Title	Testing for monetary policy convergence in european countries
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Publication Date	1997-12
Publication Information	Fountas, S. (1997). "Testing for monetary policy convergence in european countries" (Working Paper No. 019) Department of Economics, National University of Ireland, Galway.
Publisher	National University of Ireland, Galway
Item record	http://hdl.handle.net/10379/1428

Testing for Monetary Policy Convergence in European Countries

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Working Paper No. 19 **December 1997**
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[3]This paper is based on the MA Thesis of the first author submitted to the National University of Ireland, Galway. We thank participants in the Galway Economics Workshop for very helpful comments and suggestions. All remaining errors and omissions are our own responsibility.

Abstract

The paper tests for long-run monetary policy convergence and short-run policy interactions in seven ERM countries over the 1979–1992 period using the approach of multivariate cointegration and Granger-causality tests. We provide evidence for very little monetary policy convergence, even during the more stable 1987–1992 period. Our tests for short-run monetary policy interactions show that, in agreement with some other studies, Germany is not the leader country in the system as it appears to accommodate shocks in other member countries. Our tests show also that full monetary policy convergence applied among Germany, Belgium and Netherlands in the 1987–1992 period implying that these countries could be the first to join a European monetary union should a two-speed approach to monetary union become a reality.

Keywords: Policy Convergence, German Dominance Hypothesis, Common Stochastic Trends.

JEL Classification: F33, F42

1 Introduction

The European Monetary System (EMS) was established to allow member countries to reduce their inflation rates and nominal exchange rate volatility. Empirical evidence has shown this to be the case (see, for example, Artis, 1987, Rogoff, 1985). Convergence to a lower inflation rate would be consistent with long-run monetary policy convergence. However, opinion is divided on the issue whether the EMS has accomplished its primary objectives by functioning as a symmetric or asymmetric system. In other words, the necessary monetary policy convergence could have been achieved through symmetric policy adjustments or in an asymmetric fashion. Under an asymmetric system, Germany is the leader or dominant country in the EMS and other countries follow monetary policies similar to Germany's by pegging their currencies to the DM. By tying their hands, these countries manage to earn counterinflation reputation (Giavazzi and Pagano, 1988).

It would be expected that the degree of monetary policy convergence would change during the period since the set up of the EMS. Several authors have divided the pre-1992 period into at least two subperiods: the volatile March 1979 to January 1987 period and the stable February 1987 to August 1992 period. During the first subperiod, several exchange rate realignments took place and one would expect to observe lack of monetary policy convergence. However, the second period was one of considerable exchange rate stability and, therefore, one where some degree of monetary policy convergence should apply.

The issue of monetary policy convergence is very important for the creation of monetary union. Significant progress in terms of monetary policy convergence would be necessary for the establishment of monetary union. Hence, one of the objectives of this paper is to test for the change in the degree of monetary policy convergence during the pre-August 1992 period in seven EU countries. In this regard, we make use of the multivariate cointegration approach and test for the number of common stochastic trends. A single common stochastic trend would be consistent with full long-run monetary policy convergence while multiple common trends would imply less than full convergence. Lack of full long-run convergence would allow some member countries to pursue monetary policies independent of those of Germany and hence allow for more than one degree of freedom in monetary policy making in the EMS. This would allow these countries to achieve certain objectives such as domestic output growth or a competitive real exchange rate.

A finding of full convergence would imply that in the long run there is a common monetary policy applied by the member countries. However, short-run deviations from this long-run common policy would be possible and one could test for policy asymmetry, i.e., whether German monetary policy changes are independent of monetary policy changes in the system or they accommodate shocks to the other member countries. Evidence in favour of symmetric policy effects would reject the German Dominance Hypothesis (GDH).

Our objective is to test for both short-run interactions and long-run relationships in the monetary policies of seven EMS countries. We also look at smaller groups of countries that could be considered to be in the core of a European monetary union. The paper is structured as follows: section 2 presents a short literature survey and highlights differences between our approach and other studies in the area. Section 3 outlines our empirical methodology, section 4 presents and interprets our results for a group of seven countries, and section 5 looks at the issue of convergence in the core countries. Finally, section 6 summarises our results and derives some policy implications.

2 A review of the literature

The issue of monetary policy interdependence in the EMS has been the subject of extensive research since the late 1980s. The majority of this research deals with tests for short run and long-run relationships among proxies of national monetary policies using modern econometric techniques of nonstationary time series. The long- run relationship among national monetary policies is examined with the application of cointegration techniques whereas the short-run monetary policy interactions are examined using causality tests. Studies along this line of research can be classified into two groups:

(a) Bilateral approaches look at pairs of countries that include Germany. Examples include Giavazzi and Giovannini (1989), de Grauwe (1989), Karfakis and Moschos (1990) and Katsimbris and Miller (1993).

(b) Multilateral approaches look at groups of three countries or more. For example, Henry and Weidmann (1994) consider Germany, France and the U.S., MacDonald and Taylor (1991) look at Germany, France and Italy and Hafer and Kutan (1994) include in their analysis a group of five ERM countries. Katsimbris and Miller (1993) look at three-country groups that include the U.S. when performing causality tests.

Most of the above studies proxy monetary policy by some short-term interest rate. Notable exceptions are MacDonald and Taylor (1991) who use money supply and Hafer and Kutan (1994) that consider monetary base in addition to interest rates. The evidence in favour of monetary policy convergence and German dominance is mixed. MacDonald and Taylor (1991), Hafer and Kutan (1994) and Henry and Weidmann (1994) find some evidence supporting convergence. The GDH is supported by evidence provided by Karfakis and Moschos (1990), MacDonald and Taylor (1991), Henry and Weidmann (1994) and Hafer and Kutan (1994) when monetary policy is proxied by monetary base. Henry and Weidmann (1994) find also that following the German unification, the asymmetric nature of the ERM appears stronger. Evidence against the GDH is supplied by de Grauwe (1989), Fratianni and von Hagen (1990a, 1990b) and Katsimbris and Miller (1993).

For our purposes the most relevant of the above mentioned studies are MacDonald and Taylor (1991) and Hafer and Kutan (1994). MacDonald and Taylor (1991) use monthly money supply data for the period March 1979 to December 1988 and test for convergence in an EMS group of countries and a non-EMS group. The EMS group includes Germany, France and Italy. The authors find only partial convergence of monetary policies but significant evidence for the GDH.

Hafer and Kutan (1994) measure monetary policy using the proxies of overnight interest rates and monetary base. Their sample includes monthly data for the period March 1979 to December 1990 for Germany, France, Belgium, Netherlands and Italy. The authors find evidence of less than full convergence among the monetary policies of the five ERM countries for both monetary policy proxies. They interpret this evidence to imply that the GDH does not hold in the long run and "that monetary policies have not been set totally independent from others' actions" (Hafer and Kutan, 1994, p. 690). These authors test also for short-run monetary policy interactions. Their Granger-causality test results performed in a VAR in levels imply that the ERM has functioned as a symmetric system when monetary policy actions are captured by interest rates. However, significant evidence in favour of asymmetry is provided when the tests are conducted using monetary base which is perhaps a more accurate measurement of monetary policy actions.

The present paper improves upon Hafer and Kutan (1994) in several ways. First, we extend the sample period to August 1992, second, we increase the number of countries in our sample (by adding Denmark and Ireland) and, third and more important, we split the sample into two periods. The latter allows us to test for increasing convergence following the transition from an unstable ERM period highlighted by several realignments to a more stable period that lasted until August 1992. An important innovation of the paper is also the consideration of small groups of countries in order to identify which countries have experienced *full* monetary policy convergence and hence could be part of the core in a likely two-speed monetary union.

3 Econometric Methodology

It is well known that although economic time series may wander through time, i.e., be non stationary in their level, there may exist some linear combinations of these variables that will converge to a long-run relationship over time (Engle and Granger, 1987). Therefore, if a linear combination of time series that are stationary only after differencing is stationary, these series are considered to be cointegrated. The concept of cointegration is used because if there has been convergence of monetary policy, then interest rates or monetary base of EMS-member countries should move together over time. Therefore, assuming that the monetary authorities try to control the movement in short-term interest rates and that EMS countries are price takers relative to Germany, the uncovered interest parity (UIP) is[1],

$$i_t^* = i_t + \mathrm{E}[\Delta \log S_t]$$

where i_t^* is the domestic (non-German) interest rate, i_t is the German rate, E is the expectations operator, Δ is the difference operator and S is the spot exchange rate between the particular country and Germany. If the expected exchange rate between the particular country and Germany is fixed, then the expected change in the exchange rate is zero and the domestic interest rate equals that of Germany. However, if the expected change in the exchange rate is stationary under the adjustable peg system of ERM, then the above result will also hold. Therefore, the two interest rates do not have to be identical, but if they move together over time they are cointegrated.

The Engle and Granger (1987) tests for cointegration use bivariate relationships, i.e., test for the existence of a single cointegrating vector between two variables. However, problems arise with Engle and Granger (1987), when we consider more than two variables, as it is no longer possible to demonstrate the uniqueness of the cointegrating vector. Johansen (1988) and Johansen and Juselius (1990) provide a method to investigate cointegration in a multivariate setting.

Tests for cointegration require nonstationary time series of the same order of integration. Therefore, we first test for the presence of a unit root in

[1]This part draws on Hafer and Kutan (1994, p. 686).

both the levels and the first difference of the interest rates and monetary base using the Dickey-Fuller (DF) and the Augmented Dickey-Fuller (ADF) tests (Fuller, 1976 and Dickey and Fuller, 1979).

The method used to test for cointegration is the Johansen procedure introduced in Johansen (1988) and extended in Johansen and Juselius (1990). If there are $\rho - 1$ cointegrating vectors among ρ policy measures, then there is only one common policy shared by all countries and so there is complete long-run convergence of policies. If, however, the number of cointegrating vectors is less than $\rho - 1$, but greater than one, then this implies that there is some partial convergence of policies. Finally, if the number of cointegrating vectors is zero, then this means that there are several (ρ) common trends and so no long-run convergence of policies[2]. As can be seen from the above procedure, cointegration does not automatically imply convergence.

Granger-causality tests (Granger, 1986; Engle and Granger, 1987) can be used to detect if short-run changes in German policy alone are transmitted to the other EMS countries, which is evident from unidirectional causation from Germany to the other EMS countries, or whether there is general feedback among policy actions. If the GDH is correct, then Granger-causality should run from Germany to the other EMS countries but not vice versa. The definition of Granger-causality is that if X causes Y, then using past values of X will give improved predictions for Y (Harvey, 1981).

4 Data and Empirical Results

4.1 Data

We use monthly data for the period March 1979 to August 1992. Our proxies for monetary policy are short-term (overnight) interest rates and monetary base[3]. Since countries in the EMS express their short-run actions through the resulting changes in the domestic money market interest rates, this measurement is appropriate when looking at changes in monetary policy in the short term. If, however, measures were to be used beyond this point,

[2]A lack of cointegration should not necessarily imply that convergence did not take place at the end of the period. In other words, if monetary policies become closely linked at the end of the sample period, rather than during the period, our cointegration tests will not capture such a change and hence policy convergence will be rejected.

[3]Three-month interest rates were used for Denmark. It was planned that money supply (M1) would also be included in the tests. However, due to autocorrelation even after allowing for twelve lagged differences, and since unit root tests assume white noise errors it became necessary to exclude M1.

then the change in interest rates would incorporate the endogenous response resulting from changes in economic activity and inflation rates. Interest rates are taken from Eurostats, except for the Danish interest rates which is taken from the Central Bank of Denmark. We choose monetary base as a proxy for monetary policy because it reflects the actions being taken by the Central Bank to affect reserves in the banking system and so some monetary aggregates. The data for monetary base is taken from line 14 of the International Financial Statistics (IFS) data tape of the IMF. As mentioned in the introduction, in order to capture the varying degree of monetary policy coordination in the ERM, we split our sample into two subsamples, the first one including data from March 1979 to January 1987 and the second covering the February 1987 to August 1992 period.

4.2 Results

We use the natural logs for all series. As has been discussed, the first step is to establish the order of integration. This is done using the Dickey Fuller (DF) tests and the Augmented Dickey Fuller (ADF) tests with up to twelve lagged differences. A deterministic trend was included in the test regression whenever it was statistically significant[4]. The unit root tests for monetary base are reported in Table 1[5]. We include results of the ADF(2) tests since two is the lowest lag where serial correlation in the error term can be ruled out[6]. It is clear that all series are nonstationary. Having first differenced the variables, all were universally stationary.

The results for the unit root tests for interest rates for period one and two are shown in Tables 2(a) and 2(b), respectively. A deterministic trend was included in the test regression whenever it was statistically significant. It is evident that all variables are I(1). LM(12) autocorrelation tests (not reported) imply white errors.

Having established that all variables are I(1), we are now free to test for multivariate cointegration. We have applied three alternative lag length-selection criteria in order to choose the appropriate lag length in the VAR. These include Sims's modified Likelihood ratio (LR) test, the Akaike Information Criterion (AIC), and the Schwartz Bayesian Criterion (SBC). The

[4]The majority of the monetary base variables are seen to have a trend while the majority of the interest rate variables do not have a trend.

[5]The tests using monetary base cover the full sample period due to persisting autocorrelation in each of the two sub samples when running the unit root tests.

[6]The only exception is Belgium and Netherlands where we had to add more than twelve lags in the ADF regression to eliminate serial correlation in the error term. The t-statistics (not reported) imply a unit root.

application of all three criteria for interest rates (period one and two) and monetary base (full period) led to a choice of 2 lags, i.e., $k = 2$.

Table 3 shows the cointegration test results for interest rates and monetary base. Our cointegration tests assume trended variables. Let us look first at interest rates for period one. The results for the maximum eigenvalue tests indicate no cointegrating relationship. Since there are seven countries in the sample, a finding of six cointegrating vectors would indicate one common policy shared by all countries; i.e., full convergence of monetary policy. However, a finding of no cointegrating relationship, means that there has been zero convergence of policy. This is a result that we would have expected in this first period, which was characterised by lack of monetary policy coordination in the member countries. The trace test implies three cointegrating vectors, that is, there are four common stochastic trends. This result would suggest that there has been some partial convergence of monetary policy. However, since the trace test lacks power relative to the maximum eigenvalue test (Johansen and Juselius, 1990), one would place more emphasis on the latter.

Table 3 also shows the result for interest rates in period two. Looking first at the results of the maximum eigenvalue tests, we find that there is one cointegrating relationship, that is, there are six common stochastic trends. As had been expected, there was an improvement in the degree of policy convergence in this second period, although it was very small. The trace test found three cointegrating vectors, i.e., four common stochastic trends.

The final cointegration test uses monetary base as the proxy for monetary policy and covers the full time period 1979.3–1992.8. Again the appropriate lag length is set at $k = 2$. Looking first at the results for the maximum eigenvalue tests, one can see that there are three cointegrating vectors and hence four common stochastic trends. The difference in the results when monetary base is used may be due to the fact that it is a more accurate measure of monetary policy. However, it is unusual to find greater convergence over the full time period than was found using interest rates for period two (which was a more economically stable time). Three cointegrating vectors were also found when the trace test was used to test for cointegration. That is, there were four common stochastic trends.

Following the cointegration tests, each of the estimated differenced VARs was checked for autocorrelation. The results for these tests are shown in table 4. The P-Value of the LM(12) statistic is reported in each case. Autocorrelation was found not to be a problem for interest rates for periods one and two when k is set equal to 2. Finally, the VAR when using monetary base for the full period was tested, and autocorrelation was found to be a problem not only at lag 2, but also for lags up to 6[7]. Hence, the cointegration results of the VAR using monetary base should be considered with caution.

We now turn to Granger-causality tests in order to check for short-run interactions. Granger-causality tests will be used to detect if changes in German monetary policy alone are transmitted to other EMS countries, which is evident from unidirectional causation from Germany to the other EMS countries or whether there is general feedback among policy actions. These tests are performed in the VAR in first differences that includes an error-correction term, when cointegration exists. Tables 5(a), 5(b) and 6 report the F-statistics from the causality tests. The number of lags in all cases is equal to 1 since by construction the number of lags in the differenced VAR is one less than the number of lags in the VAR in levels.

Let us look first at interest rates for period one. The results of Table 5(a) show that Belgium is the only country which is statistically influenced in the short term by changes in the German interest rates. They also show that the Netherlands is a significant influence on German rates and Danish rates cause Belgian and Dutch rates.

Table 5(b) shows the Granger-causality tests for interest rates for period two. In this case not only does Germany cause Belgium, but also the Netherlands. Both France and the Netherlands have a statistical influence on German rates. A check on the estimated coefficients shows that even though bidirectional causality applies between Germany and Netherlands, the effect *of* Germany is much larger than the effect *on* Germany. Again it was found that Italy's rates Granger caused Danish rates at the 10% level of significance. Also included in table 5(b) are the t-values and significance levels for the error-correction term (ECT). As can be seen, the only country which has been significantly influenced by all the other countries (through the ECT) in the sample has been Belgium.

Finally, the results for monetary base for the full period are shown in table 6. For monetary base, France, Italy, Netherlands, and Ireland and Denmark (through the ECT), are the countries whose interest rates are Granger-caused by Germany. French, German, Dutch, Danish and Irish interest rates are influenced by all other interest rates through the ECT. However, these results should be interpreted with caution since autocorrelation exists in the VAR.

[7]Even though not reported in Table 4, the residuals in the regressions for Germany, Ireland and Italy are also serially correlated.

4.3 Discussion

Let us focus first on interest rates for period one. The results from the maximum eigenvalue tests found no cointegrating relationship, a result consistent with the exchange rate instability of that period. In their maximum eigenvalue tests, Hafer and Kutan (1994) found two cointegrating vectors, which meant there were three common trends. However, their sample ran from March 1979 to December 1990, and included only five countries (Belgium, France, Germany, Italy, and the Netherlands). Their results may show greater convergence because of there being fewer countries and also because their sample period is larger and captures better the long-run relationship between the monetary policy proxies. The aim of our paper is to compare the progress made on the convergence of monetary policy in two time periods which differ in the degree of exchange rate stability. The results from our paper clearly show that convergence of interest rates did not take place in this volatile first period.

The important question then is, was there an improvement in convergence of monetary policy in the second period, which as has been mentioned was a more stable period characterised by the complete absence of realignments? According to the maximum eigenvalue test there was one cointegrating vector, i.e., six common stochastic trends. One would have expected greater convergence in this second period, given the economic stability of the period and also given Hafer and Kutan's (1994) results. The difference in the results of Hafer and Kutan and our paper, may be due to the inclusion of two extra countries (Ireland and Denmark) in our tests for cointegration. Another reason for the difference in the results is that two relatively small sample periods are used, and since cointegration is a long-run phenomenon, this may have led to the finding of fewer cointegrating vectors.

Our tests for convergence include also monetary base for the full time period March 1979 to August 1992. Both the maximum eigenvalue and trace tests imply four cointegrating relationships. These results should be taken with caution since autocorrelation was found to be a problem in the VAR.

The Granger-causality tests also give some interesting results. The only country which was statistically influenced by Germany when using interest rates for the first period is Belgium. Hafer and Kutan (1994) found Belgium, France, and the Netherlands to be influenced by changes in the German rate[8]. Karfakis and Moschos (1990) found that the German rate

[8] Hafer and Kutan (1994) follow MacDonald and Taylor (1991) and use the VAR expressed in levels without an error-correction term to test for Granger-causality. This approach is asymptotically equivalent to using first differences and an error-correction term. Since our two sample periods are relatively small, we use first differences and the

influenced Belgium, France, Italy, and the Netherlands. Katsimbris and Miller (1993) found that along with the above four countries, Germany also Granger-caused the Irish rate. If we look at period two we see that not only does Germany Granger-cause Belgium, but also the Netherlands. Given the findings of previous papers, we would have expected to have found greater causality running from Germany to the other countries[9]. A result obtained in this paper which complements the results of Hafer and Kutan (1994), Karfakis and Moschos (1990), and Katsimbris and Miller (1993) is that the Dutch rates Granger-cause the German rates. In our study this result applies in both time periods. We also find that French rates Granger-cause German rates in the second period. These results imply that the ERM has not functioned as an asymmetric system and hence the GDH can be rejected. Our results also show significant interaction among the countries in the sample. Belgium, Denmark, and Italy Granger-caused the Dutch rate (as in Hafer and Kutan, 1994), while Denmark and Germany cause the Belgian rate in period one.

Our Granger-causality tests, when monetary base was used as a proxy for monetary policy, show that Belgium was the only country which was not influenced by Germany. Hafer and Kutan (1994) found Germany to Granger-cause France, Belgium and the Netherlands. Our results do show a high degree of interdependence among monetary policies. This is so since monetary base in each country (except Belgium and Italy) is Granger-caused by monetary base in all other countries through the ECT.

5 Core countries and Monetary union

One of the issues under discussion in the agenda on European monetary union is that of which countries will be part of the union at least at its launch. Countries contemplating membership in a single currency should have achieved full monetary policy convergence at a minimum[10]. Our re-

error-correction term to test for Granger-causality. Also, another possible reason for the stronger evidence in favour of German influence provided by Hafer and Kutan (1994) is the fact that they used more lags (four) in performing the Granger-causality tests.

[9]To examine whether the difference in our results was in part due to much smaller lags used in the VAR, we repeated our cointegration and Granger-causality tests using two lags in the VAR (i.e., three lags in the levels VAR). It turns out that the number of cointegrating vectors increases from one to two in the second period and the number of countries Granger-caused by Germany increases from three to four.

[10]Full monetary policy convergence would be necessary for a common monetary policy applied by the European Central Bank. The Maastricht convergence criteria specify additional entry requirements that relate to fiscal policy, interest rates, inflation rates and exchange rates.

sults in the last section showed lack of full monetary policy convergence among the seven countries of our sample. As has been discussed in the literature, a two-speed monetary union is a likely solution to the issue of incomplete degree of convergence among the member countries. Hence, it would be interesting to test for the degree of convergence in a smaller group of countries that could represent the core in a two-speed monetary union. In this respect, we have applied the methodology employed earlier for smaller groups of countries. Specifically, we used two 3-country groups (Germany-Netherlands-Belgium and Germany-Netherlands-France), several 4-country groups, and two groups of five countries that add Denmark and Italy, respectively to the group including Germany, Netherlands, Belgium and France. The only group of countries where *full* monetary policy convergence applies is the three-country group (Germany-Netherlands-Belgium) for the second period[11]. Applying the AIC criterion, three lags were included in the VARs in levels in both periods. Our cointegration results reported in Table 7 indicate an increase from zero to two cointegrating vectors using both the trace and maximum eigenvalue tests[12]. The result of full monetary policy convergence in the second period (i.e., a single common stochastic trend) implies that Germany, Netherlands and Belgium could be considered as the first group to join a monetary union under a two-speed approach. Somewhat surprisingly, according to our results, France should not be considered one of the core countries in a European monetary union, at least based on the criterion of monetary policy convergence.

Table 8 reports the results of Granger causality tests in the three-country VAR in first differences. In accordance with the cointegration tests, the VAR in first differences includes 2 ($= k - 1$) lags for each variable. The VAR for the second period includes also an ECT for the most significant of the two cointegrating vectors (i.e., the one corresponding to the largest eigenvalue). The cointegrating vectors are normalised such that a negative sign of the error-correction parameter implies adjustment to restore the long-run equilibrium. The results of period one confirm policy asymmetry as there is unidirectional causality from German interest rates to Belgian

[11]In the other cases, even though the degree of convergence in the second period is less than full, it is greater than that in the first period. Full convergence in the second period also applies when our sample includes Germany, the Netherlands, Belgium and Ireland. However, the estimated VAR suffers from serial correlation in the error term. The cointegration results for these cases are not reported but are available from the authors upon request.

[12]The cointegration results in the three-variable and the seven-variable cases are almost unchanged (in two cases the null can only be rejected at the 10% level) if the small-sample adjustment to the critical values suggested by Cheung and Lai (1993) is made. According to these authors, the Johansen asymptotic critical values have to be adjusted by a scale factor given by $T/(T-nk)$ where T is the effective sample size, n is the number of variables and k is the number of lags in the VAR.

and Dutch rates. The system appears to be more symmetric in the second period as German rates are also influenced by Belgian and Dutch rates (the latter through the ECT). In other words, two-way causality applies between Germany and each of Belgium and Netherlands in the second period. However, a look at the estimated coefficients shows that, as expected, the effect *of* Germany exceeds the effect *on* Germany for each of these two countries. The wrong sign of the statistically significant ECT in the equation for the German rates implies that German interest rates do not adjust to restore last period's deviation from the long-run equilibrium. Hence, the adjustment to the long-run equilibrium takes place through changes in the Dutch and Belgian interest rates.

6 Conclusions and suggestions for future research

This paper has used recent developments in the econometrics of nonstationary time series to test for long-run interdependencies and short-run interactions in the monetary policies of seven ERM countries. Our conclusions are as follows: First, our results show that there has been very little progress made on the issue of convergence of monetary policy within the EMS. Although there was a slight improvement in the second period for interest rates, our findings show that the member countries are still a long way off full monetary policy convergence. This lack of monetary policy convergence even during the second period of our study that ends in August 1992 may have contributed to the breakdown of the system in September 1992. Second, our Granger-causality tests do not support the GDH. Although Germany does play an important role in the EMS, so do a number of other countries, i.e., the Netherlands and France. As expected though, it is still the case that whenever bi-directional causality applies, the influence *of* German interest rates exceeds the influence *on* German interest rates.

Given the lack of full monetary policy convergence among the seven countries of our sample, we have also tested for the degree of convergence in a smaller group of countries that could represent the core in a two-speed monetary union. Our results show that full convergence applies for the second period of our study when the group of countries includes only Germany, Netherlands and Belgium. This finding has important policy implications as it supports those arguing in favour of monetary union which at the first stage would include only countries in the core of the ERM. Further evidence is required to determine whether extending the sample period to include the currency crisis of 1992–93 would significantly alter the present results.

Table 1
Unit Root Test Results
ADF (2) Statistics*

Monetary Base (Full Period)

Country	Levels	Differences
Belgium	-5.78	-9.98
Denmark**	-1.00	-7.84
France	0.39	-10.55
Germany	-2.14	-10.15
Ireland	-2.58	-7.59
Italy	-1.47	-9.90
Netherlands	-3.86	-12.44

* The critical value for ADF(2) is -3.45 (Fuller, 1976).
**For Denmark a time trend is not included. The critical value is -2.89 (Fuller, 1976).

Table 2(a)
Unit Root Test Results
ADF (2) Statistics*

Interest Rates (First Period)

Country	Levels	Differences
Belgium	-2.60	-6.80
Denmark	-2.24	-5.51
France	-2.26	-3.42
Germany	-0.85	-3.99
Ireland	-2.35	-6.55
Italy	-2.09	-5.13
Netherlands	-1.37	-4.94

* The critical value for ADF(2) is -2.89 (Fuller, 1976).

Table 2(b)
Unit Root Test Results
ADF (2) Statistics*

Interest Rates (Second Period)

Country	Levels	Differences
Belgium**	-2.43	-6.53
Denmark	-1.51	-3.78
France	-1.17	-5.81
Germany**	-1.56	-4.22
Ireland	-2.03	-4.52
Italy	-1.59	-4.57
Netherlands**	-1.95	-4.64

* The critical value for ADF(2) is -2.89 (Fuller, 1976).
** Belgium, Germany and the Netherlands include a time trend. The critical value is -3.45 (Fuller, 1976).

Table 3
Cointegration Test Results

Maximum Eigenvalue Test

Variable	r = 0	r ≤ 1	r ≤ 2	r ≤ 3	r ≤ 4	r ≤ 5	r ≤ 6
Interest Rates+ (Period One)	41.99	39.22	29.60	18.76	12.61	9.48	1.52
Interest Rates+ (Period Two)	57.09*	36.06	27.00	23.30	11.00	8.13	3.63
Monetary Base+ (Full Period)	70.88*	51.99*	33.78*	24.23	12.30	10.17	1.22
Asymptotic Critical Values (5%)	45.28	39.37	33.46	27.07	20.97	14.07	3.76

Trace Test

Variable	r = 0	r ≤ 1	r ≤ 2	r ≤ 3	r ≤ 4	r ≤ 5	r ≤ 6
InterestRates+ (Period One)	153.20*	111.21*	71.99*	42.38	23.62	11.01	1.52
InterestRates+ (Period Two)	166.22*	109.13*	73.07*	46.07	22.76	11.76	3.63
MonetaryBase+ (Full Period)	204.58*	133.69*	81.70*	47.92	23.69	11.38	1.22
Asymptotic Critical Values (5%)	124.24	94.15	68.52	47.21	29.68	15.41	3.76

*Denotes significance at the 5 percent level. Asymptotic critical values are obtained from Osterwald-Lenum(1992).
+Denotes the lag length k=2.

Table 4
Autocorrelation Tests in the VAR

Sample	Dependent Variable	LM(12)P-value
Interest Rates (Period One) k=2	Belgium	0.11
	Denmark	0.07
	France	0.36
	Germany	0.76
	Ireland	0.76
	Italy	0.66
	Netherlands	0.37
Interest Rates (Period Two) k=2	Belgium	0.21
	Denmark	0.22
	France	0.22
	Germany	0.14
	Ireland	0.06
	Italy	0.22
	Netherlands	0.19
Monetary Base (Full Period)		
k=2	Belgium	0.00
k=3	Belgium	0.00
k=4	Belgium	0.00
k=5	Belgium	0.00
k=6	Belgium	0.00

Table 5(a)

Granger Causality Tests

Interest Rates (Period One)

Dependent Variable	Test Statistic/Marginal Significance Level*						
	Belgium	Denmark	France	Germany	Ireland	Italy	Netherlands
Belgium	6.81 (0.01)	6.00 (0.01)	0.04 (0.85)	6.25 (0.01)	1.14 (0.28)	0.49 (0.48)	1.12 (0.29)
Denmark	2.66 (0.11)	4.28 (0.04)	8.76 (0.00)	0.53 (0.46)	9.30 (0.00)	2.79 (0.10)	0.92 (0.34)
France	1.66 (0.20)	1.77 (0.19)	21.62 (0.00)	0.00 (0.95)	1.08 (0.30)	0.76 (0.39)	0.06 (0.81)
Germany	0.00 (0.98)	0.00 (0.98)	1.14 (0.28)	0.01 (0.92)	0.18 (0.67)	0.53 (0.46)	4.12 (0.05)
Ireland	1.08 (0.30)	0.28 (0.60)	0.18 (0.67)	0.13 (0.72)	17.06 (0.00)	5.71 (0.02)	0.59 (0.44)
Italy	0.74 (0.39)	0.06 (0.80)	0.72 (0.39)	0.02 (0.88)	4.12 (0.04)	16.89 (0.00)	3.80 (0.05)
Netherlands	3.69 (0.06)	4.04 (0.05)	0.28 (0.60)	0.88 (0.35)	1.28 (0.26)	14.44 (0.00)	0.28 (0.60)

*F statistics are reported. Numbers in parentheses are marginal significance levels. One lag is included in the ECM.

Table 5(b)

Granger CausalityTests

Interest Rates (Period Two)

Dependent Variable	Test Statistic/Marginal Significance Level*						
	Belgium	Denmark	France	Germany	Ireland	Italy	Netherlands
Belgium	2.28	9.06	1.34	3.28	0.76	0.38	2.92
	(0.14)	(0.00)	(0.25)	(0.08)	(0.38)	(0.54)	(0.09)
Error-Correction Term=-6.56(0.00)							
Denmark	1.72	6.15	0.14	0.15	1.32	2.89	1.37
	(0.19)	(0.02)	(0.70)	(0.70)	(0.26)	(0.10)	(0.24)
Error-Correction Term=0.23(0.82)							
France	0.07	3.46	0.05	0.53	1.44	0.61	0.90
	(0.80)	(0.07)	(0.83)	(0.47)	(0.23)	(0.43)	(0.35)
Error-Correction Term=1.31(0.20)							
Germany	0.70	0.01	3.03	1.21	1.21	0.58	3.13
	(0.40)	(0.91)	(0.09)	(0.29)	(0.29)	(0.45)	(0.08)
Error-Correction Term=0.94(0.35)							
Ireland	1.85	0.70	0.52	0.43	7.67	0.18	0.06
	(0.18)	(0.40)	(0.47)	(0.51)	(0.01)	(0.68)	(0.80)
Error-Correction Term=0.07(0.95)							
Italy	0.00	0.00	0.66	0.09	0.92	11.22	0.72
	(0.96)	(0.96)	(0.42)	(0.77)	(0.34)	(0.00)	(0.40)
Error-Correction Term=-0.69(0.49)							
Netherlands	3.84	1.08	0.00	9.86	0.41	0.90	14.52
	(0.05)	(0.30)	(0.99)	(0.00)	(0.52)	(0.34)	(0.00)
Error-Correction Term=-0.64(0.52)							

*F statistics are reported. t-statistics are reported for the error-correction term. Numbers in parenthes are marginal significance levels. One lag is included in the ECM.

Table 6

Granger Causality Tests

Monetary Base (Full Period)

Dependent Variable	Test Statistic/Marginal Significance Level*						
	Belgium	**Denmark**	**France**	**Germany**	**Ireland**	**Italy**	**Netherlands**
Belgium	1.42	0.53	5.29	0.38	14.90	0.79	2.86
	(0.24)	(0.46)	(0.02)	(0.53)	(0.00)	(0.37)	(0.09)
Error-CorrectionTerm=-0.50(0.61)							
Denmark	0.48	0.43	0.62	0.32	0.14	0.55	1.79
	(0.49)	(0.51)	(0.43)	(0.56)	(0.70)	(0.46)	(0.18)
Error-CorrectionTerm=-1.69(0.09)							
France	0.76	0.52	28.10	2.96	0.50	0.92	3.06
	(0.39)	(0.47)	(0.00)	(0.09)	(0.48)	(0.34)	(0.08)
Error-CorrectionTerm=-1.97(0.05)							
Germany	4.66	2.75	0.02	22.94	0.01	0.98	2.60
	(0.03)	(0.10)	(0.88)	(0.00)	(0.91)	(0.32)	(0.11)
Error-CorrectionTerm=-4.38(0.00)							
Ireland	1.21	1.04	0.59	0.23	4.71	6.15	0.26
	(0.27)	(0.27)	(0.44)	(0.63)	(0.03)	(0.01)	(0.61)
Error-CorrectionTerm=-2.51(0.01)							
Italy	8.76	2.25	1.49	4.93	9.86	1.30	0.09
	(0.00)	(0.13)	(0.22)	(0.03)	(0.00)	(0.26)	(0.76)
Error-CorrectionTerm=-0.09(0.92)							
Netherlands	6.15	9.42	0.52	6.60	0.02	0.70	1.59
	(0.01)	(0.00)	(0.47)	(0.01)	(0.89)	(0.40)	(0.21)
Error-CorrectionTerm=-5.94(0.00)							

*F statistics are reported. t-statistics are reported for the error-correction term. Numbers in parentheses are marginal significance levels. One lag is included in the ECM.

Table 7
Cointegration Test Results

Maximum Eigenvalue Test

Variable	r=0	r≤1	r≤2
Interest Rates+ (Period One)	16.08	11.51	1.57
Interest Rates+ (Period Two)	21.60*	17.96*	2.14
Asymptotic Critical Values(5%)	20.97	14.07	3.76

Trace Test

Variable	r=0	r≤1	r≤2
Interest Rates+ (Period One)	29.16	13.08	1.57
Interest Rates+ (Period Two)	41.70*	20.10*	2.14
Asymptotic Critical Values(5%)	29.68	15.41	3.76

*Denotes significance at the 5 percent level. Asymptotic critical values are obtained from Osterwald-Lenum(1992).
+Denotes the lag length k=3.

Table 8
Granger Causality Tests

Interest Rates(Period One)

Dependent Variable	Test Statistic/Marginal Significance Level*		
	Belgium	Germany	Netherlands
Belgium	12.20 (0.00)	10.91 (0.00)	3.86 (0.02)
Germany	1.97 (0.14)	3.45 (0.04)	1.61 (0.21)
Netherlands	0.26 (0.77)	8.64 (0.00)	2.50 (0.09)

Interest Rates (PeriodTwo)

Dependent Variable	Test Statistic/Marginal Significance Level*		
	Belgium	Germany	Netherlands
Belgium	8.83 (0.00)	8.40 (0.00)	1.81 (0.17)
Error-Correction Term=-2.19(0.03)			
Germany	3.65 (0.03)	0.74 (0.48)	1.68 (0.20)
Error-Correction Term=4.24(0.00)			
Netherlands	1.82 (0.17)	3.42 (0.04)	2.00 (0.14)
Error-Correction Term=-2.40(0.02)			

*F statistics are reported. t-statistics are reported for the error-correction term. Numbers in parentheses are marginal significance levels. Two lags are included in the ECM.

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