MACROECONOMIC SYNCHRONIZATION BETWEEN G3 COUNTRIES*

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ABSTRACT

This paper studies the existence of a world business cycle by examining quarterly and annual comovements in production, prices, and interest rates in the three main world economies: Germany, Japan and the U.S. In accordance with earlier studies, contemporaneous relationships clearly dominate short-term dynamics. The evidence indicates that, in the last four decades, these comovements are clearly significant in all the variables, with the possible exception of short-term interest rates, and they are stronger for long-term interest rates; nevertheless, they are rather unstable over time.

Key words: comovement; synchronization; world business cycle.
JEL classification: E32; F41.

RESUMEN

Este artículo estudia la existencia de un ciclo económico mundial mediante el examen de movimientos comunes en la producción, los precios y los tipos de interés en las tres mayores economías mundiales: Alemania, Japón y los Estados Unidos. De acuerdo con estudios anteriores, las relaciones contemporáneas dominan claramente a las relaciones dinámicas a corto plazo. La evidencia indica que, en las últimas cuatro décadas, estos movimientos comunes son claramente significativos para todas las variables, con la posible excepción de los tipos de interés a corto plazo, y de mayor intensidad para los tipos de interés a largo plazo; sin embargo, son bastante inestables a lo largo del tiempo.

Palabras clave: ciclo económico mundial, movimiento común, sincronización.

1. Introduction

The presumption that different world economies undergo similar movements at the same time has a long tradition in economic thought. According to this view, there would exist common economic movements (comovements) between countries that give rise to a world business cycle. Several events have stressed this presumption in recent years. These include the increase in trade interdependencies resulting in a higher degree of openness of modern economies; the building of economic areas or unions; and the increase in capital mobility, fueled by the deregulation of financial markets and the relaxation of controls on international capital movements and foreign exchange transactions.

Numerous contributions have addressed, empirically and theoretically, this issue. From an empirical perspective, Mitchell (1927), Moore and Zarnowitz (1986), Gerlach (1988), Backus and Kehoe (1992), Bowden and Martin (1995) and Lumsdaine and Prasad (1997), among many others, find evidence in favor of a world business cycle. More theoretical research has dealt with the formation of world business cycles (Selover and Jensen, 1999), the relationship between international monetary regimes and transmission of macroeconomic shocks (Dibooglu, 2000), or the sources and channels of propagation of international cycles (Canova and Dellas, 1993, Schmitt-Grohé, 1998, and Canova and Marrinan, 1998).

Questioning all these presumptions and beliefs, one of the most intriguing features in the last years is the different behavior of the three main world economies: Germany, Japan and the United States. In the U.S., inflation and unemployment have reached their lowest level in many years, production has increased at a vigorous rate and stock markets have yielded extraordinary returns. In sharp contrast with the U.S., the Japanese economy has gone through a long stagnation in the nineties. The growth rate in production has been very low. In fact, it has been unusually low when compared to that of preceding decades, with depressed investment and stock markets that have not yet recovered from the crash that occurred in the early nineties. In Germany the situation is somewhat intermediate; while growth in production has not been so disappointing as in Japan, it is far below that of the U.S. These profound differences cause one to question the existence of a world business cycle or, at least, the existence of common economic movements in the G3 countries. Needless to say, the concepts of common economic movements and world business cycle are not exactly equal. However, given the generality (and even ambiguity) of the concept of world business cycle, in what follows it will be understood as economic fluctuations that are qualitatively and quantitatively similar and occurring at the same time in all countries. This definition is fairly operative and very close to the meaning implicitly adopted in most contributions.

Though virtually all research agrees on the existence of a world business cycle, there is important divergence. In particular, the question of the evolution of strength over time has received very different answers. As the conclusions obtained may depend heavily on several points, they must be examined in some detail. These are the following: i) the selection of variables, ii) the data frequency, iii) the countries taken into account, and iv) the statistical method.

In order to study the existence of a world business cycle, most researchers have used production (GDP or industrial production) or have built a representative variable of the business cycle. Though it seems a reasonable election, there could well exist common movements in other variables. If the interest lies in common *economic* movements, other important macroeconomic variables, like prices or interest rates, should also be considered, in addition to production, as the results may be quite different.

The frequency of data may also be critical. For a given frequency, strong comovements may exist that become weak, or even disappear, in other frequencies. A simple example will illustrate this point. Let us suppose that quarterly changes in production in country A are i.i.d., and that in country B they are exactly equal to the changes in production in country A in the preceding quarter. In this case, the contemporaneous correlation between quarterly changes in production in both countries will be exactly 0. However, the results at annual frequency are very different; contemporaneous annual cross-correlation will be exactly equal to ¾. Clearly, these different contemporaneous correlations will have their counterparts in cross-correlations at lag one. But the important message here is that a small delay of only one quarter may completely conceal the existence of comovements at quarterly frequency, although they appear clearly at annual frequency. The implications of this issue for empirical research on world business cycles are twofold. On the one hand, data frequency is not innocuous; it must be selected carefully or, even better, different frequencies must be taken into account. On the other hand, it is also interesting to examine the short-term dynamic relationships, as the distinction between synchronous and diachronic movements depends on the arbitrary election of data frequency.

Other important point is the number of countries taken into account. The mere idea of a world business cycle implies the consideration of *all* countries in the world. As this is a problematic task and interest usually lies in the study of a common business cycle between developed countries, most research has analyzed the relationships between several developed countries (see, for example, Gerlach, 1988, Backus and Kehoe, 1992, Backus, Kehoe and Kydland, 1995, Bowden and Martin, 1995 and Gregory, Head and Raynauld, 1997). Nevertheless, a large number of countries will hinder a deep and detailed analysis. If one is willing to analyze in depth the relationships held by several variables at different frequencies, the number of countries must be restricted drastically. In this respect, it is interesting to note that the three main world economies correspond to three countries –Germany, Japan and the U.S. – located in very different parts of the world, and with a clear leadership and influence in their respective areas. Limiting the analysis to these three countries would allow a deeper insight of their relationship, as well as a certain degree of world coverage.

Different methodologies have been used in the research on common economic movements. A general classification would distinguish between those contributions (for example, Baxter and Stockman, 1989, Backus and Kehoe, 1992, and Lumsdaine and Prasad, 1997) that use methods in the time domain –mainly, cross correlations– from those (for example, Gerlach, 1989 or Bowden and Martin, 1995) that use methods in the frequency domain –mainly, cross spectral coherences–. Considering all the studies, those that use spectral methods are in the minority. Surely, the reason is that these techniques require more data, as they are not used so efficiently. With macroeconomic series, the number of observations is relatively low, specially when the interest lies in the comovements over short periods of time, which implies serious limitations in the application of spectral methods. With regard to the use of cross correlations, it must be born in mind that they allow the study of relationships between *two* countries; but this method must be extended or modified if one aims to study the relationships between more than two countries at the same time.

The stability over time of economic relationships has received special attention in empirical research since Mitchell (1927). Backus and Kehoe (1992) present cross-country correlations generally higher between World War I and World War II than before World War I and after World War II. In turn, the correlations are typically larger after World War II than before World War I. Nevertheless, Zarnowitz (1992) finds a high conformity between the business cycles in the European countries before World War I, which decreased in the following two decades. More specifically, many authors have addressed the question of a possibly distinct intensity with flexible and fixed exchange rates with very different results. Gerlach (1988) finds higher coherence under the flexible exchange period, Lumsdaine and Prasad (1997) do not observe systematic differences between the Bretton Woods and the post Bretton Woods periods, and Baxter and Stockman (1989, p. 399) find that 'the international correlation of output fluctuations generally decreased in the post-1973 period compared with the earlier (Bretton Woods) period.'

The objective of this paper is to investigate the simultaneity in macroeconomic fluctuations between Germany, Japan and the U.S. Several economic variables will be examined: production, prices and interest rates, and both their quarterly and annual movements will be considered. Cross-correlation analysis between each pair of countries will be conducted, and, to study the relationships between the three countries together, the bivariate correlation analysis will be extended by using correlation matrices. Special attention will be paid to the stability of the results over time, and to avoid the possibility that comovements may be hidden by small delays, short-term dynamics will also be examined. To carry out this study, Section 2 presents the data used, industrial production, consumer prices and interest rates in Germany, Japan and the United States. In Section 3 the existence of comovements is studied, both from a bivariate (subsection 3.1) and a multivariate (subsection 3.2) perspective. The analysis of short-term dynamic relationships is carried out in Section 4. Finally, Section 5 summarizes the main results and conclusions.

2. Data

When studying the issue of common movements, the question arises of which variables to consider. Most research has considered output (industrial production or GDP) or has built a representative variable of the domestic business cycles. However, as the conclusions on the existence and magnitude of comovements could differ depending on the variable taken into account, it would be interesting to examine several variables and not restrict the analysis to a single one. Therefore, to obtain a deeper analysis of the existence of comovements, four variables will be considered. Quarterly and annual data on industrial production, consumer price indexes, short-term interest rates and long-term interest rates from Germany, Japan and the United States have been used. All these observations were collected from *International Financial Statistics*, International Monetary Fund (series xxx66..CZF…, xxx64…ZF…, xxx60B..ZF… and xxx61…ZF…, respectively). The quarterly data cover the period 1957:1-1998:4, excepting long-term interest rates for Japan, which begin in 1966:4. The annual data cover the period 1957-1998, excepting long-term interest rates for Japan, which begin in 1966. In what follows, the results that involve Japanese long-term interest rates have been obtained with their specific sample periods, although not explicitly stated.

In order to induce stationarity in these four variables, they must be detrended. The selection of a detrending procedure is a complex task because there are several possible ways of doing so, each of which is pertinent in certain circumstances and has its own implications. The two most habitual methods are the Hodrick and Prescott (1980 and 1997) filter, HP, and first differencing. The first method has been widely used, specially in those contributions interested in the coherence of business cycles, but several authors have warned of the consequences of applying this filter (see King and Rebelo, 1993, Jaeger, 1994 and Cogley and Nason, 1995). In particular, when studying comovements in HP-filtered series, there exists one potential problem, which may be important. A common tool in the analysis of comovements is the estimation of cross-correlations, but the standard errors of these estimates may be large. For HP-filtered independent random walks, Harvey and Jaeger (1993) report asymptotic standard deviations of the sample cross-correlations much higher than those obtained when at least one of the filtered series is white noise. Hence, the danger of finding spurious comovements if correct standard errors are not used.

Given all these warnings and the potential problems, the data will be first differenced. This practice has been used in Gerlach (1988), Baxter and Stockman (1989), Bowden and Martin (1995), Lumsdaine and Prasad (1997) and many others. (Augmented) Dickey-Fuller and Phillips-Perron unit root tests confirmed that the series cited above (or their logarithms) are non-stationary. Therefore, first differences were taken to induce stationarity and, thus, new series were obtained that extend from 1957:2 to 1998:4 (1958-1998, for annual data). These series are composed of the changes in the logarithms (rates of growth) of industrial production, changes in the logarithms of consumer price indexes (inflation rates), and changes in short- and long-term interest rates.

3. Macroeconomic synchronization

3.1. Bivariate framework

In order to examine the degree of coherence between economic movements in two countries, cross-country correlations will be estimated. Given two independent series, X_{1t} and X_{2t}, the asymptotic distribution of their contemporaneous cross-correlation is given by

$$r_{12} \Rightarrow AN\left(0\,,\ T^{-1}\left(1+2\sum_{k=1}^{\infty}\rho_{11}(k)\rho_{22}(k)\right)\right), \tag{1}$$

where r_{12} is the sample cross-correlation between X_{1t} and X_{2t}, AN stands for asymptotically normal, T is the sample size and $\rho_{ii}(k)$ is the autocorrelation of order k of X_{it}, i = 1, 2 (see Brockwell and Davis, 1991). This means that the asymptotic distribution of sample cross-correlation depends on the autocorrelation functions of both series, which makes the analysis of cross-correlations a problematic task. However, when one (or both) of the series is white noise, the asymptotic distribution simplifies and (1) becomes

$$r_{12} \Rightarrow AN\left(0\,,\ T^{-1}\right). \tag{2}$$

Therefore, before computing the cross-correlations, all the series were filtered using their own past. AR(p) models, for p = 1, 2, 3 and 4, were estimated for each series, and the residuals of the model with the lower Schwarz statistic were used. In all cases these residuals behave as white noise. Table 1 shows the cross-country correlation for the same (filtered) variables in the different pairs of countries, and, as these filtered variables are not autocorrelated, the P-values have been obtained according to (2). The sample periods begin in 1958:2 and 1962, as up to five data may be lost (one when first differencing and up to four when filtering). The results with quarterly and annual data are very similar. They indicate strong correlations between each pair of G3 countries in industrial production, consumer prices and long-term interest rates. Among these variables, the conformity in long-term interest rates is more intense. Nevertheless, the results with short-term interest rates are quite different. Neither quarterly nor annual comovements between Japanese short-term interest rates and those of Germany and the

U.S. are significant. In turn, quarterly comovements between Germany and the U.S. are roughly significant at the usual 5% significance level (*P*-value equal to 0.045).

Table 1. Cross-country correlations.

Variable	Countries	Quartely Correlation	Annual Correlation
Industrial Production	Germany-Japan	0.245 (0.002)	0.508 (0.002)
Industrial Production	Germany-U.S.	0.199 (0.011)	0.500 (0.002)
Industrial Production	Japan-U.S.	0.257 (0.001)	0.463 (0.005)
Consumer Prices	Germany-Japan	0.190 (0.015)	0.353 (0.032)
Consumer Prices	Germany-U.S.	0.185 (0.018)	0.493 (0.003)
Consumer Prices	Japan-U.S.	0.236 (0.003)	0.610 (0.000)
Short-term Interest	Germany-Japan	0.125 (0.111)	0.182 (0.268)
Short-term Interest	Germany-U.S.	0.157 (0.045)	0.532 (0.001)
Short-term Interest	Japan-U.S.	-0.009 (0.910)	0.177 (0.282)
Long-term Interest	Germany-Japan	0.497 (0.000)	0.712 (0.000)
Long-term Interest	Germany-U.S.	0.456 (0.000)	0.580 (0.000)
Long-term Interest	Japan-U.S.	0.318 (0.000)	0.402 (0.033)

Quarterly cross-country correlations for the period 1958:2-1998:4 and annual cross-country correlations for the period 1962-1998. *P*-values are in parenthesis and they have been computed under the hypothesis that the correlations follow a N(0, 1/*T*) distribution, *T* being the sample size.

However, in the last four decades, these three economies have suffered deep changes (especially Germany and Japan), and it could be that this synchronization has not always occurred. In order to analyze its evolution over these four decades, moving cross-country correlations were computed for sub-periods of forty-eight quarters. The first correlation was computed for the period 1958:1-1969:4. Then, a new correlation was computed by dropping the first four quarterly data and adding the following four quarterly data, and so on till the subperiod 1987:1-1998:4. The series were filtered recursively in the same way as explained above. With regard to annual correlations, they were obtained in an analogous way for the periods 1958-1969, 1959-1970, …, 1987-1998. The picture of these correlations provides a meaningful image of the evolution of the strength of comovements. Figures 1-4 show the rolling cross-country correlations in industrial production, consumer prices, short-term interest rates and long-term interest rates, respectively. As each of the correlations follow the distribution shown in (2), two horizontal lines have been drawn at $\pm 1.96 \cdot T^{-1/2}$, which represent the 95% confidence limits. This gives $\pm 1.96 \cdot 48^{-1/2} = \pm 0.283$, for quarterly data, and

Figure 1. Correlations in industrial production.

Quarterly | **Annual**

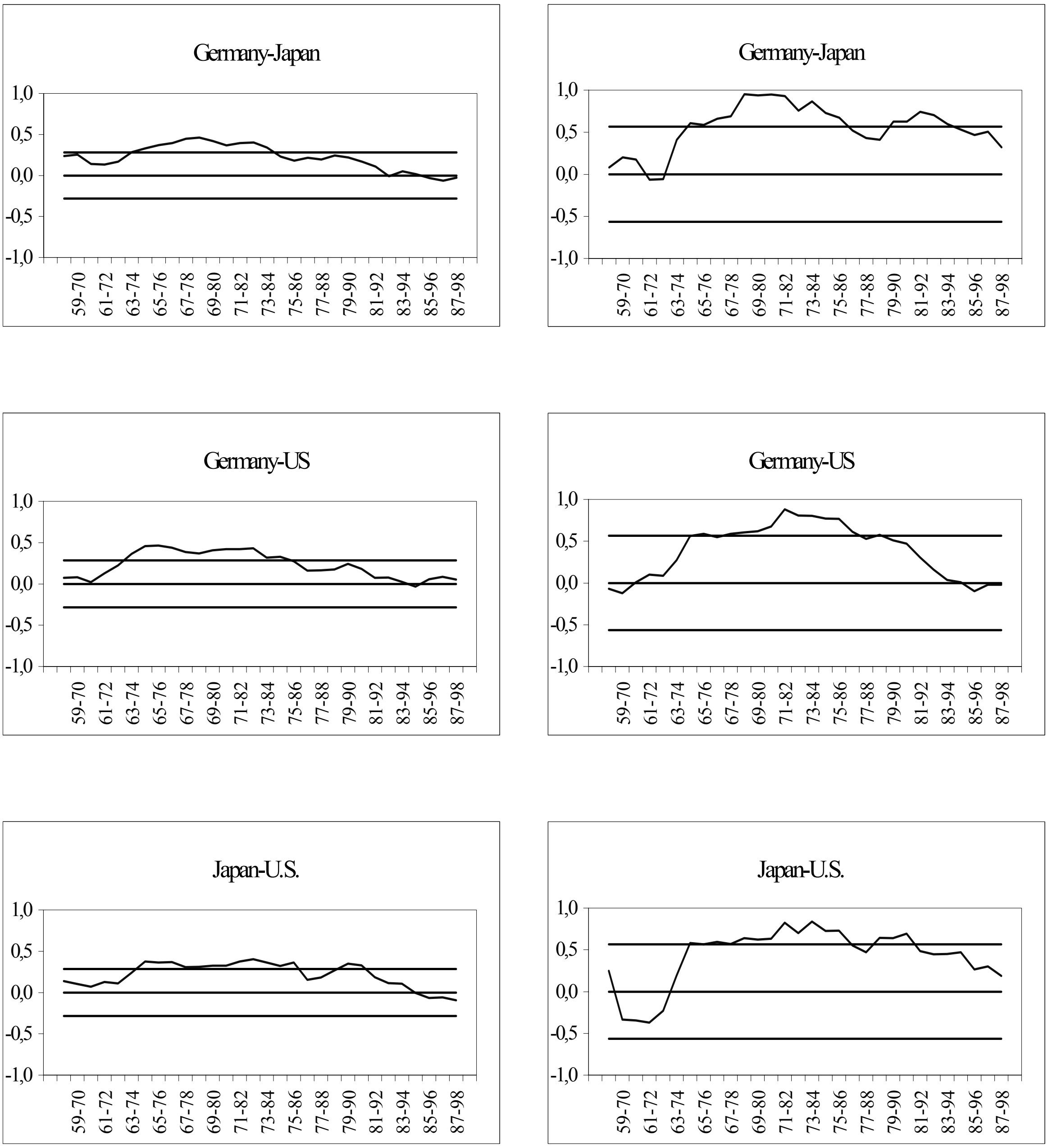


Figure 2. Correlations in consumer prices.

Quarterly **Annual**

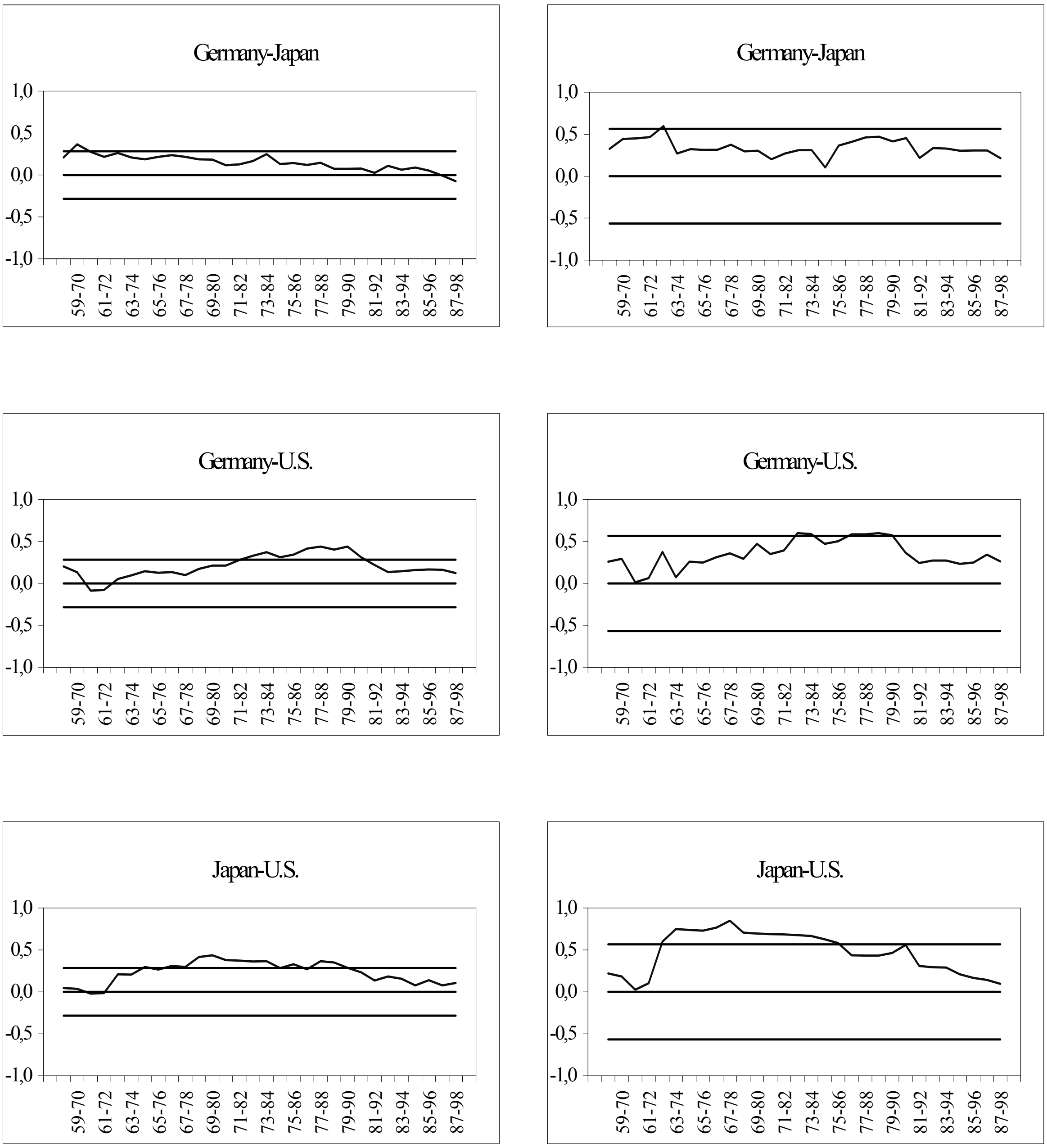


Figure 3. Correlations in short-term interest rates.

Quarterly **Annual**

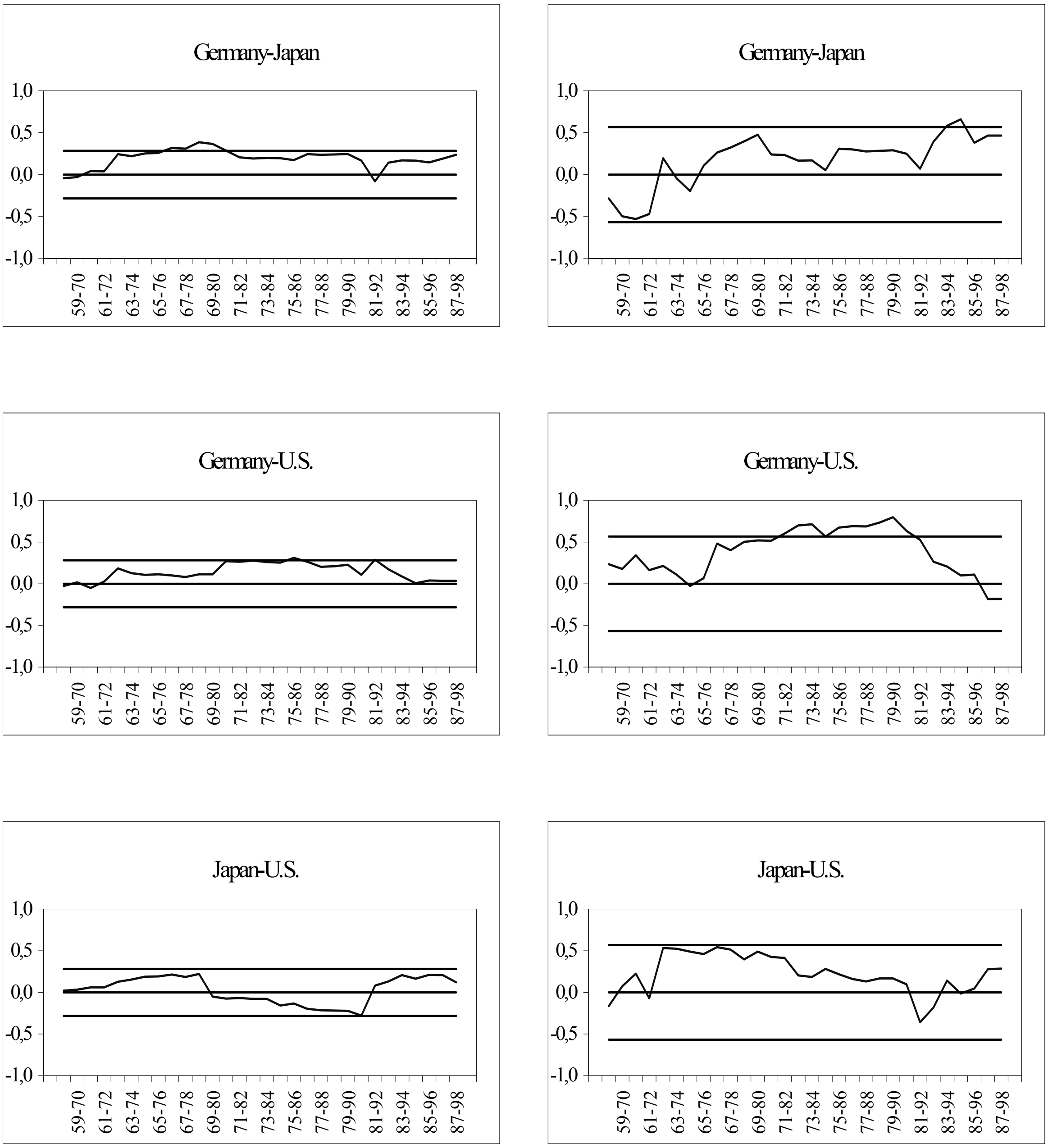
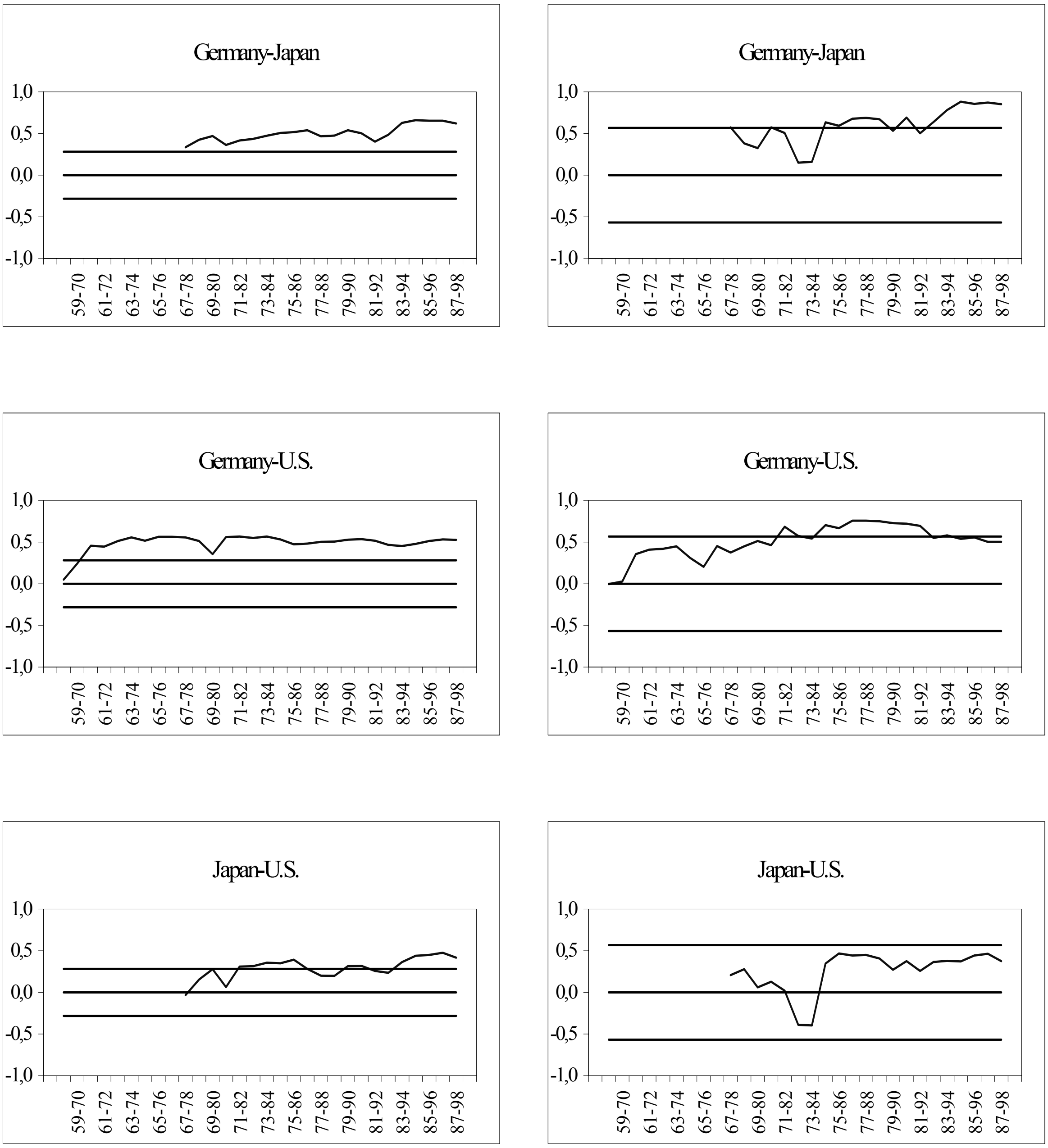


Figure 4. Correlations in long-term interest rates.

Quarterly **Annual**



$\pm 1.96 \cdot 12^{-1/2} = \pm 0.566$, for annual data. It is important to bear in mind that, in general, these cross-country correlations are not independent, as common observations are used. Only when they are at least twelve years apart, do they not share common observations and they may be considered independent.

Again, the results are relatively similar for quarterly and annual movements, though some interesting differences are observed. Annual figures are a little more erratic and not so smooth as quarterly ones; this may be due, at least partly, to the different sample sizes and to the rolling procedure. The main conclusions of these figures are twofold. First, the coherence in economic movements has not been stable; in many subperiods it has not been significant and in some it has even become negative, though not significantly. Second, there are important differences between the evolution of coherence in the different variables and in the different countries. Thus, for example, the evolution of coherence in annual industrial production between Germany and the U.S. shows an inverted "U" profile: the correlation was low in the first years, then increased, and in the last years has decreased. This inverted "U" shape is not observed, at least clearly, in other cases, though usually the degree of conformity is rather unstable. Another interesting feature, which is practically common to the three pairs of countries and to quarterly and annual movements, is the higher conformity in long-term interest rates in the last years compared to preceding decades.

3.2. Multivariate framework

Cross-correlations provide a good measure of the co-evolution of an economic variable in *two* countries. Unfortunately, they do not allow easy appreciation of the existence of comovements in the three G3 countries taken together. To analyze the comovements between more than two countries, correlation matrices may be used. In what follows, the case of n countries will be tackled, for any integer $n > 1$.

Let $\mathbf{R}$ be a square matrix of order n, whose ij-element is the (sample) correlation of a certain filtered economic variable in countries i and j. That is, $\mathbf{R}$ is a correlation matrix. The determinant of this matrix, $|\mathbf{R}|$, will lie between 0 and 1, $0 \leq |\mathbf{R}| \leq 1$, and will be a measure of the conformity of the movements in the considered economic variable in all the countries. A value of $|\mathbf{R}|$ close to 1 denotes the absence of comovements in the countries taken together, while a value close to 0 denotes strong comovements.

Under the null hypothesis that all cross-correlations are zero, $\rho_{ij} = 0$, for $i, j = 1$, 2, …, n and $i \neq j$, $-(T-1)\log|\mathbf{R}|$ follows asymptotically a χ^2 distribution with $n(n-1)/2$ degrees of freedom (see Kendall, Stuart and Ord, 1983). This property could be used to formally analyze the existence of comovements between the three countries under study. Table 2 shows these statistics and their *P*-values. Once more, quarterly and annual results are very alike. In agreement with previous results, the null hypotheses of absence of comovements are clearly rejected in all cases. The accordance of economic movements is stronger for long-term interest rates and weaker (though clearly significant) for short-term rates.

Table 2. Tests of comovements in Germany, Japan and the U.S.

Variable	$-(T-1)\log\|\mathbf{R}\|$ (Quarterly data)	$-(T-1)\log\|\mathbf{R}\|$ (Annual data)
Industrial Production	24.69 (0.000)	24.05 (0.000)
Consumer Prices	18.92 (0.000)	26.98 (0.000)
Short-term Interest	6.78 (0.000)	13.54 (0.004)
Long-term Interest	72.31 (0.000)	41.54 (0.000)

T denotes the sample size and **R** is the correlation matrix whose *ij*-element is the sample correlation of the (filtered) variable in countries *i* and *j* in the period 1958:2-1998:4 (quarterly data) or 1962-1998 (annual data). *P*-values are in parenthesis and they have been computed under the hypothesis that the statistics follow a χ^2_3 distribution.

As before, these results are uninformative of the evolution of the comovements over time. Therefore, rolling determinants and their corresponding tests statistics will be computed following a method analogous to that used in sub-section 3.1. With quarterly data, the sample size for each determinant is 48, and for annual data it is only 12. Given these sample sizes, one may wonder whether the asymptotic distribution is misleading. Consequently, 50,000 simulations were generated for $-(T-1)\log|\mathbf{R}|$, for different sample sizes, *T* = 12, 20, 30 and 48, and **R** being a matrix of sample correlations of three independent N(0, 1) random variables. Table 3 shows the quantiles of the sample distribution of $-(T-1)\log|\mathbf{R}|$ and the quantiles of the asymptotic distribution χ^2_3. It may be seen that for sample sizes moderately high, like *T* = *48*, for example, the asymptotic distribution provides an acceptable approximation. But for low sample sizes, like *T* = 12, the critical value of the asymptotic distribution is much lower than the critical value from the simulations. Thus, using the asymptotic distribution would incorrectly yield too many rejections of the null; that is, too many detections of comovements.

Table 3. Sample distribution of $-(T-1)\log|\mathbf{R}|$.

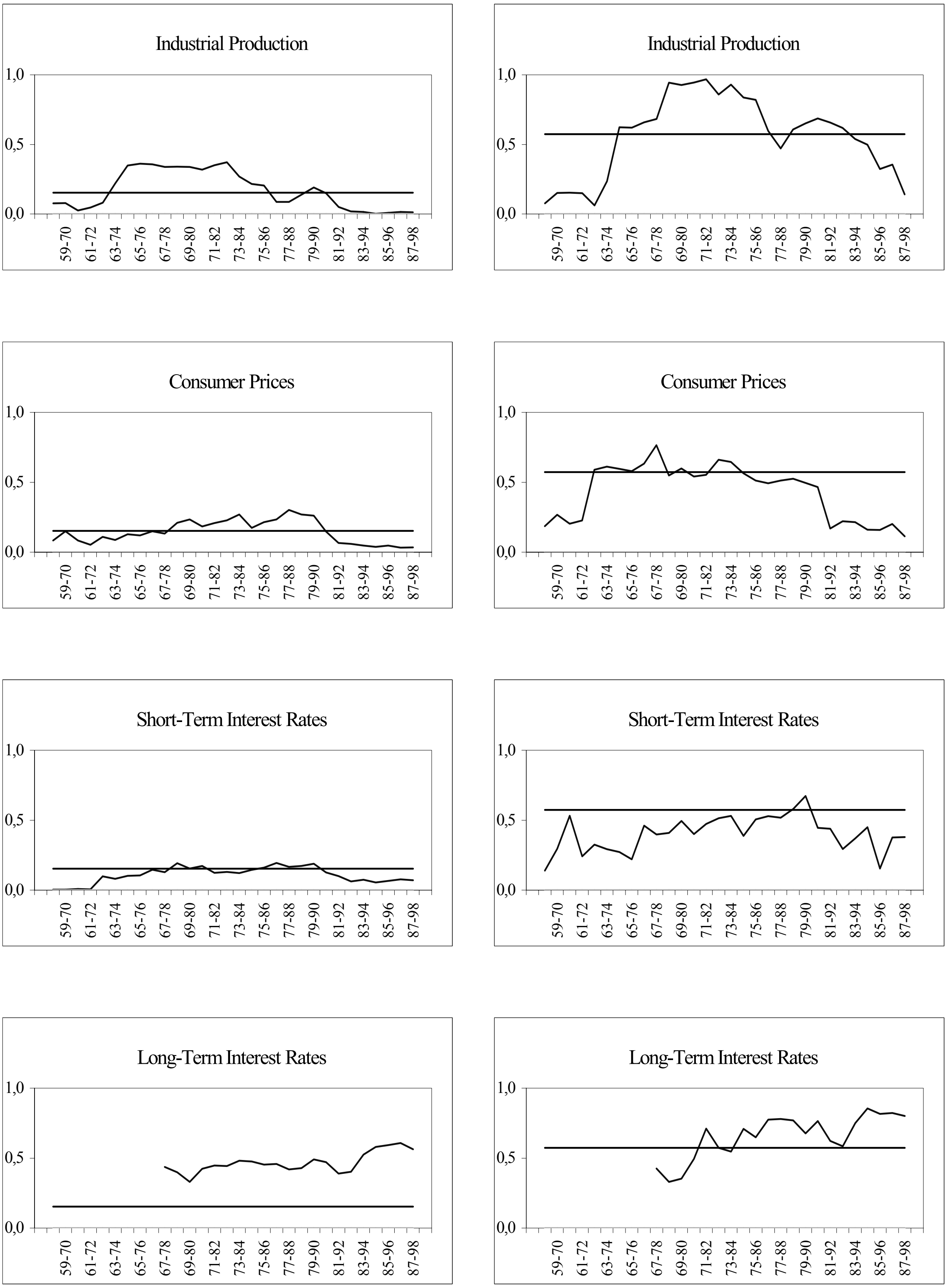
Quantil	$T = 12$	$T = 20$	$T = 30$	$T = 48$	χ^2_3
0.90	7.48	6.96	6.69	6.51	6.25
0.95	9.36	8.50	8.39	8.11	7.81
0.99	13.6	12.2	12.1	11.8	11.3

Sample distribution of $-(T-1)\log|\mathbf{R}|$ in 50,000 simulations. T denotes the sample size and **R** is the correlation matrix of three independent N(0, 1) random variables.

For a significance level equal to 0.05, the critical value for $T = 48$ obtained in the simulations is 8.11. Therefore, when testing for absence of quarterly comovements, the null is rejected if $-(T-1)\log|\mathbf{R}| > 8.11$, or, equivalently, if $|\mathbf{R}| < 0.842$. As it seems to be much more intuitive, the measure $\Lambda = 1 - |\mathbf{R}|$ will be used instead of $|\mathbf{R}|$. Λ will also be comprised between 0 and 1: $0 \le \Lambda \le 1$. High values of Λ imply strong comovements while low values imply the absence of comovements. Therefore, the null hypothesis of absence of comovements will be rejected if $\Lambda > 1 - 0.842 = 0.158$. If the asymptotic distribution had been used instead, the critical value would have been 0.153, which is very close to the value obtained with the simulations. Analogously, with annual data, as $T = 12$, the null hypothesis of absence of comovements will be rejected if $\Lambda > 0.573$. Now, this value is clearly higher than the value obtained with the asymptotic distribution (0.508). Figure 5 shows the evolution of the rolling values of Λ. Two horizontal lines have been drawn for $\Lambda = 0.158$ and $\Lambda = 0.573$, respectively. Values above these lines indicate the rejection of the null hypothesis of absence of comovements at the 0.05 significance level. As the three countries are now taken into account, Figure 5 synthesizes the preceding figures and the features described above are confirmed: a strong instability over time and a distinct behavior of the different variables. Thus, the inverted "U" profile in industrial production and the increasing conformity in long-term interest rates which were observed in the different pairs of G3 countries are also clearly observed in the comovements of the three countries taken together.

Figure 5. Coherence in G3 countries.

Quarterly **Annual**



Though many theories predict strong differences in the transmission process across exchange rate regimes, the evidence reported here does not confirm this presumption. No clear change across regimes is observed in the comovements of production, prices or short-term interest rates. These results are in line with the macroeconometric model of Ahmed *et al*. (1993) and with Lumsdaine and Prasad (1997), which do not find systematic differences with flexible and fixed exchange rates. While the result for short-term interest rates may be explained by its nature of policy target, the result for long-term interest rates is rather different. These display higher coherence in the last years of the sample, but this does not seem to be due to a different exchange rate regime because the change occurs gradually. Instead, coherence increase may be linked to the increase in international capital movements and world financial integration. On the other hand, these results also support the model proposed by Greenwood and Williamson (1989), where output, interest rates and inflation are positively correlated and, interestingly, unaffected by the exchange rate regime.

4. Short-term dynamic relationships

The existence of common synchronous economic movements does not preclude the possibility of dynamic or non-synchronous relationships. A fraction of the economic fluctuations in one of the G3 countries could be shared by another country in the same period, but another fraction could be transmitted through different channels. This transmission may take time and, therefore, its effect would be reflected in the following periods. In addition to the economic synchronicity, there could exist lead- and lag-relationships between the G3 countries that take place in the short term. The existence of these short-term relationships does not exclude other possible long-term relationships (for example, convergence or cointegration). To detect these relationships, filtered movements in each of the four variables and in each of the three countries were regressed against a constant and four lags of the same variable in the other countries. Table 4 displays the coefficients of determination of these regressions and the P-values corresponding to the F-test of the null hypotheses of nullity of the coefficients accompanying the four lags.

Table 4. Tests of causation.

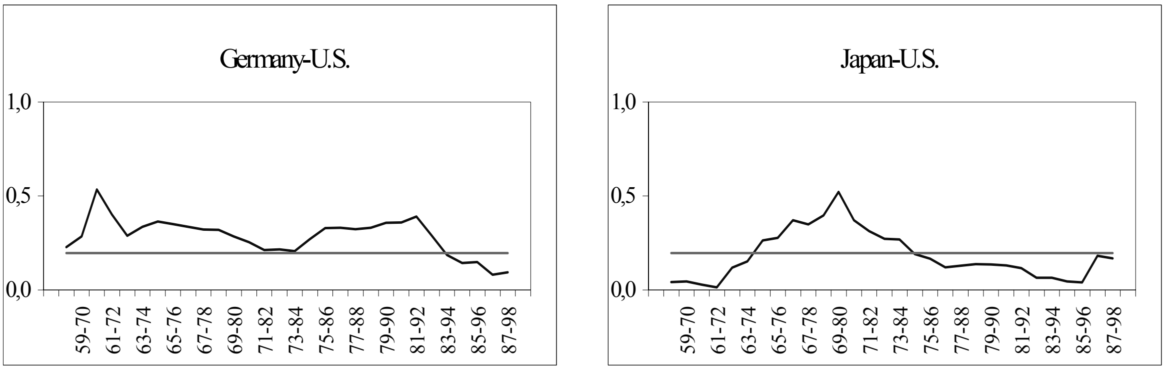
Variable	Country	Countries	R^2 (Quarterly data)	R^2 (Annual data)
Industrial Production	Germany	Japan	0.087 (0.006)**	0.137 (0.232)
Industrial Production	Germany	U.S.	0.026 (0.374)	0.028 (0.897)
Industrial Production	Germany	Japan, U.S.	0.093 (0.053)	0.176 (0.542)
Industrial Production	Japan	Germany	0.015 (0.651)	0.072 (0.588)
Industrial Production	Japan	U.S.	0.033 (0.250)	0.196 (0.081)
Industrial Production	Japan	Germany, U.S.	0.042 (0.562)	0.214 (0.373)
Industrial Production	U.S.	Germany	0.087 (0.006)**	0.090 (0.467)
Industrial Production	U.S.	Japan	0.053 (0.072)	0.085 (0.498)
Industrial Production	U.S.	Germany, Japan	0.117 (0.012)*	0.140 (0.714)
Consumer Prices	Germany	Japan	0.034 (0.242)	0.083 (0.507)
Consumer Prices	Germany	U.S.	0.085 (0.007)**	0.055 (0.707)
Consumer Prices	Germany	Japan, U.S.	0.109 (0.020)*	0.153 (0.653)
Consumer Prices	Japan	Germany	0.075 (0.014)*	0.086 (0.049)*
Consumer Prices	Japan	U.S.	0.053 (0.072)	0.075 (0.562)
Consumer Prices	Japan	Germany, U.S.	0.141 (0.002)**	0.154 (0.647)
Consumer Prices	U.S.	Germany	0.037 (0.195)	0.014 (0.971)
Consumer Prices	U.S.	Japan	0.018 (0.577)	0.210 (0.062)
Consumer Prices	U.S.	Germany, Japan	0.056 (0.337)	0.235 (0.294)
Short-term Interest	Germany	Japan	0.011 (0.768)	0.109 (0.431)
Short-term Interest	Germany	U.S.	0.177 (0.000)**	0.076 (0.601)
Short-term Interest	Germany	Japan, U.S.	0.187 (0.000)**	0.143 (0.784)
Short-term Interest	Japan	Germany	0.063 (0.035)*	0.247 (0.033)*
Short-term Interest	Japan	U.S.	0.085 (0.007)**	0.271 (0.026)*
Short-term Interest	Japan	Germany, U.S.	0.102 (0.031)*	0.392 (0.038)*
Short-term Interest	U.S.	Germany	0.021 (0.493)	0.129 (0.278)
Short-term Interest	U.S.	Japan	0.023 (0.441)	0.239 (0.061)
Short-term Interest	U.S.	Germany, Japan	0.050 (0.429)	0.411 (0.038)*
Long-term Interest	Germany	Japan	0.059 (0.119)	0.302 (0.072)
Long-term Interest	Germany	U.S.	0.096 (0.003)**	0.130 (0.288)
Long-term Interest	Germany	Japan, U.S.	0.160 (0.008)**	0.351 (0.309)
Long-term Interest	Japan	Germany	0.082 (0.031)*	0.200 (0.182)
Long-term Interest	Japan	U.S.	0.067 (0.072)	0.181 (0.232)
Long-term Interest	Japan	Germany, U.S.	0.132 (0.027)*	0.257 (0.467)
Long-term Interest	U.S.	Germany	0.027 (0.362)	0.047 (0.804)
Long-term Interest	U.S.	Japan	0.096 (0.016)*	0.238 (0.163)
Long-term Interest	U.S.	Germany, Japan	0.108 (0.097)	0.349 (0.314)

Coefficients of determination (R^2) in the regressions of filtered changes in the variable indicated in the first column in the country indicated in the second column on a constant and four lags of changes in the same variable in the countries indicated in the third column. The *P*-values (in parenthesis) correspond to the test of nullity of all coefficients excluding the intercept. * denotes significant at the 5% level. ** denotes significant at the 1% level.

Two important results arise from Table 4. First, dynamic relationships are, in general, much weaker than contemporaneous ones. This is in accordance with earlier studies (Hickman and Filatov, 1983, Stulz and Wasserfallen, 1985, and Dellas, 1986) that pointed out the preponderance of synchronic relationships over dynamic ones. Without taking into account possible long-term relationships, comovements are mainly simultaneous. In most regressions, the nullity of coefficients cannot be rejected, thus meaning that there are not short-term dynamic relationships in many cases. Second, quarterly dynamic relationships are stronger than annual ones. None of the annual regressions is significant at the 1% level, and only five of them are significant at the 5% level. As denoted by *P*-values, quarterly regressions are somewhat more significant. This difference is probably due to the fact that the (weak) short-term dynamic relationships only last a few quarters and most of them disappear after one year. Quarterly correlations presented in Section 3 are unable to reflect this inter-temporal dependence, but, to a large extent, it is incorporated in the annual results of that same section. Some additional interesting features are observed when examining quarterly regressions. First, and most important, the relationships are more intense for interest rates. Movements in U.S. interest rates lead those of Germany and Japan. This fact occurs in long-term and, more strongly, in short-term interest rates. Second, the inflation rate in Germany is led by the U.S. inflation rate, and these countries together lead the Japanese inflation rate. Third, movements in Japanese industrial production lead those in Germany, and, in turn, German movements anticipate those in the U.S., both relationships being similar in intensity.

Although most regressions in Table 4 are non-significant, it is interesting to examine the significant relationships more closely. In particular, one could wonder whether these have been stable over time. Their stability was analyzed by examining the moving coefficients of determination obtained analogously to the moving correlations and determinants in the preceding section. Many of these relationships are rather unstable over time and with different profiles. This result is in accordance with other studies that find remarkable lacks of stability in macroeconomic relationships (see, for example, Stock and Watson, 1996). Two examples are shown in Figure 6. These correspond to the quarterly regressions of German and Japanese short-term interest rates against those of the U.S. As reflected in Table 4, both regressions are significant at the 1% level in the whole period; however, the evolution over time of the strength of the relationships is very distinct. With the exception of the last sub-periods, the influence of U.S. movements in short-term interest rates on German ones is relatively stable over time and always significant at the 5% level. In sharp contrast, the influence on the movements in Japanese short-term interest rates is very unstable and clearly non-significant in many sub-periods.

Figure 6. Dynamic relationships in short-term interest rates.



This preponderance of synchronic over dynamic relationships can be regarded as evidence in favor of those theories that attribute the origin of world cycles to common shocks. If the origin of world cycles were the transmission of economic fluctuations between countries, one should expect to find weaker synchronic and stronger dynamic comovements, given that this transmission should take unavoidable lags. This feature is in line with many contributions, which do not confirm the common belief in economic theory on the 'import' of business cycles (Canova and Marrinan, 1998, Canova and Dellas, 1993, and Schmitt-Grohé, 1998). Under different models, these authors are unable to explain the transmission of economic movements through different channels, even in cases like the U.S. and Canada (Schmitt-Grohé, 1998). On the contrary, comovements in production seem to be affected by common shocks; in particular, common oil shocks that occurred in the seventies and in the early eighties gave rise to a sharp increase in the strength of these comovements.

Finally, it is worth mentioning that all the results obtained in sections 3 and 4 are fairly robust to the election of forty-eight quarters or twelve years as the 'window lengths'. Obviously, as the length increases, the evolution of cross-correlations becomes flatter, and, conversely, when it decreases the evolution is more irregular. But the features pointed out in this paper are also observed with different lengths, and other reasonable elections yielded similar results.

5. Conclusions

While traditional economic thought has accepted the existence of common economic movements between developed countries, recent economic performance in the three main world economies questions this presumption. To cast some light on this issue, this paper has examined the existence of economic comovements between Germany, Japan and the U.S. As some problems may arise with the variables taken into account and the data frequency, quarterly and annual comovements in industrial production, consumer prices and short- and long-term interest rates have been analyzed, and their stability studied.

Cross-correlations and correlation determinants are used to test for the existence of comovements between pairs of countries and between the three countries taken together. The results clearly indicate the existence of comovements, with the possible exception of short-term interest rates. In nearly all cases, these comovements are stronger for long-term interest rates and industrial production. However, moving correlations and determinants suggest that these relationships are not stable over time; they indicate very different degrees of cohesion in the different sub-periods. As the transmission of economic movements across countries may take some time, short-term dynamic relationships between these variables have also been examined. In general, dynamic relationships are much weaker than contemporaneous ones, and quarterly relationships are more intense than annual ones. This suggests that dynamic dependence fades away after a few quarters, and, therefore, is captured to a large extent by annual correlations. In addition to their weakness, the dynamic relationships also present clear instabilities over time.

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