obtained by applying OLS to an autoregressive distributed lag (ADL) model with appropriate lag length.

To test the existence of a long-run relationship between y and x_1 x_2 ... x_k , the cyclical components of the countries of interest, the following error-correction version of the ADL model is used:

$$\text{(4)} \qquad \Delta y_t = \alpha_0 + \alpha_1 t + \gamma y_{t-1} + \sum_{i=1}^{k} \theta_i x_{it-1} + \sum_{i=1}^{p-1} \psi_i \Delta y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{p-1} \eta_{ij} \Delta x_{it-j} + \varepsilon_t$$

where k+1 is the number of countries (7 here) and p is the maximum lag (4 here). The procedure is to test the joint null hypothesis that $\gamma = \theta_i = 0$, for all i = 1, ..., k, against the alternative that they are not all zero. If the null hypothesis is true there is no long-run relationship between the variables. This is the conventional Wald or F-test. However, since the asymptotic distributions of both statistics are non standard irrespective of whether the regressors are I (0) or I (1), or mutually cointegrated, a bounds testing procedure with critical values has been proposed and reported by Pesaran *et al* (1996). Thus, if the computed Wald or F-statistic falls outside the critical value bounds, a conclusive inference can be drawn without needing to know the order of integration of the underlying regressors. But if the Wald or F-statistic falls inside the critical value bounds, inference would be inconclusive and knowledge of the order of integration of the underlying variables is needed before conclusive inferences can be made.

Long-run estimates are derived from the unrestricted ADL model:

$$\textbf{(5)} \qquad y_t = \alpha_0 + \sum_{i=1}^{p} \phi_i y_{t-i} + \sum_{j=1}^{k} \sum_{i=1}^{q} \beta_{ji} x_{jt-i} + \varepsilon_t$$

The terms α_0, ϕ_i and β_{ji} are parameters and their respective long-run values can be estimated using:

[3] The source is OECD, Main Economic Indicators, April 1999.

[4] A major difficulty of this methodology is that after computation the last twenty observations are lost.

$$a_0^* = \frac{a_0}{1 - f_1 - f_2 - \ldots - f_p},$$

$$b_j^* = \frac{b_{j0} + b_{j1} + \ldots + b_{jq}}{1 - f_1 - f_2 - \ldots - f_p}$$

Having specified the long-run analysis, we can proceed to the short-run analysis. The general short-run model can be expressed as:

$$\Delta y_t = \sum_{i=1}^{p} l_i \Delta y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q} d_{ji} \Delta x_{jt-i} + a(y_{t-1} - a_0^* - bx_{t-1}) + e_t \qquad (6)$$

where, as before, y_t and x_{jt} are the cyclical components of the countries under study; and a_0^* and b (vector) are the long-run parameters, while x_t is a vector of the explanatory variables. Therefore, α is an error correction coefficient that measures the speed of adjustment, and a negative sign means that the model is converging to the long-run equilibrium path. In relation to our particular purpose of analysis, the error correction coefficient can also be associated with the concept of synchronisation since for a given shock to the leader country, this coefficient indicates the speed at which the system converges to its equilibrium position.

3. THE STATIC ANALYSIS

The data used in this study are seasonally adjusted figures on quarterly GDP at constant (1990) prices. For reasons of availability and homogeneity of the data we have centred the attention on the G7 countries: United States, Canada Japan, Germany, France, Italy, and the United Kingdom[5]. The sample period is 1960:1 – 1998:2, and except for France, the main statistical source is International Financial Statistics (IFS), published by the IMF. France GDP during the sample period 1960:1 – 1971:4 was taken from DRI and linked to the IMF series.

Figure 1 plots the evolution of the logarithm of GDP and trend component for each country of the G7 for 1960:1 - 1998:2. The HP filter with λ = 1,600 was used to determine the cyclical and trend components for 1960:1 – 1998:2. In table 1 the correlations of the cyclical components are presented for both 1960:1 - 1979:4 and 1980:1 -1998:2. Many of the correlations change substantially between these two periods, particularly for Germany, suggesting changes in cyclical behaviour.

Figure 2 shows the cyclical components for each country and the G7 aggregate. During the 1970s the output gap is greater than before or after this decade, probably as a result of the two oil crises. Perhaps the most surprising result in Figure 2 is the gradual smoothing of the aggregate business cycle for the G7 since the seventies. This pattern is observed not only in periods of expansion but also in periods of recession. From 1970, the periods in which the growth cycle was greater than its potential level of production are: 1972:2–1974:2; with a maximum value of 2.99 % in 1973:1; 1977:2–1980:1, with a maximum value equal to 2.94 % in 1978:4, and from 1987:4–1990:3, where the maximum value reaches to 1.32 %. Lastly the most recent expansion is in 1997:1–1998:2, where the registered maximum value hardly reaches 0.55 % in 1997:1. In the same way, the intensity of recessions also falls starting from the sudden change of the price of oil in 1973. More specifically, the most intense periods where GDP grew below its potential level took place during 1974:3–1977:1, with a minimum value of –3.49 % in 1975:1. From this latter date there is

[5] Overall these countries produced 75.6% of the world production as measured in terms of 1990´s, PPPs.

no other significant recessive cycle until 1981:4 –1983: 4, when the minimum was located at –2.69 % in 1982:4. The last period of recession is 1995:1–1996:4, but the minimum growth is small, being - 0.75% in 1995:4.

This general pattern of a gradual decline in aggregate economic fluctuations could be the outcome of two different, but not mutually exclusive, reasons. The first is that the level of activity in each one of the G7 countries is fluctuating less; and the second reason could be that even though individual fluctuations did not change, the degree of synchronisation has diminished. Putting it differently, periods of expansion in some countries can coincide with periods of recession in others and the net effect is a declining trend of the aggregate cycle. The question then is: which of these two reasons has been the responsible of the lower variability of the G7 business cycle?. To answer this question the decomposition of the variance in (3) might be of some help. From (3) it is possible to estimate a recursive measure of aggregate variability in which a distinction can be made between the change in individual variability on the one hand and the change of synchronisation on the other.

In (3), the first term represents the sum of the individual variabilities, while the second term picks up the degree of synchronisation, or correlation, between countries. In the absence of synchronisation (i.e. when the correlation coefficient is zero), aggregate cyclical variability is entirely explained by the sum of individual variabilities. The evolution of these three magnitudes is shown in Figure 3. Two conclusions are worth mentioning. Firstly, fluctuations of the aggregate index of variability, after a sudden increase during 1968:3 – 1979:2, tend to decline after this period. At the same time, the index of individual variability or idiosyncrasy shows a similar pattern until 1983:4, when both indexes started to diverge. This changing pattern, however, lasted eight years, from 1983:4, before converging to similar values from 1992:4. Secondly, the index of synchronisation, in contrast, is positive until 1983:4 when the sign changes to negative until 1992:1 when it stabilises around a value close to zero. Therefore, the gradual decline of aggregate variability over the past two decades is due to both an important increase of individual variability and, at the same time, a sharp reduction of synchronicity across countries. This result suggests that overall the G7 business cycle has become less synchronous and depends to a greater extent on each country-specific shock. That is, this result confirms the existence of asymmetry in the transmission of common shocks. Let us now further explore this conclusion at a more disaggregated level.

Figures 4, 5 and 6 plot a recursive measure of the covariance between the countries and illustrate some relevant regularities and discrepancies of the business cycles in the G7. Figure 4 shows the closer links between the business cycles of the Euro-zone members of G7, namely, Germany, France and Italy. The evolution of the covariance between these three countries is similar from 1967, though more recently, the covariance between France and Italy indicates a more synchronous cycle than the one indicated by the covariance between these two countries and Germany. It should be noted that, for a number of reasons, Germany has shown a high level of idiosyncrasy during the past fifteen years. The unification of East and West Germany in 1990, as well as the associated changes of macroeconomic policies are amongst the major reasons.

Figures 5 and 6 have the following features: First, from the middle of the eighties onwards, except for the UK, the cycles of the European members of the G7 are not synchronised with the US cycle. In effect, the UK business cycle is more linked to fluctuations in the US and Canada than to the German business cycle. In particular, this fact becomes more evident from the early eighties. Second, as has already been stated, there is a regular pattern of fluctuations between Canada, the UK and the US over the whole period of analysis. Third, also from the middle of the eighties onwards, there is a strong negative covariance, and therefore a higher idiosyncratic behaviour, between the UK and the USA cycles with respect to the cycle in Germany.

Another interesting result is shown in Figure 7, which plots on the one hand, the evolution of the weighted[6] cyclical components for Germany, France and Italy, (the Euro-cycle) and on the other hand, the weighted cyclical components for the US, Canada, and the UK (the Anglo-cycle). The most striking feature is that from the early eighties, these two cycles move in opposite directions. This is confirmed in

[6] The weights for the Euro-zone are: 0.4252 for Germany, 0.2936 for France and 0.2812 for Italy. For the Anglo countries the weights are:0.0421 for Canada, 0.1237 for the UK and 0.8342 for the USA.

Figure 8 where the negative correlations can be seen. Clearly, given the short period of time since the emergence of this new pattern, we cannot be certain that there are two cycles within the G7. A possible explanation is that the two oil shocks created an artificially high degree of international synchronisation in the 1970s and early 1980s. However, more recent data and research are needed before arriving at a definite conclusion.

4. DYNAMIC ANALYSIS

We now turn to the empirical analysis of the cyclical component. From the way that the cyclical component is defined in (1) it is expected to be stationary. Table 2 presents the results of the augmented Dickey-Fuller test for unit roots and in every case the null hypothesis of non-stationarity is rejected. The conclusion is that the cyclical component is stationary. Therefore the use of the standard cointegration techniques is inappropriate and instead the autoregressive-distributed lag (ADL) approach of Pesaran *et al*.(1996) is adopted.

This starts with a general dynamic model (4) relating changes in the variable of interest, here each of the cyclical components of the G7 countries, to past changes of itself and other variables, and also the lagged levels of these variables. Estimation allows tests to be performed for evidence of a long-run relationship between the variables and also for the existence of an error-correction model (ECM).

The results for the tests for the existence of a long-run relationship between each country's cyclical component and that of all the other 6 countries for 1960:1 - 1998:2 are shown in table 3. In only one case, Germany with 4 lags, is the null hypothesis of no long-run relationship accepted. However, when the data period is split, for 1960:1 - 1979:4 the evidence in favour of the existence of a long-run relationship is weaker, and for 1980:1 - 1998:2 there is no support for a long-run relationship for Germany. An obvious explanation for the latter period is the effect of re-unification of Germany. However, overall, the conclusion here is that there are long-run relationships between these cyclical components. According to Artis and Zhang (1997), the oil shocks of 1973 and 1979 were international in character and resulted in common cyclical movements. We note that this contrasts with the implication of Figure 3 that the degree of synchronisation is variable and generally small.

In order to examine the direction of any relationships the results of Granger non-causality tests are given in table 4. The variables are the cyclical components for each of the G7 countries and the null hypothesis is that the business cycle component of the country in the first column does not cause, in the Granger sense, the business cycle component of the countries in the other columns but on the same row. The body of the table gives the probabilities where this hypothesis is rejected. That is, they indicate where there is evidence of causality.

Unfortunately the results in table 4 are not very clear. While there is a tendency for Germany and Italy to Granger-cause France, and for the UK, US and Canada to be inter-related, there is also evidence of causality from Canada to France, Italy to the US, and Japan to the UK.

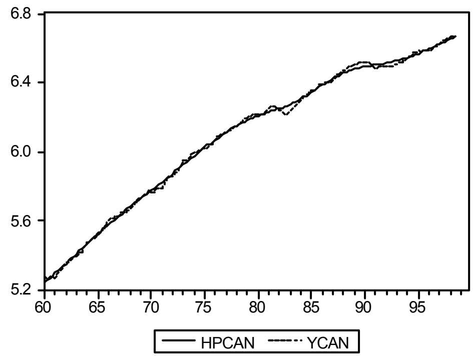
Tables 5 and 6 present the results of estimating (4) for the Euro-zone and Anglo countries respectively. All the F-values are significant so there is evidence of long-run relationships within these groups. The estimated long-run parameters are given in table 7, where it is assumed that Germany is the leader in the Euro-zone and the US is the leader in the Anglo-zone. The result for Germany is problematic since it implies a negative long-run relationship between the German and Italian cycles. However, if the data are split into two periods the coefficient is -0.1384 for 1960:1 - 1979:4 while for 1980:1 - 1998:2 it is 0.3043.

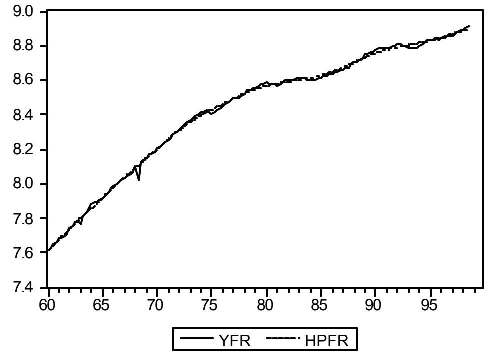
The estimated short-run models are reported in table 8 where the error-correction terms are negative and significant. The speed of convergence is higher for the Euro-zone than for the Anglo-zone. This could be interpreted as a higher degree of synchronisation for the Euro-zone. Alternatively it could be a faster speed of adjustment after an asymmetric shock, which does not necessarily mean greater synchronisation in view of the negative sign on the parameter for Italy.

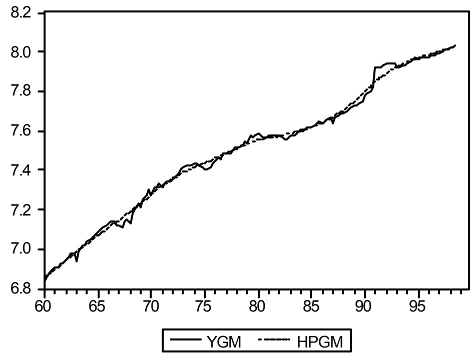
5. CONCLUSIONS

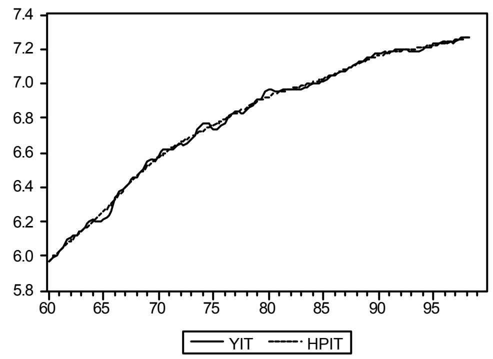
In this paper we have used the Hodrick-Prescott filter to decompose real GDP for the G7 countries into cyclical and trend components. The resulting series of cyclical components were then examined for static relationships, using correlations and graphs, long-run relationships using ADL models, and short-run relationships, using error-correction models. The main results are that evidence has been found that since 1960 the patterns of cyclical behaviour have changed. There was low variability in the 1960s but the oil shocks in the 1970s increased cyclical fluctuations. However, since 1980 cyclical fluctuations have declined as a result of a decline in synchronisation of the cycles in these countries, and two separate cycles seem to be developing since 1990. One is for Germany, Italy and France, whilst the other is for the US, UK and Canada. Within each of these groups there are both long-run and short-run relationships between the cyclical components of GDP. Whether these two cycles are a short-run statistical artefact will become apparent in the next few years.

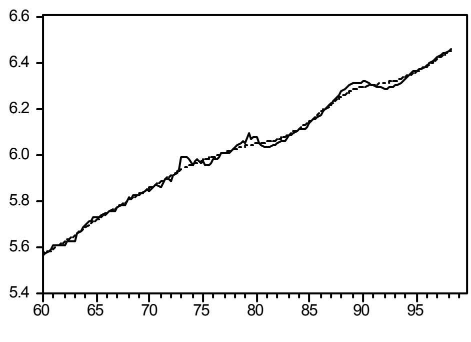
Figure 1. G7 Logarithm of GDP and Trend Components. 1960:1-1998:2

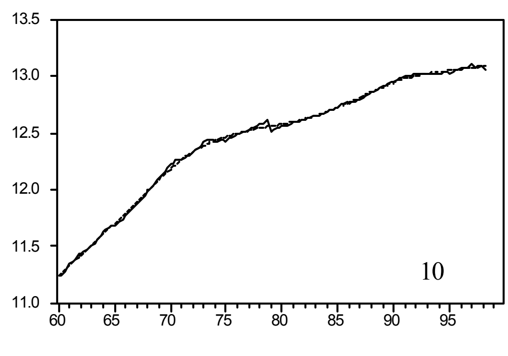


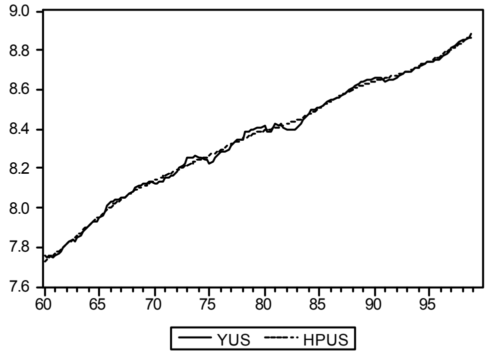








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8.6
8.4
8.2
8.0
7.8
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60
65
70
75
80
85
90
95
YUS
HPUS

Figure 2. G7-GDP’s Cyclical Components for each country and aggregate

(1960:1-1998:2)

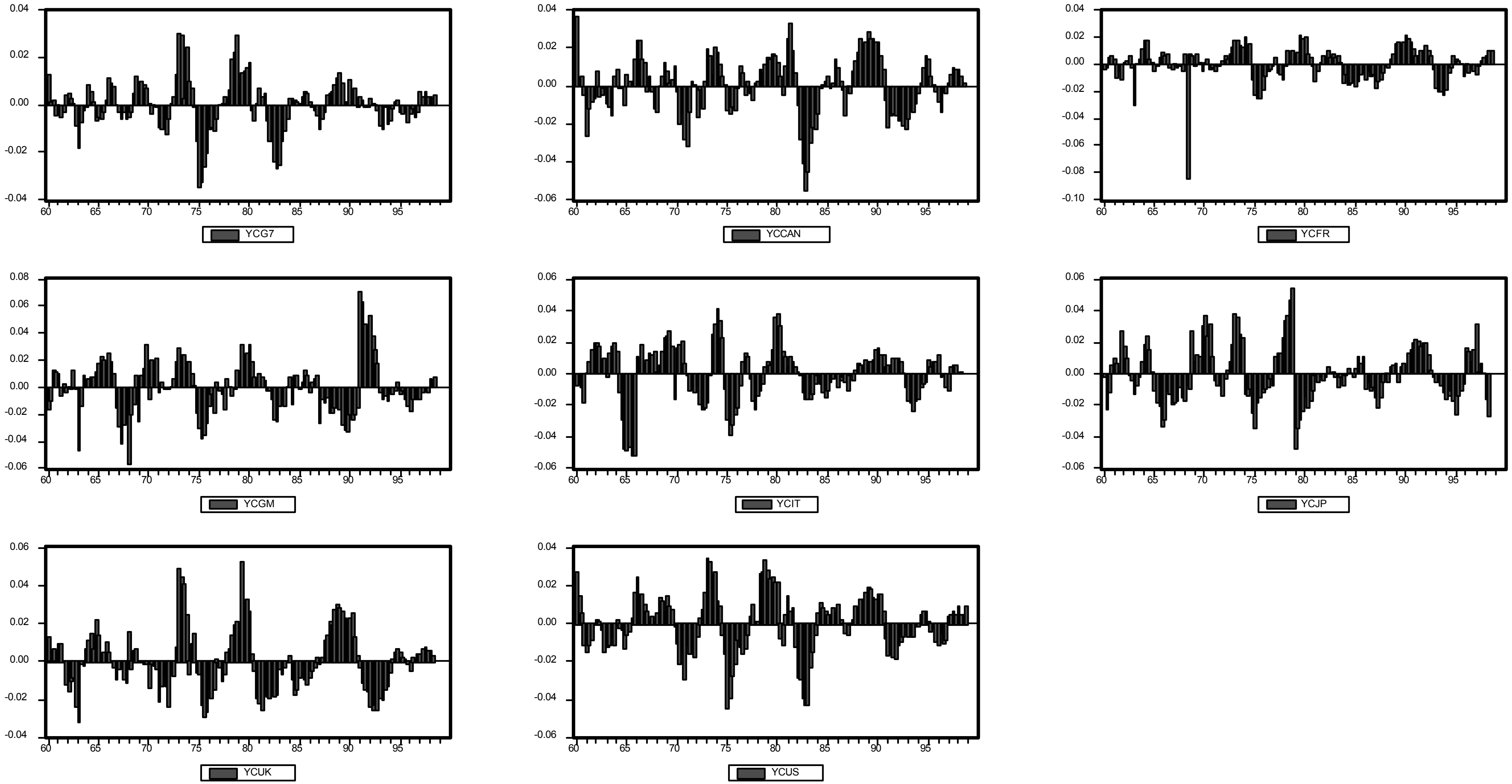


Figure 3. Individual variability, aggregate variability and index of synchronisation

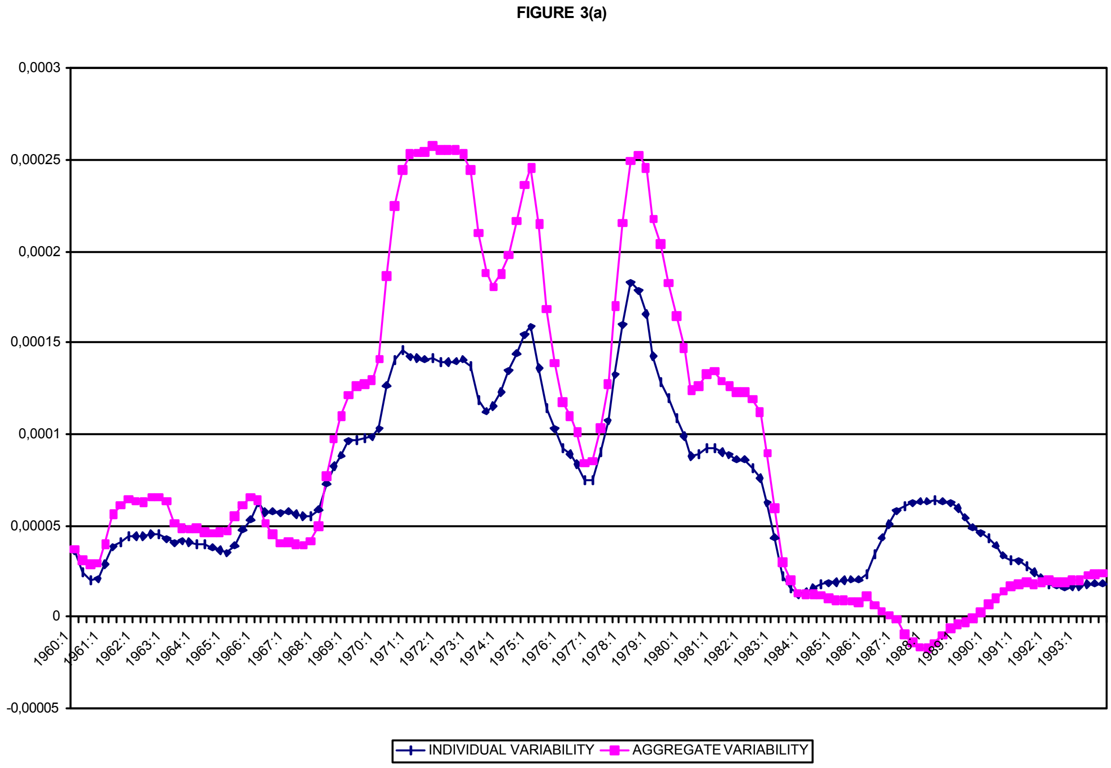
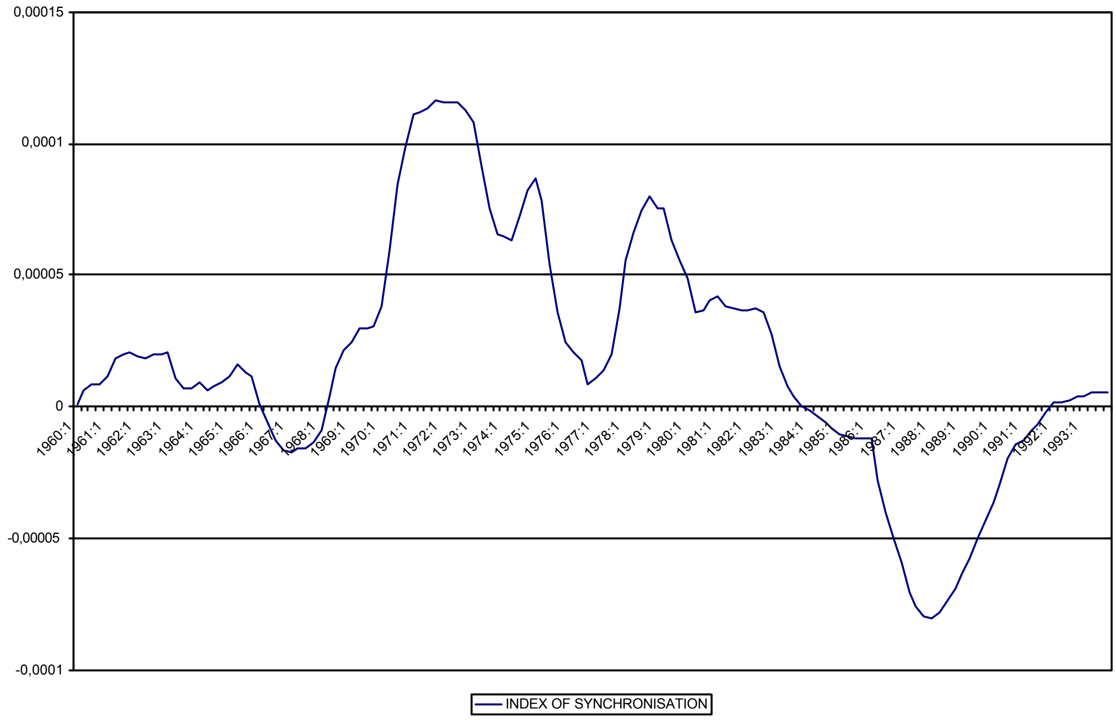


FIGURE 3(b)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INDEX OF SYNCHRONISATION

Figure 4. Covariance between business cycles of Euro-zone members of G7

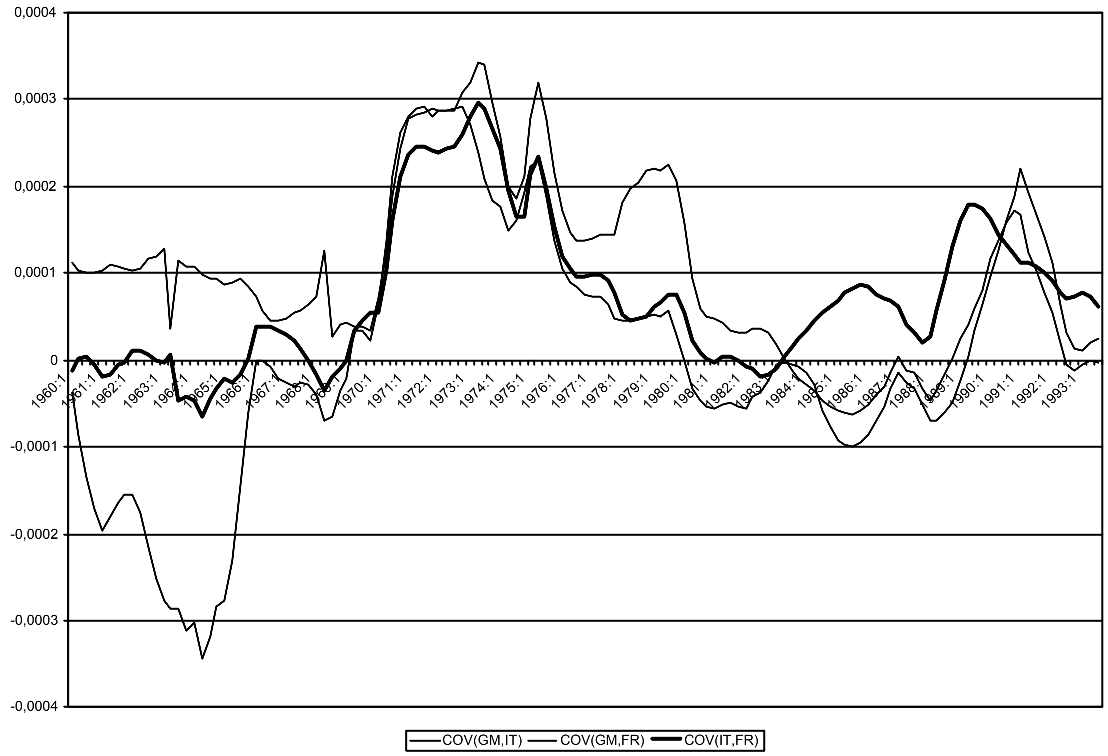

Figure 5. Covariance between business cycles of G7 Euro-zone members and the US

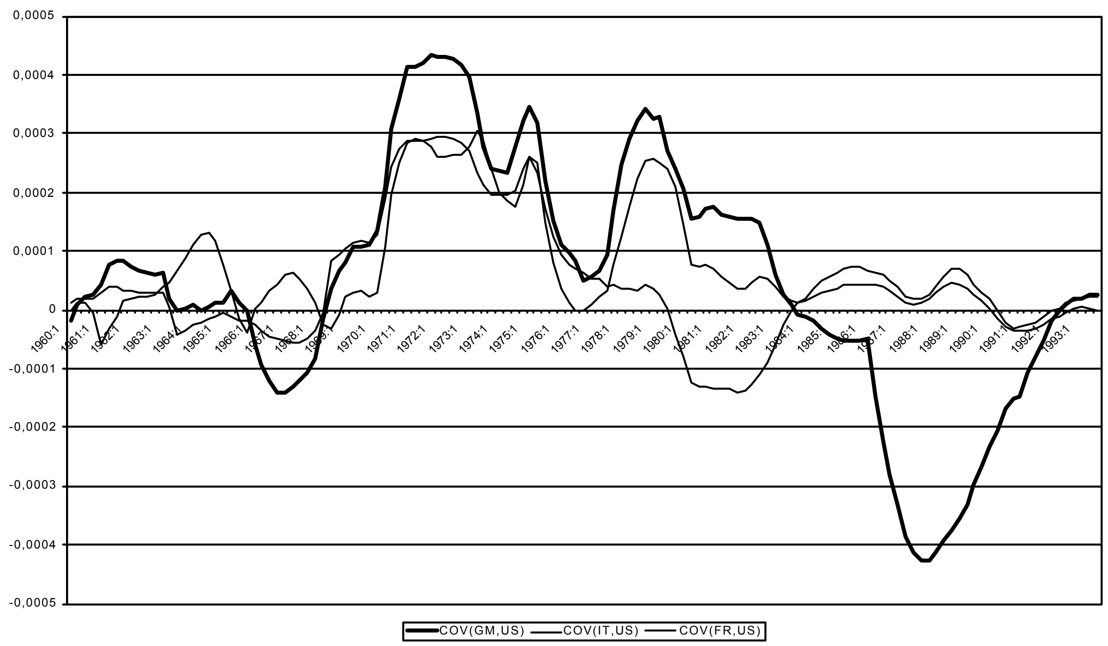

Figure 6. Covariance between Anglo-cycle (Canada, UK, US) and Germany

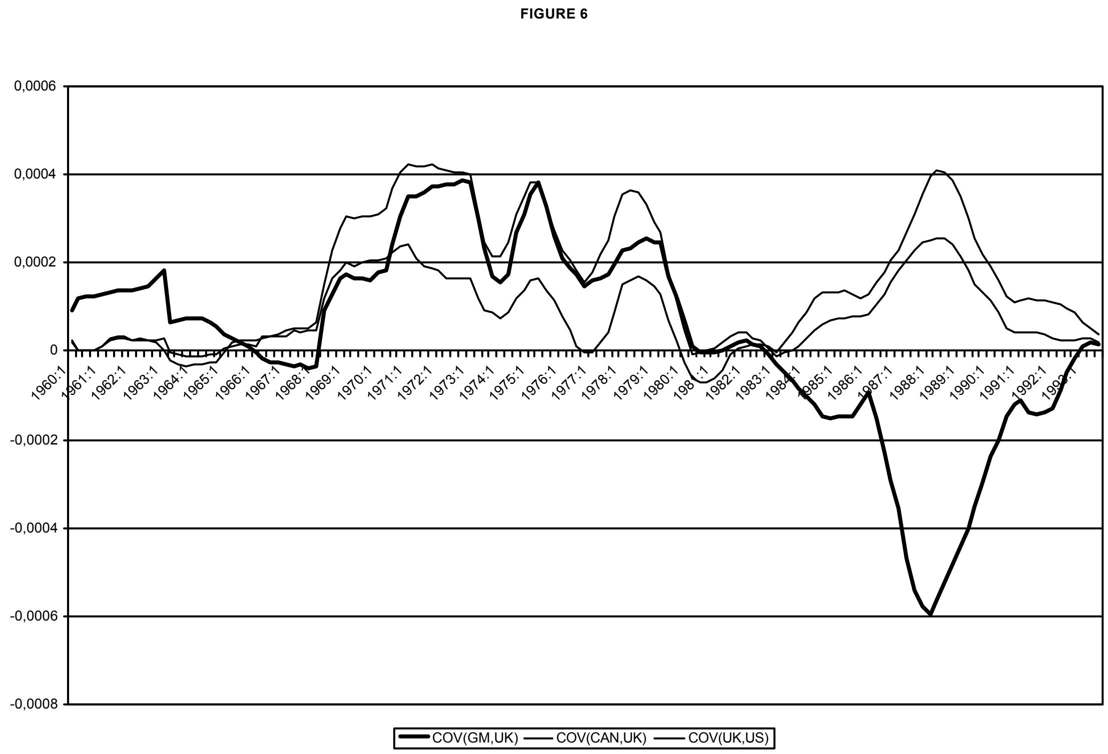

Figure 7. Evolution of the Euro-cycle and the Anglo-cycle

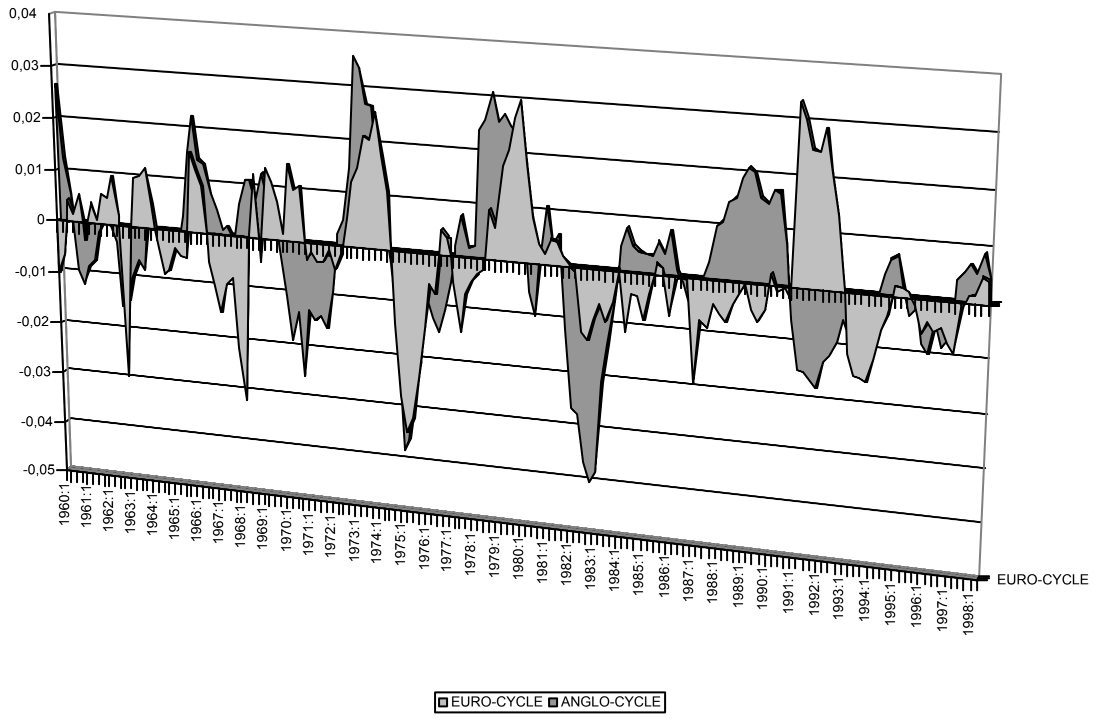

Figure 8. Correlation between the Euro-cycle and the US cycle

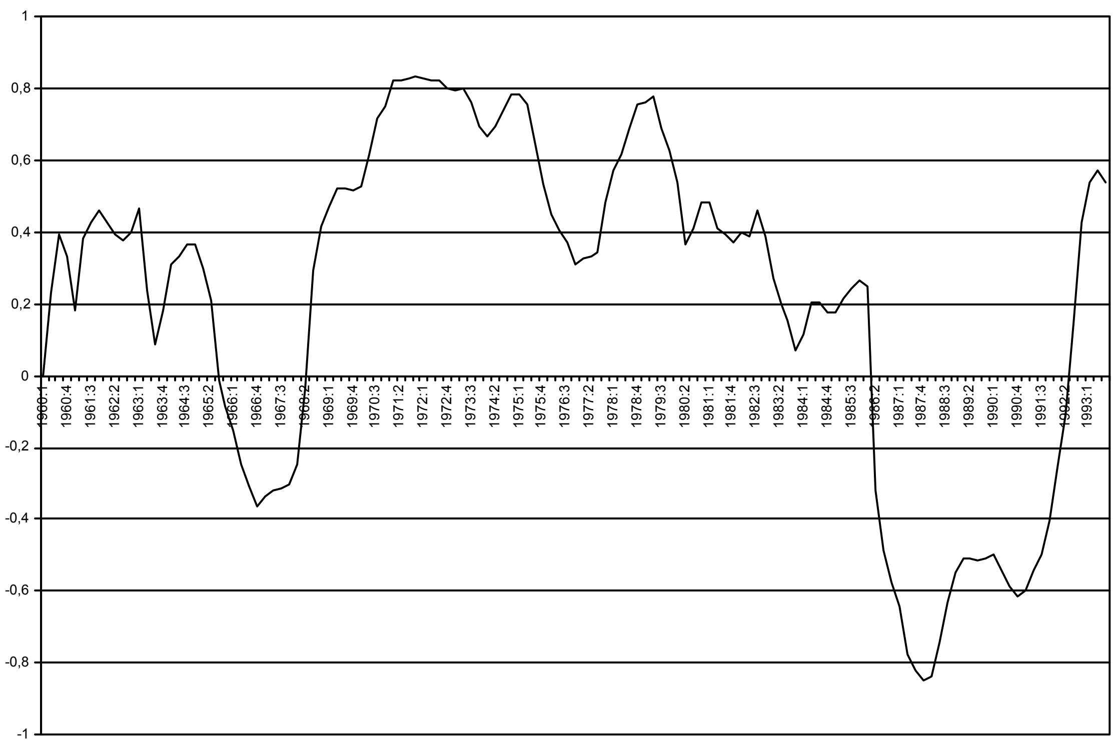

Table 1 Correlations of Cyclical Components

Upper triangle - 1960:1 - 1979:4 Lower triangle - 1980:1 1998:2

Country	France	Germany	Italy	Japan	Canada	UK	US
France	1.00	0.53*	0.24*	0.17*	0.34*	0.51*	0.40*
Germany	0.07	1.00	0.06	0.25*	0.32*	0.54*	0.36*
Italy	0.67*	0.22*	1.00	0.13	0.16*	0.08*	0.25*
Japan	0.24*	0.23*	0.08	1.00	-0.03	0.20	0.18*
Canada	0.13	-0.24*	0.48*	-0.15	1.00	0.48*	0.71*
UK	0.39*	-0.44*	0.40*	-0.06	0.55*	1.00	0.65*
US	-0.01	-0.16	0.33*	-0.13	0.87*	0.54*	1.00

* - signficantly different from 0 at the 5% (two-tailed) level.
The absolute critical values are 0.158 for the upper triangle and 0.164 for the lower triangle.

Table 2 Unit Root Tests

ADF order		CANADA			FRANCE			GERMANY			UNITED KINGDOM		
	Intercept	t-statistic*	LM		t-statistic	LM		t-statistic	LM		t-statistic	LM	
			1	4		1	4		1	4		1	4
0	No	-4.36*	10.00**	5.21**	-4.17*	0.015	2.17	-4.17*	0.015	2.17	-4.17*	0.015	2.17
	Yes	-4.35*	9.94**	5.16**	-	-	-	-	-	-	-	-	-
1	No	-4.51*	-0.01	1.04	-3.82*	0.64	2.40	-3.82*	0.64	2.40	-3.82*	0.64	2.40
	Yes	-	-	-	-	-	-	-	-	-	-	-	-
2	No	-4.74*	1.29	1.10	-3.84*	2.03	2.36	-3.84*	2.03	2.36	-3.84*	2.03	2.36
	Yes	-4.72*	1.27	1.08	-4.22*	0.66	2.12	-4.26*	2.70	5.43**	-		-
3	No	-5.27*	0.00	0.95	-4.25*	0.04	2.14	-3.81*	1.29	5.53**	-4.50*	0.49	1.89
	Yes	-5.25*	0.00	0.94	-4.61*	0.12	1.91	-3.79*	1.45	5.41**	-	-	-
4	No	-4.45*	2.54	0.63	-4.18*	0.67	1.56	-5.61*	2.68	0.95	-4.57*	0.29	1.84
	Yes	-4.43*	2.51	0.62	-4.18*	0.70	1.56	-	-	-	-		
ADF order		ITALY			JAPAN			UNITED STATES					
	intercept	t-statistic	LM		t-statistic	LM		t-statistic	LM				
			1	4		1	4		1	4			
0	No	-3.95*	14.97**	6.86**	-5.46*	6.66**	8.37**	-3.65*	14.78**	6.55**			
	Yes	-3.94*	14.87**	6.81**	-5.44*	6.62**	8.34**	-3.64*	14.67**	6.50**			
1	No	-5.10*	11.15**	2.94**	-5.34*	13.94**	9.47**	-4.42*	7.20**	2.37			
	Yes	-5.10*	11.08**	2.93**	-5.32*	13.84**	9.44**	-4.41*	7.16**	2.35			
2	No	-6.14*	0.04	0.51	-5.45*	9.06**	8.76**	-5.05*	0.88	1.71			
	Yes	-	-	-	-5.43*	9.00**	8.71**	-	-	-			
3	No	-5.52*	3.17	0.89	-5.89*	7.00**	2.34	-4.82*	0.26	0.43			
	Yes	-	-	-	-5.87*	6.94**	2.31	-	-	-			
4	No	-5.22*	0.21	0.13	-6.05*	9.77**	2.20**	-4.94*	0.00	0.27			
	Yes		-	-	-6.02*	9.69**	2.80**	-					

Sample period: 1960:1 1998:2.
Variables representing the cyclical component are: yccan (Canada), yccfr (Francia), yccgm (Germany), ycit (Italy), ycuk (United Kingdom), ycjp (Japan), ycus (United States)

(*) Significant at the 5% level. (**) Denotes rejection of the null hypothesis of no serial correlation up to lag order p (1 or 4). LM is Lagrange Multiplier Test for autocorrelated disturbances.

Table 3. F-statistics for testing the existence of a long run relationship between the international business cycle. (1960:1-1998:2)

G-7				
$p, q_1, \ldots q_6$	$F(can/yc_i)$	$F(fr/yc_i)$	$F(gm/yc_i)$	$F(it/yc_i)$
2, 2,..., 2	5.46	5.89	3.65	3.87
3, 3, ..., 3	4.89	4.44	3.65	4.55
4, 4, ..., 4	5.39	4.55	3.51*	4.97
	$F(jp/yc_i)$	$F(uk/yc_i)$	$F(usa/yc_i)$	
	4.10	6.42	4.29	
	4.23	5.27	5.49	
	5.00	4.42	4.35	

(*) Accepts the null hypothesis of non-existence of a long-run relationship between the variables.
Critical value bounds for this test are computed by Pesaran et al (1996a). In the present application the critical values at the 95 per cent level are given by 2.476 to 3.646.

Table 4. Granger non causality test[1]

2 lags	**CAN**	**FR**	**IT**	**GM**	**JP**	**UK**	**US**
CAN	-	0.00597	0.00780	-	-	-	-
FR	-	-	-	-	-	-	-
IT	-	**0.00329**	-	-	-	0.01442	0.00485
GM	**0.02835**	**0.00182**	-	-	-	-	-
JP	-	-	-	0.01950	-	0.01017	-
UK	**0.00607**	0.02326	0.01864	-	-	-	**0.04801**
US	**4.9E-07**	0.02174	0.00705	-	-	**0.00676**	-
3 lags	**CAN**	**FR**	**IT**	**GM**	**JP**	**UK**	**US**
CAN	-	0.01373	-	-	-	-	-
FR	-	-	-	-	-	-	-
IT	-	**0.00665**	-	-	-	0.04827	0.01602
GM	-	**0.00248**	-	-	-	-	-
JP	-	-	-	-	-	0.00346	-
UK	**0.00173**	-	-	-	-	-	**0.02485**
US	**6.6E-07**	-	-	-	-	**0.01733**	-
4 lags	**CAN**	**FR**	**IT**	**GM**	**JP**	**UK**	**US**
CAN	-	0.04969	-	-	-	-	-
FR	-	-	-	-	-	-	-
IT	-	**0.02349**	-	-	-	-	0.02201
GM	-	**0.00328**	-	-	-	-	-
JP	-	-	-	-	-	0.02527	-
UK	**0.00250**	-	-	-	-	-	**0.00895**
US	**2.1E-05**	-	0.01600	-	-	**0.03025**	-
5 lags	**CAN**	**FR**	**IT**	**GM**	**JP**	**UK**	**US**
CAN	-	0.00850	-	-	-	-	-
FR	-	-	-	-	-	-	-
IT	-	**0.04846**	-	-	-	-	0.03349
GM	-	**0.00338**	-	-	-	-	-
JP	-	-	-	-	-	0.03317	-
UK	**0.00611**	-	-	-	-	-	**0.01838**
US	**3.9E-05**	-	-	-	-	**0.03159**	-

1. Countries on the first column do not cause in the sense of Granger those in the next columns (2^{nd}-8^{th}) with the p-value included in the cells. We have only indicated the p-value for the cases in which the null hypothesis (of non-causality) is rejected. The p-value reported correspond to an F-test or the Wald statistic for the joint hypothesis:

$$\beta^k_1 = ... = \beta^k_1 = 0$$

Where the β^k_j's are the parameters associated with the cyclical component of the country k lagged j periods, being the dependent variable the cyclical component of the country on the first column. For example the p-value of the $cell_{2,3}$ has been obtained through the following equation:

$$yccan_t = a_0 + a_1 yccan_{t-1} + a_2 yccan_{t-2} + b_1 ycfr_{t-1} + b_2 ycfr_{t-2} + x_t$$

In this case the null hypothesis is: $\beta_1 = \beta_2 = 0$.

Table 5. F-statistic for testing the existence of a long-run relationship between Germany, Italy and France. (1960:1-1998:2).

	EURO-ZONE (3)		
p, q_1, q_2	F(gm/ fr, it)	F(fr/gm, it)	F(it/fr, gm)
2, 2, 2	6.69	8.48	7.58
3, 3, 3	7.05	6.36	10.92
4, 4, 4	5.05	6.86	8.74

Critical value bounds for the present specification with constant, no trend, k = 2 and 95 per cent level of confidence are (3.793; 4.855).

Table 6. F-statistic for testing the existence of a long-run relationship between UK Canada and US.

	ANGLO COUNTRIES		
p, q_1, q_2	F(us/can, uk)	F(uk/can, us)	F(can/us, uk)
2, 2, 2	8.79	7.83	9.14
3, 3, 3	10.91	6.42	8.02
4, 4, 4	8.06	7.32	7.43

Critical value bounds for the present specification with constant, no trend, k = 2 and 95 per cent level of confidence are (3.793; 4.855).

Table 7. Long-run coefficients. (1960:1-1998:2)

GERMANY-FRANCE-ITALY			USA-UK-CANADA		
$YCGM_t$	AIC-ARDL (1, 0, 1)	SCHWARZ (1, 0, 0)	**$YCUS_t$**	AIC-ARDL (1, 0, 3)	SCHWARZ (1, 0, 3)
Intercept	0.0003512	0.0003652	Intercept	0.0002347	-
$YCFR_t$	0.5573978	0.5549591	$YCUK_t$	0.4363014	-
$YCIT_t$	-0.1525547	-0.0472302	$YCCAN_t$	0.0493264	-

Table 8. Error correction models. (1960:1-1998:2)

GERMANY-FRANCE-ITALY			USA-UK-CANADA		
	AIC (1,0,1)	SCHWARZ (1, 0, 0)		AIC (1, 0, 3)	SCHWARZ (1, 0, 3)
$\Delta ycgm_t =$			$\Delta ycus_t =$		-
$\Delta ycit_t$	0.171159* (1.625)	-	$\Delta yccan_t$	0.397576 (6.374)	-
a'_{t-1}	-0.301751 (-5.142)	-0.299076 (-5.037)	$\Delta yccan_{t-1}$	0.147728 (2.291)	-
-	-	-	$\Delta yccan_{t-2}$	0.204455 (3.259)	-
-	-	-	b'_{t-1}	-0.270013 (-5.481)	-
R^2	0.160909	0.142160	R^2	0.345059	-
F-statistic	28.95667	-	F-statistic	25.99151	-
LM (F, 1) LM (F, 4)	1.190 5.187**	0.493944 4.051984**	LM (F, 1) LM (F, 4)	0.192 0.649	-

t-statistics in parenthesis.

$a'_{t-1} = ycgm_{t-1} - 0.5573978ycfr_{t-1} + 0.1525547ycit_{t-1} - 0.0003512$ (AIC)
$a'_{t-1} = ycgm_{t-1} - 0.5549591ycfr_{t-1} + 0.0472302ycit_{t-1} - 0.0003652$ (SCHWARZ)
$b'_{t-1} = ycus_{t-1} - 0.4363014ycuk_{t-1} - 0.0493264yccan_{t-1} - 0.0002347$ (AIC & SCHWARZ)

(*) Denotes that the null hypothesis of non-significance is accepted at 95 per cent of confidence.
(**) The null hypothesis of non-autocorrelation is rejected at 5 per cent level of significance. To solve the problem of autocorrelation the endogenous variable with four lags, $\Delta ycgm_{y-4,}$ was included in the estimation. In that case LM (F, 4) = 0.085, when the model is selected by the Akaike information (AIC) criteria and 0.106267 when the model follows the Schwarz Bayesian criteria. The new equations are:

$$\Delta ycgm_t = \underset{(5.29)}{0.368479}\ \Delta ycgm_{t-4} + \underset{(2.15)}{0.212872}\ \Delta ycit_t - \underset{(-6.06)}{0.332676}\ a'_{t-1} + v_t \quad \text{(AIC)}$$

$R^2 = 0.294713$

$$\Delta ycgm_t = \underset{(5.02)}{0.353495}\ \Delta ycgm_{t-4} - \underset{(-5.82)}{0.325829}\ a'_{t-1} + u_t \quad \text{(SCHWARZ)}$$

$R^2 = 0.272494$

$a'_{t-1} = ycgm_{t-1} - 0.5573978ycfr_{t-1} + 0.1525547ycit_{t-1} - 0.0003512$ (AIC)
$a'_{t-1} = ycgm_{t-1} - 0.5549591ycfr_{t-1} + 0.0472302ycit_{t-1} - 0.0003652$ (SCHWARZ)

$b'_{t-1} = ycus_{t-1} - 0.4363014ycuk_{t-1} - 0.0493264yccan_{t-1} - 0.0002347$ (AIC & SCHWARZ)

References

ARTIS, M. J. and ZHANG, W. (1995). International Business Cycles and the ERM: Is There a European Business Cycle. *International Journal of Finance Economics, Vol* **2**, 1-16.

BACKUS, D. K. and KEHOE, P. J. (1992). International evidence on the historical properties of business cycles. *American Economic Review*, **82,** 864-88.

BAXTER, M. and STOCKMAN, A. C. (1989). Business cycles and the exchange rate regime. *Journal of Monetary Economics,* **23**, 377-400.

BEAN, C.R. (1992). Economic and monetary union in Europe. *CEPR.* Discussion Paper no. 722. October.

CANOVA, F. (1991). Detrending and business cycle facts. European University Institute, Florence, Working Paper Eco. No. 91/58.

CANOVA, F. (1995). Vector autoregresive models: Specification, estimation inference and forecasting, in *Handbook of Applied Econometrics,* eds M. H. Pesaran and M. Wickens, Basil Blackwell, Oxford.

CHRISTODOULAKIS, N., DIMELIS, S., and KOLLINTZAS, T. (1995). Comparisons of Business Cycles in the EC: Idiosyncracies and Regularities. *Economica*. **62**. 1-27.

COGLEY, T. , and NASON, J. M. (1995). Effects of the Hodrick-Prescott Filter on Trend and Difference Stationary Time Series: Implications for Business Cycles Research. *Journal of Economic Dynamics and Control*. **19**, 235-278.

DANTHINE, J. P. and GIRARDIN, M. (1989). Business cycles in Switzerland. *European Economic Review*, **33**, 31-50.

EUROPEAN COMMISSION (1995). Tecnical note: the Commission services' method for the cyclical adjustment of government budget balances. *European Economy,* 60**.**

GERLACH, H. M. S. (1988). World business cycles under fixed and flexible exchange rates. *Journal of Money, Credit and Banking*, **20**, 621-632.

HARVEY, A. C., JAEGER, A. (1993). Detrending, Stylized Facts and the Business Cycle. *Journal of Applied Econometrics,* **8**, 231-247**.**

HODRICK, R.J. and PRESCOTT, E.C. (1997) "Post-war U.S. Business Cycles: An Empirical Investigation," *Journal of Money, Credit, and Banking*, **29**, 1–16.

HUFBAUER, G.C. and SCHOOT, J.J. (1992). North American Free Trade: Issues and Recommendations. Washington, DC: Institute for International Economics.

JOHANSEN, S. (1988). Statistical Analysis of cointegration vectors. *Journal of Economic Dynamics and Control,* Vol. **12**, 231-54.

KING, R. G. and REBELO, S. T. (1993). Low frequency and real business cycles. *Journal of Economic Dynamics and Control,* **17,** 207-31.

KYDLAND, F. E. and PRESCOTT, E. C. (1990). Business cycles: real facts and a monetary myth. *Federal Reserve Bank of Minneapolis Quarterly Review,* **14(2)**, 3-18.

MITCHELL, W. C. (1927). Business Cycles: The Problem and its Setting, New York: National Bureau of Economic Research.

PESARAN, M. H. And Shin, Y. (1996). An autoregressive distributed lag modelling approach to cointegration analysis. Cambridge: Department of Applied Economics, Cambridge University.

VON HAGEN, J. and NEWMAN, M. J. M. (1992). Real exchange rates within and between currency areas: how far away is EMU?. *CEPR.* Discussion Paper no. 660. June

ZARNOWITZ. V. (1985). Recent Work on Business Cycles in Historical Perspective: A Review of Theories and Evidence. *Journal of Economic Literature, Vol. XXIII,* 523-580.