THERE WAS MONETARY AUTONOMY IN EUROPE ON THE EVE OF EMU? THE GERMAN DOMINANCE HYPOTHESIS RE-EXAMINED

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ABSTRACT

In this paper we re-examine the German dominance hypothesis, as a way to assess whether the loss of monetary autonomy in Europe associated with EMU had been significant**.** We use Granger-causality tests between the interest rates of Germany and all the countries participating at any time in the European Monetary System, with the sample period running until December 1998. Our results would support a weak version of the hypothesis, with Germany playing a certain "leadership" or special role in the EMS, although she would not had been strictly the "dominant" player.

Key words: European monetary union, German dominance hypothesis, Granger-causality
JEL codes: F33, F36, E50

1. Introduction

Beginning on January 1st 1999, and following the adoption of a common currency (the euro) and the starting of the European Central Bank's operations, 11 European countries now form a monetary union (the Economic and Monetary Union, EMU). As it becomes obvious, EMU means the loss of monetary independence of the participating countries, which might be seen as a cost, at least at a first sight.

Things are not so simple, however. As it is well known, according to the so-called "inconsistent trinity" principle a fixed exchange rate, full capital mobility, and the independence of monetary policy, are not mutually compatible. And this situation roughly applied to the European economies before EMU, which shared a quasi-fixed exchange rate system (the European Monetary System, EMS), and especially following the elimination of capital controls after the Single European Act in 1990-92. This fact led to the countries participating in the EMS to realize that they were gradually losing the control of their monetary policies in favor of the Bundesbank, the central bank of Germany, i. e., the country presumed to act as a leader in the EMS. Hence, EMU could emerge as an economic response to that situation, on allowing those countries to regain some control over monetary policy thanks to the creation of an European Central Bank replacing the Bundesbank, in which they could have a vote (Wyplosz, 1997).

In fact, a general consensus had emerged in Europe which would justify the previous argument, i. e., that the EMS had worked in an asymmetric way, with Germany assuming the leading role and the remaining countries passively adjusting to German monetary policy actions. In its turn, these countries would have benefited from behaving in such a way, since they would have taken advantage of the firmly established anti-inflation credibility of the Bundesbank [see, e. g., Giavazzi and Pagano (1988) or Mélitz (1988)]. This discussion ultimately lies in the so-called *n*-1 problem faced by fixed exchange rate systems, since there are only *n*-1 exchange rates among the *n* countries participating in an exchange rate agreement. Therefore, in such a situation, either one country becomes the leader and sets monetary policy independently (with the other countries following it), or all countries are allowed to decide jointly over the implementation of monetary policy (De Grauwe, 1997).

The first empirical studies on the subject seemed to confirm the hypothesis of German dominance into the EMS [see, e. g., Giavazzi and Giovannini (1987,1989) or Karfakis and Moschos (1990)]. However, these conclusions were not confirmed in further research, most of it consisting of tests for Granger-causality between German and other countries' interest rates at a monthly or quarterly frequency [see, among others, Cohen and Wyplosz (1989), von Hagen and Fratianni (1990), Koedijk and Kool (1992), Katsimbris and Miller (1993), or Hassapis, Pittis and Prodromidis (1999)]. In this way, a milder support for the hypothesis was found in the above quoted papers; namely, that the other countries' interest rates depended on the German ones, but also conversely, even though in a lower extent in terms of both size and persistence. Finally, results along these lines were also reported in some studies using high frequency (i. e., daily) data on interest rates [see Gardner and Perraudin (1993), Henry and Weidmann (1995) and Bajo, Sosvilla and Fernández (1997)], so that it might seem that Germany would have played a special role in the EMS, although calling it "dominance" would be too strong.

In this paper we re-examine the German dominance hypothesis, as a way to assess whether the loss of monetary autonomy in Europe associated with EMU had been significant (which, in its turn, could be taken as an argument in favor of EMU itself). The empirical methodology makes use of Granger-causality tests between the monthly interest rates of Germany and all the countries participating at any time in the exchange rate mechanism (ERM) of the EMS, with the sample period running until December 1998. This paper contributes to the existing literature in the following respects:

a) The sample period covers until just the eve of EMU, i. e., December 1998. This allows us to include the most recent events in European monetary history, such as the German reunification, the monetary turmoil at the end of 1992, the broadening of the EMS fluctuation bands in August 1993, and the rather quiet period leading to the birth of EMU. Regarding previous studies on the subject, those with a more recent sample period are Hassapis, Pittis and Prodromidis (1999), who use quarterly data until the end of 1994, and Bajo, Sosvilla and Fernández (1997), who use daily data until February 1997.

b) The analysis is extended to all the countries participating at any time in the ERM of the EMS. So, unlike previous studies (with the only exception of Bajo, Sosvilla and Fernández (1997)), that consider only the founding members of the EMS (i. e., Germany, France, Italy, Belgium, the Netherlands, Denmark, and Ireland), our analysis also includes those countries which later joined the ERM of the EMS (i. e., Spain, the UK, Portugal, and Austria).

c) Granger-causality in a cointegration setting is properly tested. That is, an error-correction mechanism (ECM) is included into every equation to be estimated when cointegration is found, which allows us to distinguish between short-run and long-run Granger-causality[1]. Also, and following Katsimbris and Miller's (1993) suggestion, Granger-causality relationships between German and the other countries' interest rates have been investigated both in a bivariate and a trivariate setting, in order to avoid possible spurious results due to the omission of some relevant variable. As usual, the US interest rates is the additional variable added to the analysis.

d) Finally, and given the importance of the choice of lag lengths in Granger-causality tests, these have been selected by means of an appropriate method. In particular, we have used Hsiao's (1981) sequential approach, specifically designed to avoid imposing often false or spurious restrictions on the model. Notice that, unlike the VAR approach performed in other studies [as in, e. g., Hassapis, Pittis and Prodromidis (1999)], our procedure implies that, for any pair of variables tested for Granger-causality between them, the number of lags of the right-hand side variables is not constrained to be the same.

The rest of the paper is structured as follows. The econometric methodology of the paper is discussed in Section 2, and the empirical results are shown in Section 3. The main conclusions are presented in Section 4.

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[1] Katsimbris and Miller (1993) were the first to notice this point, usually overlooked in the available empirical studies on this subject.

2. Econometric methodology

As stated before, the econometric methodology used in this paper is based on Granger-causality tests (Granger, 1969). As it is well known, the results from these tests are highly sensitive to the order of lags in the autoregressive process. An inadequate choice of the lag length would lead to inconsistent model estimates, so that the inferences drawn from them would be likely to be misleading. In this paper, we will identify the order of lags for each variable by means of Hsiao's (1981) sequential approach, which is based on Granger's concept of causality and Akaike's final prediction error criterion.

Suppose two stationary variables, X_t and Y_t, on which we would like to test for Granger-causality. Consider the models:

$$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-i} + u_t \quad (1)$$

$$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{j=1}^{n} \gamma_j Y_{t-j} + v_t \quad (2)$$

and then the following steps are used to apply Hsiao's procedure:

(i) Take X_t to be a univariate autoregressive process as in (1), and compute its final prediction error criterion (FPE hereafter) with the order of lags i varying from 1 to M. Choose the lag that yields the smallest FPE, say m, and denote the corresponding FPE as $FPE_X(m,0)$.

(ii) Treat X_t as a controlled variable with m lags, add lags of Y_t to (1) as in (2), and compute the FPEs with the order of lags j varying from 1 to N. Choose the lag that yields the smallest FPE, say n, and denote the corresponding FPE as $FPE_X(m,n)$.

(iii) Compare $FPE_X(m,0)$ with $FPE_X(m,n)$. If $FPE_X(m,0)>FPE_X(m,n)$, then Y_t is said to Granger-cause X_t, whereas if $FPE_X(m,0)<FPE_X(m,n)$, then X_t would not be Granger-caused by Y_t.

Finally, by repeating steps (i) to (iii) with Y_t as the dependent variable, whether or not X_t Granger-causes Y_t can be established.

Recall that before it was assumed that X_t and Y_t were stationary variables. However, if they are integrated of order one (i. e., first-difference stationary) and are cointegrated, equations (1) and (2) need to be amended to:

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \delta z_{t-1} + u_t \tag{3}$$

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta Y_{t-j} + \delta z_{t-1} + v_t \tag{4}$$

where z_t is the ECM (Engle and Granger, 1987). Notice that if X_t and Y_t are I(1) but are not cointegrated, the coefficient δ in equations (3) and (4) is assumed to be equal to zero.

Now, the previous definitions of Granger-causality for stationary variables can be applied to the case of I(1) variables from equations (3) and (4). In particular, if $FPE_{\Delta X}(m,0)>FPE_{\Delta X}(m,n)$, Y_t is said to Granger-cause X_t in the short run; and if δ is significantly different from zero, Y_t is said to Granger-cause X_t in the long run. Conversely, if $FPE_{\Delta X}(m,0)<FPE_{\Delta X}(m,n)$, X_t would not be Granger-caused by Y_t in the short run; and if δ is not significantly different from zero, X_t would not be Granger-caused by Y_t in the long run. As before, by repeating the procedure with ΔY_t as the dependent variable, the hypothesis of short-run and long-run Granger-causality from X_t to Y_t could be tested.

To conclude, notice that the above procedure corresponds to the bivariate case. Testing for Granger-causality in the trivariate case requires amending the previous equations to:

$$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{k=1}^{p} \theta_k W_{t-k} + u_t \tag{1'}$$

$$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{j=1}^{n} \gamma_j Y_{t-j} + \sum_{k=1}^{p} \theta_k W_{t-k} + v_t \tag{2'}$$

where W_t denotes the third variable, for the case in which X_t, Y_t, and W_t are stationary; and, for the case in which the three variables are I(1) and cointegrated:

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \sum_{k=1}^{p} \theta_k \Delta W_{t-k} + \delta z_{t-1} + u_t \tag{3'}$$

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta Y_{t-j} + \sum_{k=1}^{p} \theta_k \Delta W_{t-k} + \delta z_{t-1} + v_t \tag{4'}$$

so that the relevant comparison is now between $\text{FPE}_X(m,0,p)$ and $\text{FPE}_X(m,n,p)$, and between $\text{FPE}_{\Delta X}(m,0,p)$ and $\text{FPE}_{\Delta X}(m,n,p)$, respectively; where $(m,0,p)$ and (m,n,p) are the combinations of lags leading to the smallest FPE in each case.

3. Empirical results

The data used in this paper are the three-month interbank onshore interest rates, at a monthly frequency, of Germany, France, Italy, Belgium, the Netherlands, Denmark, Ireland, Spain, the UK, Portugal, Austria, and the US. The previous list includes all the European countries participating at any time in the ERM of the EMS, and coincides with that of the countries joining EMU from the outset, which the exceptions of Denmark and the UK, and the inclusion of Luxembourg and Finland[2]. The beginning of the sample period is March 1979 (i. e., when the ERM started to operate) for the founding members of the EMS (France, Italy, Belgium, the Netherlands, Denmark, and Ireland), and the month of accession to the ERM for the newcomers: June 1989 for Spain, October 1990 for the UK, April 1992 for Portugal, and January 1995 for Austria, with the data for Germany and the US adjusting accordingly in each case. The end of the sample is in all cases December 1998 (i. e., the last month before the starting of EMU), and all the data come from the *Statistic Bulletin* of the Bank of Spain.

As a first step of the analysis, we tested for the order of integration of the variables by means of the Dickey-Fuller and Phillips-Perron tests. According to the results from both tests, shown in Table 1, the null hypothesis of a unit root was not rejected in all cases, at the same time that the null of a second unit root was always rejected.

Next, we tested for cointegration between the German interest rate and the interest rates of the other European countries in our sample, both in a bivariate and trivariate setting, in the latter case including the US interest rate as an additional variable. Two tests were performed: the (cointegrating regression) augmented Dickey-Fuller and Phillips-Ouliaris tests. Both tests were computed using the residuals from the (bivariate or trivariate) cointegrating regressions estimated by the method proposed by Phillips and Hansen (1990), robust to the presence of serial correlation and endogeneity bias.

The results of the cointegration tests appear in Table 2. As can be seen, the only interest rates appearing to be cointegrated with the German ones in the bivariate case would be those of

[2] Notice that Luxembourg, a founding member of the EMS, is not included in the sample since she already formed a monetary union with Belgium before EMU. Also, Finland, which participated in the ERM of the EMS since October 1996, is not included given the small number of observations available.

Austria and the Netherlands; whereas, in the trivariate case (i. e., when the US interest rates are included into the cointegration equation), cointegration is also found in the cases of Belgium, Denmark and Ireland. These results should not be too surprising since, as noticed by Caporale and Pittis (1995), the integration of the financial markets of the EMS countries would had been a gradual process, leading to a slow convergence process of interest rates towards the German levels. Hence, cointegration should be expected only when full convergence had been achieved[3].

Now, we are able to perform Granger-causality tests in a cointegration framework, and the results for the bivariate case are shown in Table 3. German interest rates appear to Granger-cause all the other EMS interest rates, the opposite being also true in all cases but those of Austria, Ireland, and the UK; bilateral causality is also found between German and US interest rates. Notice, however, that, when bilateral Granger-causality is found, the decrease in FPEs is greater when German interest rates are added to the equations explaining the other interest rates than in the opposite case (the exception being the US case). On the other hand, bilateral long-run causality would appear in the case of the Netherlands, whereas German interest rates would cause those of Austria in the long run, but not the other way round. These results would suggest that, although there would have been some degree of symmetry in the EMS, the influence of Germany on the other EMS countries would have been greater than the other way round.

Next, we turn to the trivariate case in Table 4. Beginning with causality between German interest rates and those of the other EMS countries, the results, shown in part A) of Table 4 are quite similar to those in Table 3. The only exception would be the bilateral Granger-causality now found for Austria; also, Danish interest rates do not appear to Granger-cause the German ones, even though the difference between FPEs in this case would be very small. Again, the German interest rates add more explanatory power to the equations explaining the other interest rates than in the opposite case. Regarding long-run Granger-causality, it would arise in a bilateral way for Belgium, Denmark, and the Netherlands; also, German interest rates would Granger-cause those of Austria, and, more surprisingly, Irish interest rates would Granger-cause those of Germany, although only at a 10 per cent significance level.

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[3] Some evidence along these lines for the Spanish case can be found in Camarero, Esteve and Tamarit (1997).

We have also tested for Granger-causality between the US interest rates and those of the EMS countries other than Germany, as well as between German and US interest rates, with the results appearing in parts B) and C) of Table 4, respectively. As can be seen, the US interest rates would Granger-cause those of Spain, France, Italy, and Portugal, in the short run; Denmark, the Netherlands, and Ireland, in the long run; and Austria and Belgium, both in the short run and the long run. In its turn, the interest rates of Belgium, Denmark, France, the Netherlands, Ireland, Italy, Portugal, and the UK would Granger-cause the US interest rates in the short run. On the other hand, bilateral short-run Granger-causality is found between German and US interest rates in most cases (the exceptions being when the interest rates of Spain, Portugal, and the UK are included in the regressions), but no clear long-run Granger-causality is detected (other than that found from the US to Germany when the interest rates of Denmark are used).

Finally, we have also tested for structural change in all the estimated equations shown in tables 3 and 4, by means of the Chow test. The dates chosen are: November 1990 (the German reunification), September 1992 (the beginning of the turbulent period affecting the EMS), and August 1993 (the broadening of the fluctuation bands in the EMS), and the tests are only performed for the interest rates of the EMS founding members, given the reduced number of observations available for the newcomers. As can be seen in Table 5, the null hypothesis of no structural change is not rejected almost generally. The more relevant exception would be the French case, where a structural change in Granger-causality from Germany would be detected following the German reunification and the monetary turmoil at the end of 1992, both in the bivariate and trivariate models.

To summarize, bilateral Granger-causality has been found between the interest rates of Germany and the other countries participating at any time in the ERM of the EMS, the main exceptions being Ireland and the UK[4]. However, when bilateral Granger-causality is found, the increase in explanatory power is greater when German interest rates are added to the equations explaining the other interest rates than the other way round. Therefore, our results would point to a certain “leadership” or special role of Germany within the EMS, although we could not talk of

[4] In fact, Artis and Zhang (1997) found that Ireland and the UK would have followed in recent years a different cyclical evolution as compared to the other European countries.

“dominance” in a strict sense. In particular, and according to the terminology introduced by Hassapis, Pittis and Prodromidis (1999), we could establish the following typology:

a) Strong German dominance: the UK.
b) Weak German dominance of type 1: Spain and Portugal.
c) Weak German dominance of type 2: Austria, Belgium, France, and Italy.
d) Semi strong German dominance: Denmark, Ireland, and the Netherlands.

4. Conclusions

In this paper we have re-examined the German dominance hypothesis, extending previous findings by other authors to all the countries participating at any time in the ERM of the EMS, with the sample period covering until just the eve of EMU, i. e., December 1998. The empirical methodology makes use of Granger-causality tests between the interest rates of Germany and the other EMS countries, in a proper cointegration framework where the lag lengths of the variables have been chosen by means of Hsiao's sequential approach in order to avoid misleading inferences arising from inconsistent model estimates. The tests have been performed in both a bivariate and a trivariate setting, in this case including the US interest rate as the additional variable.

Summarizing, our results point to a mutual but asymmetrical relationship between Germany and the other countries participating at any time in the ERM of the EMS, since bilateral Granger-causality was found between the interest rates of Germany and those of the other countries (with the exceptions of Ireland and the UK), although the German interest rates added more to the explanation of the other interest rates than in the opposite case. Also, we did not find evidence of significant structural changes in the estimated relationships following the German reunification, the monetary turmoil at the end of 1992, and the broadening of the fluctuation bands in the EMS.

Therefore, our results would support a weak version of the hypothesis of German dominance during the working of the EMS, since there would have prevailed a mutual relationship among the monetary policies of all the countries involved (with the exceptions of Ireland and the UK), even though that relationship would have been stronger from Germany to the other countries than in the opposite way. Then, Germany would have played a certain "leadership" or special role in the EMS, although she would not had been strictly the "dominant" player.

Regarding the policy implications of the paper, these would provide some mild support to the hypothesis about EMU as an economic response to the loss of monetary autonomy in Europe in favor of Germany, especially after the achievement of full capital mobility in the first nineties (Wyplosz, 1997). Also, the position of the Mediterranean countries (Italy, Spain, and

Portugal) faced to EMU does not seem to be quite different to that of the “core” European countries, at least in terms of the autonomy of their monetary policies. The same can be said for Denmark and the UK, two countries currently not in EMU; in fact, according to our results, the UK would have been (together with Ireland) the country the most “dominated” by German monetary policy actions.

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TABLE 1
UNIT ROOT TESTS

A) DICKEY-FULLER TEST

Country	Levels			First differences		
	τ_τ	τ_μ	τ	τ_τ	τ_μ	τ
Germany	-2.41	-1.96	-1.07	-4.75[a]	-4.77[a]	-4.77[a]
Austria	-2.03	-2.61[c]	-1.78[c]	-5.29[a]	-4.98[a]	-4.75[a]
Belgium	-2.31	-0.93	-0.80	-9.68[a]	-9.61[a]	-9.61[a]
Denmark	-2.94	-1.37	-1.34	-8.79[a]	-8.80[a]	-8.77[a]
Spain	-3.16[c]	-0.56	-1.56	-4.26[a]	-4.24[a]	-3.88[a]
France	-2.19	-1.29	-0.77	-11.41[a]	-7.38[a]	-7.38[a]
Netherlands	-2.44	-1.77	-1.17	-5.65[a]	-5.67[a]	-5.64[a]
Ireland	-2.38	-1.66	-1.21	-8.06[a]	-8.07[a]	-8.01[a]
Italy	-2.88	-0.43	-0.82	-12.27[a]	-12.11[a]	-12.10[a]
Portugal	-2.05	-1.22	-2.51[b]	-7.71[a]	-7.74[a]	-7.41[a]
UK	-2.74	-3.13[b]	-2.14[b]	-4.26[a]	-3.76[a]	-3.46[a]
US	-1.78	-1.78	-1.11	-11.54[a]	-11.57[a]	-11.58[a]

Notes:
(i) τ_τ, τ_μ, and τ are the Dickey-Fuller statistics with drift and trend, with drift, and without drift, respectively.
(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively. The critical values are taken from MacKinnon (1991).

B) PHILLIPS-PERRON TEST

Country	Levels			First differences		
	$Z(t_{\tilde{\alpha}})$	$Z(t_{\alpha^*})$	$Z(t_{\hat{\alpha}})$	$Z(t_{\tilde{\alpha}})$	$Z(t_{\alpha^*})$	$Z(t_{\hat{\alpha}})$
Germany	-2.07	-1.26	-0.59	-11.29[a]	-11.23[a]	-11.23[a]
Austria	-2.00	-2.74	-1.86	-5.02[a]	-4.80[a]	-4.57[a]
Belgium	-3.52[c]	-1.09	-0.81	-12.78[a]	-12.72[a]	-12.71[a]
Denmark	-2.68	-1.05	-1.19	-10.52[a]	-10.51[a]	-10.48[a]
Spain	-2.47	-0.05	-2.15[b]	-8.87[a]	-8.86[a]	-8.32[a]
France	-3.59[b]	-1.03	-0.73	-11.39[a]	-11.29[a]	-11.28[a]
Netherlands	-2.09	-1.29	-0.95	-12.88[a]	-12.86[a]	-12.85[a]
Ireland	-3.13	-1.61	-1.21	-12.40[a]	-12.39[a]	-12.36[a]
Italy	-3.19	-0.39	-0.82	-12.39[a]	-12.22[a]	-12.19[a]
Portugal	-3.12	-1.07	-2.61[a]	-7.71[a]	-7.69[a]	-7.28[a]
UK	-2.18	-3.24[b]	-2.75[a]	-5.47[a]	-5.27[a]	-5.05[a]
US	-3.23	-1.85	-1.12	-10.86[a]	-10.86[a]	-10.85[a]

Notes:
(i) $Z(t_{\tilde{\alpha}})$, $Z(t_{\alpha^*})$, and $Z(t_{\hat{\alpha}})$ are the Phillips-Perron statistics with drift and trend, with drift, and without drift, respectively.
(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively. The critical values are taken from MacKinnon (1991).

TABLE 2
COINTEGRATION TESTS

A) DICKEY-FULLER TEST

Country	Bivariate	Trivariate
Austria	-3.71[a]	-3.64[a]
Belgium	-1.90	-3.00[b]
Denmark	-2.41	-3.99[a]
Spain	-1.71	-1.77
France	-1.74	-2.16
Netherlands	-3.45[b]	-3.76[a]
Ireland	-2.35	-3.74[a]
Italy	-1.02	-2.35
Portugal	-1.40	-1.76
UK	-1.95	-1.85

Notes:

(i) The test refers to the cointegrating-regression augmented Dickey-Fuller statistics on the Phillips-Hansen residuals.

(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively. The critical values are taken from MacKinnon (1991).

B) PHILLIPS-OULIARIS TEST

Country	Bivariate	Trivariate
Austria	-3.78[b]	-3.73[b]
Belgium	-2.03	-3.59[c]
Denmark	-2.52	-3.73[b]
Spain	-1.85	-1.55
France	-1.86	-2.81
Netherlands	-4.01[a]	-4.01[b]
Ireland	-2.70	-3.63[c]
Italy	-1.25	-2.54
Portugal	-1.65	-1.92
UK	-2.46	-2.14

Notes:

(i) The test refers to the cointegrating-regression $Z(t_{\hat{\alpha}})$ statistic on the Phillips-Hansen residuals.

(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively. The critical values are taken from Phillips and Ouliaris (1990).

TABLE 3
GRANGER-CAUSALITY TESTS: BIVARIATE MODELS

Country	FPE (*m*,0)	FPE (*m*,*n*)	ECM	Causality $X \rightarrow G$	FPE (*m*,0)	FPE (*m*,*n*)	ECM	Causality $G \rightarrow X$
Austria	0.0149 *m*=1	0.0155 *n*=1	-0.1537 (-0.7379)	NO	0.0152 *m*=1	0.0144 *n*=5	-0.6003[a] (-2.6320)	YES
Belgium	0.0989 *m*=12	0.0958 *n*=12	---	YES	0.3492 *m*=5	0.3122 *n*=5	---	YES
Denmark	0.0989 *m*=12	0.0976 *n*=8	---	YES	0.3578 *m*=4	0.3384 *n*=5	---	YES
Spain	0.0307 *m*=4	0.0298 *n*=2	---	YES	0.1341 *m*=4	0.1176 *n*=7	---	YES
France	0.0989 *m*=12	0.0938 *n*=10	---	YES	0.2609 *m*=6	0.2037 *n*=6	---	YES
Netherlands	0.0985 *m*=12	0.0974 *n*=10	-0.0771[b] (-2.3080)	YES	0.0969 *m*=12	0.0899 *n*=5	-0.0686[b] (-1.9849)	YES
Ireland	0.0989 *m*=12	0.0996 *n*=1	---	NO	0.6269 *m*=6	0.6152 *n*=1	---	YES
Italy	0.0989 *m*=12	0.0986 *n*=10	---	YES	0.3091 *m*=11	0.2996 *n*=4	---	YES
Portugal	0.0300 *m*=1	0.0292 *n*=2	---	YES	0.4266 *m*=5	0.4028 *n*=4	---	YES
UK	0.0294 *m*=4	0.0299 *n*=1	---	NO	0.0632 *m*=4	0.0540 *n*=5	---	YES
US	0.0989 *m*=12	0.0885 *n*=10	--	YES	0.4866 *m*=12	0.4810 *n*=5	---	YES

Notes:

(i) *m* and *n* denote the lags for the dependent variable and the additional regressor, respectively, leading to the smallest FPE in each case; the maximum number of lags tried has been 12. *X* and *G* denote every country in the first column of the table, and Germany, respectively.

(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively, for the *t*-statistics of the ECMs (in parentheses).

TABLE 4
GRANGER-CAUSALITY TESTS: TRIVARIATE MODELS

A) Causality between German and EMS interest rates

Country	FPE (m,p)	FPE (m,n,p)	ECM	Causality $X \rightarrow G$	FPE (m,p)	FPE (m,n,p)	ECM	Causality $G \rightarrow X$
Austria	0.0142 m=1 p=9	0.0140 n=5	0.2869 (0.8850)	YES	0.0126 m=1 p=1	0.0120 n=5	-1.0391[a] (-3.9299)	YES
Belgium	0.0886 m=12 p=12	0.0860 n=12	-0.0306[b] (-2.0038)	YES	0.3028 m=10 p=11	0.2728 n=4	-0.0716[a] (-2.6084)	YES
Denmark	0.0878 m=12 p=12	0.0879 n=8	-0.0355[b] (2.5414)	NO	0.3261 m=4 p=1	0.2326 n=5	-0.0584[a] (-3.3077)	YES
Spain	0.0311 m=4 p=1	0.0300 n=2	---	YES	0.1334 m=4 p=1	0.1158 n=7	---	YES
France	0.0885 m=12 p=10	0.0811 n=10	---	YES	0.2472 m=6 p=12	0.2107 n=6	---	YES
Netherlands	0.0889 m=12 p=10	0.0872 n=8	-0.0602[c] (-1.8794)	YES	0.0917 m=12 p=7	0.0898 n=5	-0.0741[b] (-2.0086)	YES
Ireland	0.0879 m=12 p=12	0.0885 n=1	-0.0200[c] (-1.8355)	NO	0.5905 m=6 p=1	0.5904 n=1	-0.0774[a] (-3.6342)	YES
Italy	0.0885 m=12 p=10	0.0883 n=9	---	YES	0.3114 m=12 p=1	0.2985 n=4	---	YES
Portugal	0.0308 m=1 p=1	0.0300 n=2	---	YES	0.3938 m=5 p=7	0.3448 n=12	---	YES
UK	0.0298 m=4 p=1	0.0303 n=1	---	NO	0.0615 m=4 p=1	0.0593 n=2	---	YES

Notes:

(i) m, n and p denote the lags for the dependent variable, the additional regressor, and the US interest rate, respectively, leading to the smallest FPE in each case; the maximum number of lags tried has been 12. X and G denote every country in the first column of the table, and Germany, respectively.

(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively, for the t-statistics of the ECMs (in parentheses).

TABLE 4 (continued)

B) Causality between US and EMS interest rates

Country	FPE (*m*,*p*)	FPE (*m*,*n*,*p*)	ECM	Causality $X \rightarrow US$	FPE (*m*,*p*)	FPE (*m*,*n*,*p*)	ECM	Causality $US \rightarrow X$
Austria	0.0088 m=2 p=1	0.0089 n=1	0.2359 (1.3164)	NO	0.0117 m=1 p=5	0.0110 n=7	-1.3027[a] (-4.4229)	YES
Belgium	0.4853 m=12 p=5	0.4080 n=10	-0.0024 (-0.1018)	YES	0.2924 m=10 p=5	0.2722 n=11	-0.0707[b] (-2.5594)	YES
Denmark	0.4830 m=12 p=5	0.4699 n=3	-0.0404 (-1.5850)	YES	0.3244 m=4 p=5	0.3269 n=1	-0.0584[a] (-3.3077)	NO
Spain	0.0293 m=1 p=1	0.0297 n=1	---	NO	0.1176 m=4 p=7	0.1126 n=3	---	YES
France	0.4810 m=12 p=5	0.4725 n=4	---	YES	0.2037 m=6 p=6	0.2028 n=1	---	YES
Netherlands	0.4834 m=12 p=5	0.3337 n=10	-0.0135 (-1.0108)	YES	0.0203 m=12 p=5	0.0892 n=6	-0.0759[b] (-2.0678)	NO
Ireland	0.4851 m=12 p=5	0.4531 n=11	-0.0038 (-0.1763)	YES	0.5872 m=6 p=1	0.5898 n=5	-0.0865[a] (-3.8541)	NO
Italy	0.4810 m=12 p=5	0.4707 n=1	---	YES	0.2996 m=11 p=4	0.2985 n=1	---	YES
Portugal	0.0250 m=10 p=7	0.0240 n=6	---	YES	0.4028 m=5 p=4	0.3611 n=7	---	YES
UK	0.0311 m=1 p=1	0.0282 n=2	---	YES	0.0540 m=4 p=5	0.0596 n=9	---	NO

Notes:

(i) *m*, *n* and *p* denote the lags for the dependent variable, the additional regressor, and the German interest rate, respectively, leading to the smallest FPE in each case; the maximum number of lags tried has been 12. *X* and *US* denote every country in the first column of the table, and the US, respectively.

(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively, for the *t*-statistics of the ECMs (in parentheses).

TABLE 4 (continued)

C) Causality between US and German interest rates

Country	FPE (m,p)	FPE (m,n,p)	ECM	Causality $G \rightarrow US$	FPE (m,p)	FPE (m,n,p)	ECM	Causality $US \rightarrow G$
Austria	0.0099 m=2 p=1	0.0089 n=1	0.2359 (1.3164)	YES	0.0157 m=1 p=1	0.0149 n=9	0.1377 (0.5983)	YES
Belgium	0.4749 m=12 p=12	0.3960 n=12	-0.0210 (-0.8942)	YES	0.0960 m=12 p=12	0.0859 n=10	-0.0296[c] (-1.9368)	YES
Denmark	0.4828 m=12 p=3	0.4699 n=5	-0.0404 (-1.5850)	YES	0.0966 m=12 p=8	0.0877 n=10	-0.0343[b] (-2.4637)	YES
Spain	0.0312 m=1 p=1	0.0297 n=1	---	YES	0.0298 m=4 p=2	0.0300 n=1	---	NO
France	0.4865 m=12 p=1	0.4837 n=5	---	YES	0.0938 m=12 p=10	0.0787 n=12	---	YES
Netherlands	0.4149 m=12 p=6	0.3237 n=10	-0.0136 (-1.0398)	YES	0.0979 m=12 p=10	0.0852 n=12	-0.0618[c] (-1.9218)	YES
Ireland	0.4627 m=12 p=11	0.4488 n=12	-0.0108 (-0.4962)	YES	0.0990 m=12 p=1	0.0885 n=12	-0.0200[c] (-1.8355)	YES
Italy	0.4740 m=12 p=1	0.4705 n=4	---	YES	0.0986 m=12 p=10	0.0888 n=10	---	YES
Portugal	0.0241 m=10 p=2	0.0242 n=1	---	NO	0.0292 m=1 p=2	0.0300 n=1	---	NO
UK	0.0287 m=1 p=2	0.0274 n=3	---	YES	0.0299 m=4 p=1	0.0303 n=1	---	NO

Notes:

(i) *m*, *n* and *p* denote the lags for the dependent variable, the additional regressor (Germany or the US), and every country in the first column of the table, respectively, leading to the smallest FPE in each case; the maximum number of lags tried has been 12. *G* and *US* denote Germany and the US, respectively.

(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively, for the *t*-statistics of the ECMs (in parentheses).

TABLE 5
TESTS OF STRUCTURAL CHANGE

A) Causality between German, EMS, and US interest rates (bivariate models)

Country	*X→G*			*G→X*		
	1990:11	1992:09	1993:08	1990:11	1992:09	1993:08
Belgium	0.5252	0.4756	0.3123	1.1132	1.0152	0.8799
Denmark	1.3472	1.3029	0.5235	1.3876	1.7864[c]	0.2547
France	0.5022	0.4016	0.3828	1.5967[c]	1.8587[c]	1.4990
Netherlands	0.4646	0.5268	0.2645	0.8114	0.7042	0.2745
Ireland	0.3362	0.2346	0.1506	1.5070	1.5177	0.2638
Italy	0.3457	0.3019	0.2628	0.9628	0.4445	1.2499
US	0.3505	0.3290	0.2949	0.9173	0.4890	0.4483

B) Causality between German and EMS interest rates (trivariate models)

Country	*X→G*			*G→X*		
	1990:11	1992:09	1993:08	1990:11	1992:09	1993:08
Belgium	0.5029	0.5729	0.3505	1.2957	1.2268	1.0542
Denmark	0.8851	0.8811	0.4032	1.1086	1.3526	0.4097
France	0.7199	0.6993	0.6706	1.4200[c]	1.9734[a]	1.1229
Netherlands	0.5464	0.5647	0.3102	0.5611	0.5602	0.2417
Ireland	0.3142	0.5294	0.2884	1.6267	1.8469[c]	0.4687
Italy	0.3982	0.2810	0.4058	1.0061	1.1471	0.4841

C) Causality between US and EMS interest rates (trivariate models)

Country	*X→US*			*US→X*		
	1990:11	1992:09	1993:08	1990:11	1992:09	1993:08
Belgium	0.8602	0.5491	0.4969	1.2361	1.1744	1.0092
Denmark	0.9676	0.5811	0.4331	1.1086	1.3526	0.4097
France	1.1509	0.7850	0.4990	1.5068	1.3741	0.7552
Netherlands	0.9628	0.4741	0.4667	0.5337	0.5841	0.2509
Ireland	0.6805	0.4278	0.2664	1.4710	1.7668[b]	0.3264
Italy	1.2955	0.5716	0.4139	1.0061	1.1471	0.4841

D) Causality between US and German interest rates (trivariate models)

Country	*G→US*			*US→G*		
	1990:11	1992:09	1993:08	1990:11	1992:09	1993:08
Belgium	0.9875	0.5805	0.5685	0.5524	0.6168	0.3963
Denmark	0.9676	0.5811	0.4331	0.9626	0.9138	0.4228
France	0.8817	0.4799	0.4143	0.6514	0.6230	0.6146
Netherlands	0.7843	0.5370	0.5363	0.6044	0.6204	0.2831
Ireland	0.9433	0.5308	0.4029	0.3142	0.5294	0.2884
Italy	1.0824	0.4630	0.3363	0.4374	0.4408	0.2775

Notes:
(i) *X*, *G*, and *US* denote every country in the first column of the tables, Germany and the US, respectively.
(ii) (a), (b), and (c) denote significance at the 1%, 5%, and 10% levels, respectively.