Bank of England

Discussion Papers

No 31

What has the European Monetary System achieved?

by

M P Taylor

and

M J Artis

March 1988

No 31

What has the European Monetary System achieved?

by

M P Taylor

and

M J Artis

March 1988

Mark Taylor conducted this study while on the staff of the Bank's Economics Division. He is now the Robert Fleming Professor of Finance and Investment at the University of Dundee. Michael Artis is Professor of Economics at the University of Manchester. Both are Fellows of the Centre for Economic Policy Research.

The object of this series is to give a wider circulation to research carried out in the Bank and to invite comment upon it. Any views expressed in this paper are strictly those of the authors and should in no way be construed as representing the views or policies, past or present, of the Bank of England. The authors are grateful for comments on an earlier draft from John Arrowsmith, Roger Clews, John Flemming, Tony Latter, Chris Taylor and other staff members of the Bank of England, as well as David Currie, Charles Goodhart, Andrew Harvey, Peter Sinclair, Tom Rothenberg and participants at the LSE econometrics workshop and the Money Study Group 1987 annual conference, but the authors alone remain responsible for any errors or omissions.

Issued by the Economics Division, Bank of England, London, EC2R 8AH to which requests for individual copies and applications for mailing list facilities should be addressed; envelopes should be marked for the attention of the Bulletin Group.

ISBN 0 903312 91 3

ISSN 0142-6753

CONTENTS

Abstract 1

1 Introduction 2

2 Provisions of the EMS 3

3 Exchange rate volatility and the EMS 4

3.1 Previous volatility studies 4
3.2 Some new exchange rate volatility tests 5
3.3 Exchange rate volatility tests: empirical results 9
3.4 Testing for a shift in the conditional variance 10

4 Interest rate volatility and the EMS 12

4.1 Capital controls and the EMS 12
4.2 Volatility transfer 14

5 Currency substitutability and risk premia 15

5.1 Testing for risk premia in the EMS 15
5.2 Empirical results 18

6 Real exchange rates and the EMS: random walk or dragging anchor? 20

6.1 Testing for unit roots in real exchange rates 21
6.2 Empirical results 23

7 Conclusions 24

Appendix: Density and asymptotic score functions for the non-parametric tests 25

References 37

ABSTRACT

This paper attempts to provide some answers to a number of related questions: Has the EMS reduced (real or nominal, bilateral or effective) exchange rate volatility? If so, has this been at the expense of increased interest rate volatility? How important have capital controls been for the operation of the EMS? Has the exchange rate mechanism reduced the volatility of unanticipated exchange rate changes? Has the EMS been effective in making ERM currencies close substitutes? What have been the implications of the EMS for the longer-run stabilisation of real exchange rates? Because of the uncertainty surrounding the statistical distributions of changes in asset prices in general and exchange rates in particular, an innovative theme of the paper is the use of non-parametric or semi-non-parametric econometric and statistical procedures wherever possible. An exception to this is in our analysis of shifts in the conditional variance of exchange rate changes, where we estimate autoregressive conditionally heteroscedastic (ARCH) parameterisations. Briefly, we conclude that the EMS has reduced the volatility of both exchange rates and interest rates; that capital controls probably have been important in its operation and that it has reduced the conditional volatility of exchange rates. We attribute many of these findings to the enhanced credibility of the exchange rate policies of ERM member countries. Some of our findings, however, namely that ERM member currencies do not appear to be perfect substitutes and that there is evidence of long-run misalignment within the EMS, do indicate that the EMS may indeed still be in its early days in terms of some of its longer-term goals.

1 INTRODUCTION

This paper attempts to provide some answers to a number of related questions: Has the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) reduced (real or nominal, bilateral or effective) exchange rate volatility? If so, has this been at the expense of increased interest rate volatility? How important have capital controls been for the operation of the EMS? Has the ERM reduced the volatility of unanticipated exchange rate changes? Has the EMS been effective in making member currencies close substitutes? What have been the implications of the EMS for the longer-run stabilisation of real exchange rates?

To attempt to answer these questions meaningfully, however, requires clarification of the perceived aims and objectives of the EMS. It is common ground that the formal objective of the EMS (or, more strictly of its exchange rate mechanism) is the stabilisation, within generally narrow pre-agreed bounds, of member countries' nominal exchange rates. The likelihood of this being achieved was initially greeted with scepticism, especially on this side of the Channel. Yet the sceptics have been confounded by an unforseen display of flexibility which has ensured the system's survival.

Since the EMS is an exchange rate mechanism of a customs union it must be expected, if it is to survive in the long run, to ensure that member countries' competitiveness is protected; otherwise, the protection-reducing achievements of the customs union must be called into question as countries seek to restore their terms of trade. This is to suggest that, at the same time as the immediate and formal objective of the system is to stabilise nominal rates of exchange, its inner long-run rationale involves a requirement on real rates of exchange. This fundamental ambiguity accounts for the what Goodhart (1986) has termed an 'unholy alliance' of those advocating British participation in the ERM, between those who seek to consolidate the counter-inflation gains of recent years (by targeting the DM/£ rate essentially) and those who wish to protect the competitiveness of sterling from what they regard as the excessive appreciation of the 1980/1981 period. The two objectives are clearly not compatible without a convergence of inflation, at equilibrium levels of activity and external balance, between the member countries. In the period of the system's functioning so far, progress towards this objective has been provided in the historical context of the second OPEC oil shock which induced among countries generally, and members of the EMS in particular, a strong desire to reduce inflation. Given Germany's low inflation rate and reputation in recent years for counter-inflationary policy, this implied to a degree convergence on the German standard.

At the same time, starting from a position of high and divergent rates of inflation, the transition (not yet at all complete) to a converged state of low inflation has required that full advantage should be made of the provisions for flexibility contained in the system. We now turn to a brief account of what these are.

2 PROVISIONS OF THE EMS

The provisions of the ERM of the European Monetary System provide for participating countries to maintain their exchange rates within bilateral limits of ±2 1/4%. Exceptionally, Italy negotiated a wider margin of ±6% at the outset of the system. In addition to the provisions for a margin of fluctuation, realignments are permitted and in all, eleven such realignments have been undertaken to date. Their timing and amounts are shown in Table 1 (see page 26).

The system is formally organised around a composite currency, the ECU, with central rates for participating currencies being expressed in terms of it. Whilst this is purely formal, the ECU gave the opportunity for the introduction of an interesting technical innovation of the EMS, the divergence indicator and threshold positions. According to these provisions, when a currency triggered its divergence indicator threshold (calculated as the ECU value of a 75% departure of its bilateral rates against all the other countries), a presumption was created that the country concerned should take corrective action. This technical provision was designed both to provide an early warning of bilateral limit infringements and, more important, to isolate an errant currency - the one standing out against all the others. There was little doubt that in the minds of those who constructed these provisions that the errant currency was going to be the strong DM.[1] It is one of the curiosities of the history of the system that in fact the DM has not often been at the higher end as its permitted range and, more important, that the inflation policy priority has been so strong that it was not desired to single it out (cf Padoa-Schioppa, 1983). Some observers do believe, though, that the divergence indicator provisions have assisted convergence and stabilisation because a country does not like to attract the presumption of action which follows the public triggering of a threshold: it would prefer to undertake action on its own initiative and at its own discretion (cf Melitz, 1985).

---

1 Ludlow (1982) gives a detailed and informative account of the negotiations leading to the institution of the EMS.

In addition to the formal provisions of the ERM it is important to note that the introduction of the system did not require the abolition of exchange controls and significant controls over capital movements were retained, notably by France and Italy. These controls may have been helpful in fostering system stability, both by giving the authorities of the country concerned the whip-hand in negotiating realignments and by avoiding the immediate convergence of monetary policy which freedom from control, coupled with the obligation to defend central bilateral parities, would have implied.[2]

3 EXCHANGE RATE VOLATILITY AND THE EMS

In this section, we present some new evidence on the effect of the ERM on exchange rate volatility by an examination of a number of nominal and real, bilateral and effective exchange rate changes.

3.1 Previous Volatility Studies

As already noted, there have been eleven realignments of the currencies participating in the EMS; this, together with the fact that quite wide variations are allowed by the parity grid margins, leaves it an open question in principle whether the provisions of the System actually do induce a greater degree of stability in either the nominal or the real exchange rate.

The difference, stressed by John Williamson (1985), between the concepts of exchange rate volatility and misalignment, is important here. Volatility is a 'high frequency' concept referring to movements in the exchange rate over comparatively short periods of time. Misalignment, on the other hand, refers to the capacity for an exchange rate to depart from its fundamental equilibrium value over a protracted period of time. It is known, without reference to statistical detail, that the two major currencies which have exhibited most marked misalignments in recent history are the US dollar and the pound sterling. No EMS currency has exhibited medium-term misalignment on a comparable scale. For the reasons given by Williamson it seems fair to argue that the greater welfare significance attaches to the diminution of misalignment than to the reduction of volatility where there is (perhaps surprisingly) little evidence to support the view that volatility is welfare-reducing. To be more precise, what has been tested is whether exchange rate volatility appears to be trade-reducing. While a study by Akhtar and Hilton (1984) found that it was so for US-German trade, comparable studies by the

---

2 See section 4 below and the symposium of papers forthcoming in The European Economy (1987).

Bank of England (1984) and the International Monetary Fund (1983) failed to confirm this finding for alternative trade flows, time period and volatility measures. Recent work by Cushman (1986) has, however, discovered evidence of volatility effects on trade when 'third country' effects are controlled for (eg dollar-mark volatility may affect US-UK trade).

Nevertheless, a number of studies have concentrated on the evidence that the EMS has reduced exchange rate volatility, most notably those by Ungerer et al (1983), the European Commission (1982), Padoa-Schioppa (1983), Rogoff (1985) and, most recently, Ungerer et al (1987). There are a large number of possible variations in the statistical approach to this question - the choice of exchange rates (bilateral, effective, nominal, real); data frequency (daily, weekly, monthly, quarterly); the standard against which stability is to be judged (the level or change in exchange rates, conditional or unconditional); the precise statistical measure chosen (standard deviation, etc). Then there is the question of the counterfactual - supplied in these studies and others like them by the behaviour in the pre- and post-EMS period of a control group of non-EMS currencies. Without exception, however, the EMS in these studies has been judged as having contributed to improving the stability of intra-EMS bilateral exchange rates; the improvement is less marked for effective rates, and it has been argued in qualification that, with the lengthier data period over which it is now possible to run these tests, it is possible to show, in certain cases, that the earlier claims to stability of the EMS have weakened with the passage of time (cf House of Commons Select Committee 1985, p xiii).

3.2 Some New Exchange Rate Volatility Tests

All of the studies cited above, which have tested for a downward shift in exchange rate volatility for members of the EMS post-March 1979, have generally relied on purely descriptive statistics. As such, they can be at most suggestive, and it is perhaps difficult to scientifically assess the performance of the EMS in this respect in the light of this evidence. The most straightforward approach to the problem, namely estimating a specific parameterisation of the volatility and testing for a structural shift after March 1979, is fraught with pitfalls. This is because economists are far from certain concerning the correct statistical distribution of exchange rate changes. It is by now a stylised fact that percentage exchange rate changes tend to follow leptokurtic (fat tailed, highly peaked) distributions. Westerfield (1977), for example, finds that the stable paretian distribution with characteristic exponent less than two provides a superior fit to the change in the logarithm of spot exchange rates than the normal distribution.

In a similar vein, Rogalski and Vinso (1977) suggest Student's t-distribution as a good approximation. It may well be that the distribution of exchange rate changes is normal, but that the variance shifts through time - perhaps according to the amount of 'news'; this would give the appearance of a stable, leptokurtic distribution. Some evidence for such behaviour is provided by Boothe and Glassman (1987) who find that mixtures of normal distributions provide some of the best fits to their data. The possibility of a heteroscedastic conditional variance is pursued in subsection 3.4 below.

We wish to stress the importance of attempting to capture the correct distributional properties of exchange rate changes in any volatility study. By relying on simple variance measures, the studies cited above are implicitly invoking a normality assumption, the legitimacy of which a growing number of studies are, at the very least, bringing into question (see Boothe and Glassman, 1987 for additional references). For example, it might conceivably be the case that exchange rate changes at a certain frequency have a Cauchy distribution, for which no finite moments of any order exist.

In order to try and circumvent some of these problems, we decided to apply non-parametric tests for volatility shifts which do not require actual estimation of the distributional parameters. Instead, exchange rate changes are ranked in order of size and inferences are drawn with respect to the shape of the ranking. Intuitively, if a significant number of lower-ranked percentage changes were recorded in the latter half of the sample, a reduction in volatility would be indicated. The exact procedure is as follows.

Let Δe_t be the change in the (logarithm of the) exchange rate at time t, then the maintained hypothesis is:

$$\Delta e_t = \mu + \sigma_t \varepsilon_t \qquad (1)$$

$$\sigma_t = \exp \{\alpha + \beta z_t\}$$

where μ, α and β are unknown, constant scalars, ε_t is independently and identically distributed with distribution function F and density function f, and z_t is a binary variable reflecting the hypothesised change in volatility, ie:

$$z_t = \begin{cases} 1, & t \leq \text{March } 1979 \\ 0, & \text{otherwise} \end{cases}$$

Given (1), the null hypothesis of no shift in volatility is then:

$$H_0: \beta = 0 \tag{2}$$

Hajek and Sidak (1967) (henceforth HS) develop a number of non-parametric rank tests for dealing with problems involving this kind of framework, which, under appropriate regularity conditions, are locally most powerful (HS pp 70-71). The test statistics take the form:

$$\varsigma = \sum_{t=1}^{T} (z_t - \bar{z})\, \alpha\, (u_t) \tag{3}$$

where, $\bar{z}$ is the arithmetic mean of the z_t sequence of T observations ($\bar{z} = T^{-1} \Sigma_{t=1}^{T} z_t$), and u_t is defined as follows. Let $r(\Delta e_i)$ be the rank of Δe_i - ie Δe_i is the $r(\Delta e_i)$-th smallest change in the total sequence considered; then

$u_t = r(\Delta e_t)/(T + 1)$.

Clearly, u_t must lie in the closed interval $[1/(T+1), T/(T+1)]$ (for no ties in rank). The function $\alpha(.)$ in (3) is a score function defined in HS (p 70), depending upon the assumed density of ε_t, ie f. HS define a class of functions which can be used in place of the score function in large samples, since $\alpha(.)$ may in practice be difficult to evaluate. If F is the assumed distribution function of ε_t:

$$F(x) = \int_{-\infty}^{x} f(y)dy$$

and $F^{-1}(u)$ is the inverse of F:

$$F^{-1}(u) = \inf\{x \mid F(x) \geq u\}$$

then the asymptotic score function, $\psi(.)$, is defined (HS p 19):

$$\psi : (0,1) \to \Pi$$

$$\psi(u) = -F^{-1}(u)\left[\frac{f'\{F^{-1}(u)\}}{f\{F^{-1}(u)\}}\right] - 1 \tag{4}$$

Under the maintained hypothesis (1), the statistic

$$\eta = \sum_{t=1}^{T} (z_t - \bar{z})\, \psi(u_t) \tag{5}$$

(ie as in (3) with $\alpha(.)$ replaced by $\psi(.)$) will be asymptotically normally distributed. Under the null hypothesis (2), η will have mean zero and variance ρ^2 given by (HS pp 159-160):

$$\rho^2 = \left\{ \sum_{t=1}^{T} (z_t - \bar{z})^2 \right\} \int_0^1 \left\{ \psi(u) - \bar{\psi} \right\}^2 du \tag{6}$$

where

$$\bar{\psi} = \int_0^1 \psi(u)\, du$$

The test is now as follows. For a given choice of f, η can be calculated as in (5) and referred to the normal distribution, to construct a test of any given nominal size, of the null hypothesis (2) (no change in volatility). Significantly negative values of η reflect a negative value for β in (1) - ie an increase in volatility post-March 1979, whilst significantly positive values of η imply a reduction in volatility post-March 1979. The statistic η in (5) provides the locally most powerful test among the class of all possible tests (HS p 249).

Note that although the test procedure just outlined is non-parametric in the sense that no volatility measures are actually estimated, in implementing the procedure we cannot avoid choosing an appropriate distribution for changes in the exchange rate. In order to try and minimise the damage due to choosing an inappropriate distribution we selected four well-known ones - hopefully, the true distribution of exchange rate changes is close to one of them. The densities used correspond to the normal, logistic, double exponential and Cauchy distributions. The density and asymptotic score functions (as defined in (4)) for these distributions are given in the appendix. All of the chosen distributions are symmetric and both the double exponential and Cauchy distributions have fat tails.[3]

---

3 Another relevant distribution would have been Student's t. However, the score function (4) for this distribution would have been very difficult to compute. A possibility not considered is that there was a change in distribution of ERM exchange rate changes post-March 1979 (eg shifted from normal to Cauchy). Tests for this kind of behaviour could conceivably be based on likelihood ratio tests, although one might suspect that the discriminatory power of such procedures would be low.

3.3 Exchange Rate Volatility Tests: Empirical Results

Monthly (end-month) data on bilateral US dollar exchange rates were taken from the IFS data tape for the period January 1973 to December 1986. Bilateral rates against the German mark and UK sterling were also constructed by assuming a triangular arbitrage condition. Real exchange rates were constructed by deflating by the wholesale price index (also from the IFS tape). The currencies used included six ERM members - German mark, Danish kroner, Belgian franc, French franc, Italian lira and Dutch guilder - and four non-ERM members - US dollar, UK sterling, Japanese yen and Canadian dollar. All results reported are for shifts in the volatility of monthly exchange rate changes. In each case, the test statistics were converted to standard normal variates under the null hypothesis by dividing through by the standard deviation ρ (see (6)).

As would be expected, the results of applying these tests to nominal bilateral rates (not reported) indicated a significant reduction in volatility for ERM currencies against the mark, whilst dollar rates generally showed a significant <u>rise</u> in volatility post-1979. Perhaps a little more interesting is that these results are largely echoed by those in Table 2a (see page 27), which gives results of the tests applied to <u>real</u> mark bilateral exchange rates. There is strong evidence of a significant reduction in volatility in the real mark exchange rate against most of the ERM currencies, which is in marked contrast for all the real mark exchange rates against the non-ERM currencies. With the exception of the dollar-lira real rate, there are no significant shifts in volatility recorded for either the dollar or the sterling real rates (not reported).

Table 2b (see page 28) reports results of the tests applied to nominal effective rates, using the standard IMF (multilateral exchange rate model or MERM) effective indices. This appears to weaken the volatility reduction effect for the EMS currencies - only the Italian lira and, to a lesser extent, the German mark, show a significant post-March 1979 volatility reduction. For the non-ERM currencies, both the US dollar and UK sterling effective indices show a significant post-ERM <u>rise</u> in volatility, while the Canadian dollar shows a significant <u>reduction</u> in volatility. The results reported in Table 2c (see page 29) for the real effective MERM rates (deflated by a basket of wholesale price indices, using the standardised MERM weights for the top ten currencies) are much more clear cut. These show a fairly marked reduction in real exchange rate volatility for all the EMS countries, a slightly less marked increase in volatility of the real US dollar rate, with no significant shift for the other currencies.

Let us summarise the results so far. There is strong evidence of reduced intra-ERM exchange rate volatility post-March 1979, and signs of increased volatility in dollar and (to a slightly lesser extent) sterling rates. These results hold, moreover, for both real and nominal exchange rates.

3.4 Testing for a Shift in the Conditional Variance

In a large number of modern macroeconomic models, unanticipated disturbances have a far greater effect than anticipated disturbances. Thus, it is of some interest to attempt to test for a shift in the conditional variance of exchange rate changes post-March 1979. That is to say, one should test for a shift in the variance of unanticipated movements in the exchange rate.

Rogoff (1985) has tested for a shift in conditional variance by essentially estimating the variance of the forward rate prediction error. Although Rogoff claims that his results are robust to the presence of small, time-varying risk premia in the foreign exchange market, this method really implicitly assumes uncovered interest rate parity and, more important, conditional homoscedasticity of exchange rate changes. Recent work by, in particular, Cumby and Obstfeld (1984) and Domowitz and Hakkio (1985) has strongly suggested the presence of conditional heteroscedasticity or, more particularly, autoregressive conditional heteroscedasticity (ARCH - see Engle 1982) effects in exchange rate innovations. At an intuitive level, the exchange rate will clearly be easier to forecast in some periods than in others.

It is, however, a 'stylised fact' concerning the foreign exchange market that the (logarithm of the) exchange rate appears to approximate very closely to a random walk (see eg Mussa 1984, Goodhart 1987, Goodhart and Taylor 1987). Moreover, there is also some evidence that the current spot rate outperforms the current forward rate as a spot rate predictor (Goodhart 1987). Accordingly, a tractable way of estimating the conditional variance might be to model the evolution of the exchange rate as a random walk with an ARCH disturbance.[4]

Using the Lagrange multiplier test procedure suggested by Engle (1982), we detected the presence of first-order ARCH effects in the random walk innovations for a majority of the nominal bilateral exchange rates investigated. Accordingly, we decided to estimate models of the form:

$$e_t = e_{t-1} + u_t \tag{7}$$

$$h_t = E(u_t^2 \mid I_{t-1}) = \alpha_0 + \alpha_1 u_{t-1}^2$$

where e_t is the exchange rate and I_{t-1} is the information set at time t-1. The system (7) was estimated by maximum likelihood methods, using the scoring alogorithm described in Engle, 1982. In each case nine scoring steps were carried out; this was in every case more than adequate to achieve convergence in terms of the gradient around the inverse Hessian (Belsley, 1979, Engle, 1982). For each nominal bilateral exchange rate, the ARCH parameterisation was estimated for the pre- and post-EMS periods separately and a likelihood ratio statistic for a shift in the coefficients was constructed. The results are reported in Table 3 (see page 30).

Consider first the results for the German mark nominal bilateral rates (Table 3a - see page 30). With the single exception of the mark-Belgian franc rate, there is a significant shift in the ARCH coefficients for the EMS currencies post-March 1979, and in each case the mean conditional standard deviation of exchange rate changes ($h_t^{1/2}$) is lower for the second period (this effect is particularly marked for the mark-lira and mark-Dutch guilder exchange rates). There is, however, no significant shift in the ARCH coefficients for the non-ERM mark exchange rates.

---

4 As noted above, heteroscedastic normal exchange rate changes would account for the appearance of leptokurtosis and this is therefore an alternative interpretation to that offered above. A more general approach would be to estimate the conditional variance non-parametrically (see eg Pagan and Ullah 1986). This possibility is currently under investigation by the present authors.

The ARCH estimates for the US dollar nominal bilateral rates (Table 3b - see page 31) indicate, with the single exception of the US dollar-Canadian dollar rate, a significant shift in the coefficients and a rise in the conditional forecast variance post-March 1979.

The results for sterling nominal rates (not reported) showed no sign of a shift in conditional volatility post-March 1979.

Overall, therefore, these results tend to confirm our earlier findings for shifts in (unconditional) volatility - there is a significant reduction in the conditional variance of exchange rate innovations for the ERM currencies against the mark, and signs of a significant rise in the conditional variance of US dollar exchange rate innovations.

4 INTEREST RATE VOLATILITY AND THE EMS

4.1 Capital Controls and the EMS

It has been argued that exchange controls over capital flows have been a particularly important feature of the functioning of the EMS. The two major member countries outside Germany - France and Italy - have deployed substantial measures of capital control. Belgium, with its two-tier market arrangements, has discriminated between commercial, or current account, and capital transactions.

The significance of these controls was first effectively highlighted by Rogoff (1985), who noted the substantial violations of (covered) interest parity exhibited by France and Italy. Subsequently, Giavazzi and Giovannini (1986) and Giavazzi and Pagano (1985) have analysed and documented further the impact of these controls. Despite anecdotal suggestions that the measures have been ineffective, a contrary impression of effectiveness is indicated by the wedge between 'off-shore' (Euro) interest rates and 'on-shore' (domestic) interest rates for the countries concerned. Accordingly, we employed the non-parametric tests outlined in Section 3, to test for a shift in the volatility of the offshore-onshore (short-term) interest differential post-March 1979, for most of the countries considered above. The results are reported in Table 4 (see page 32); they do indeed indicate a sharp rise in the offshore-onshore interest differential for the franc and lira, while there is some evidence of a reduction in volatility of the differential for the mark and guilder. Given that the relaxation of UK and Japanese exchange control was almost contemporaneous with the formation of the EMS, it is hardly surprising that Table 4 reveals strong evidence of a reduction in the UK and Japanese offshore-onshore differentials.

In the absence of an exchange rate agreement and capital controls, equilibrium for a system characterised by inflation differentials of the kind noted in the previous section could be expected to imply a steady depreciation of the high inflation countries' nominal exchange rates vis-à-vis the low inflation 'anchor' country (Germany) at a rate just equal to the difference in interest and inflation rates. With an agreement to restrain the movement of the exchange rate and only to adjust by way of periodic realignments, the interest differential has to oscillate in order to compensate for the switch from a situation in which a realignment is expected to a situation in which it has just occurred, although the degree of oscillation may be mitigated if central rates are realigned before parity limits are reached. Capital controls attenuate this compensatory interest rate fluctuation and prevent the possibility of destabilising speculation. On the assumption that they do not contain the needed adjustment permanently, or for periods long enough to induce major distortion in the real rate of exchange, a case in favour of their use would be that they reduce the perceived welfare losses of fluctuating interest rates and remove the prospect of the 'peso problem' phenomenon (Krasker 1980). In the context of the present functioning of the EMS, it has been argued that it is the presence of capital controls that has made it possible to indulge in the inflation-constraining, underindexed crawling peg realignment policy that speculation might otherwise have made impossible. Without the controls, the market might have forced the authorities' hand and liquidated the overvaluation of weak currencies which the authorities have used as a weapon in their campaign against inflation. This would be the strong case for controls, illustrating the welfare-enhancing effects of the action of 'throwing sand in the wheels' of finance, as advocated by Tobin (1982) some years ago and by Dornbusch (1986) more recently. If there is anything in this argument (and the present authors reserve judgement), the prospect for the future functioning of the EMS gains added interest in the context of the liberalisation of controls in France and Italy and the possible full participation by the UK, with its liberal payments regime, in the system.

4.2 Volatility Transfer

One anti-ERM argument which is sometimes advanced rests on the notion that advanced macroeconomic systems naturally generate a 'lump of uncertainty' which can be pushed from one point in the economy but which will inevitably reappear elsewhere (see eg Batchelor 1983, 1985). For example, it might be argued that removing or reducing exchange rate volatility will inevitably induce a rise in interest rate volatility. Such a conclusion might follow from inverting a standard exchange rate equation and noting that the interest rate is the only other major 'jump variable' in the system. Such a phenomenon might be termed 'volatility transfer'. Insofar as the burden of increased interest rate volatility falls more widely on the general public than that of exchange rate volatility (which presumably falls mainly on the company or more particularly the tradable goods sector), then the welfare argument must hinge on which sector would find it easier to hedge the induced risk. Given that there already exist well-developed forward foreign exchange markets, it is probable that such an argument would come down against membership of the ERM.

However, it is not at all clear that ERM membership is in fact equivalent to 'inverting the exchange rate equation'. Insofar as membership enhances the credibility of policy, there may be a significant reduction in speculative attacks on the exchange rate and hence a <u>reduction</u> in the volatility of short-term interest rates (if the authorities use interest rates as at least a short-term measure for 'leaning into the wind'). Alternatively viewed, there may be a shift in the economic structure according to the Lucas (1976) critique.

In an attempt to shed some light on these arguments we carried out the non-parametric volatility shift tests for monthly changes in both onshore and offshore short-term interest rates; the results are reported in Tables 5a (page 33) and 5b (page 34) respectively.

The welfare arguments alluded to above would seem to imply that the important question is whether or not the ERM has resulted in a transmission of volatility to <u>onshore</u> rather than <u>offshore</u> rates, since these are more likely to impact on the general public. Given the use of capital controls by some countries over much of the data period it is, however, also of interest to examine whether there has been a shift in <u>offshore</u> interest rate volatility post 1979. The results using offshore rates, reported in Table 5b, are qualitatively similar to those using onshore rates. In particular, there are no signs of increased interest rate volatility for any of the EMS currencies and significant indications of reductions in volatility for the lira and the guilder. Again, there is also evidence of increased interest rate volatility post-March 1979 for the US and Canadian offshore rates.

From our discussion in the previous sub-section, the effective operation of French and Italian exchange controls for much of the post-ERM period would be expected to achieve a reduction in onshore interest rate volatility and this is borne out, at least for the Italian case. There is also, however, strong evidence of a reduction in Dutch onshore interest rate volatility whilst the converse is true for US and Canadian onshore rates. Interestingly, there is also evidence of a reduction in the volatility in UK onshore interest rates.

5 CURRENCY SUBSTITUTABILITY AND RISK PREMIA

Following Canzoneri (1982), we can say that the creation of an exchange rate union converts external shocks affecting member countries asymmetrically into symmetric ones; if the permanence of the union is credible, one member currency is as good as another's and an external shock inducing a flight of capital into, say, the mark, should affect the franc and lira in the same way, relieving pressure on the cross rates. Indeed, a dimunition of the exposure of German competitiveness to sentiment against the dollar was apparently a major motivation of German interest in the founding of the EMS (Ludlow, 1982). It therefore seemed of some interest to examine for the substituability of EMS currencies during the period of operation of the EMS.

5.1 Testing for risk premia in the EMS

A number of authors have examined the issue of foreign exchange risk premia - see for example Domowitz and Hakkio, 1985, and Taylor, 1988. Testing for non-zero risk premia between currencies is an indirect and imperfect way of testing for perfect substitutability. The configuration of asset demand and supply may be such that the risk premium may be contingently zero between currencies whose assets are less than perfect substitutes in agents' portfolios. A non-zero risk premium is nevertheless evidence of imperfect substitutability. Thus, a non-zero risk premium is a necessary but not a sufficient condition for assets denominated in those currencies to be perfect substitutes.

A non-zero risk premium should be detected as deviations from the non-risk adjusted uncovered interest parity (UIP) condition. The UIP theorem states that the interest differential between two financial assets, identical in every relevant respect except currency of denomination, should be exactly offset by the expected rate of change of the exchange rate between the relevant currencies over the period to maturity. Under the maintained hypothesis of rational expectations, the risk-adjusted UIP condition may be written:

$$\rho_t + E\,(e_{t+n} \mid I_t) - e_t = i_t - i_t^* \tag{8}$$

where e_t is the (logarithm of the) domestic price of foreign currency, i_t is the exchange rate on the domestic security with n periods to maturity, an asterisk denotes a foreign variable and ρ_t denotes the (possibly time-varying) risk premium. If, for example, ρ_t is positive, agents require a premium for holding the domestic security over and above the expected depreciation adjusted interest differential.

Because of the difficulty in obtaining observed expectations of the future spot rate, empirical tests of UIP (ie that (8) holds with ρ_t identically zero) have generally relied on indirect evidence by assuming covered interest parity (the forward exchange premium is equal to the interest differential - see Taylor 1987a) which together with UIP and rational expectations then implies the optimality of the forward rate as a spot rate predictor. In contrast to early work by Frenkel (1981), a number of studies have rejected the simple UIP condition using this indirect method (Hansen and Hodrick 1980, Hakkio 1981, Baillie, Lippens and McMahon 1983, amongst others). We propose, however, to test currency substitutability directly by inferring the optimal conditional forecast of the future spot rate from the time series properties of the data, using a method originally developed by Sargent (1979) to test the rational expectations model of the term structure of interest rates. Since this methodology is by now well known, we shall give only a brief discussion. For further details see, eg Taylor 1987b.

Setting the risk premium in (8) identically equal to zero the UIP condition becomes:

$$E(e_{t+n} \mid I_t) - e_t = i_t - i_t^* \tag{9}$$

If the one-period rate of depreciation, Δe_t, and the interest differential together form a linearly indeterministic, jointly covariance stationary process, then the multivariate form of a statistical theorem, known as Wold's decomposition (Hannan 1970) implies that the process has a unique, infinite-order moving average representation. For a suitably chosen value of n, this can be approximated in finite samples by an n-th order bivariate vector autoregression. This can be written[5],[6]:

$$\begin{bmatrix}\Delta e_t \\ i_t - i_t^*\end{bmatrix} = \sum_{i=1}^{n}\begin{bmatrix}\alpha_i \\ \gamma_i\end{bmatrix}\Delta e_{t-i} + \sum_{i=1}^{n}\begin{bmatrix}\beta_i \\ \delta_i\end{bmatrix}(i - i^*)_{t-i} + \begin{bmatrix}\varepsilon_t \\ \eta_t\end{bmatrix} \qquad (10)$$

where the innovations process $w_t = (\varepsilon_t \ \eta_t)'$ is vector white noise:

$$E\,(w_t\, w_{t-i}')_i = \begin{cases}\Theta, & i = 0\\ o, & i \neq 0\end{cases}$$

In companion form the model is:

$$Z_t = \Phi Z_{t-1} + \nu_t \qquad (11)$$

where

$$\Phi = \left[\begin{array}{ccc|c|ccc|c}
\alpha_1 & \alpha_2 \ \ldots\ldots & \alpha_{n-1} & \alpha_n & \beta_1 & \beta_2 \ \ldots\ldots & \beta_{n-1} & \beta_n \\ \hline
 & I_{n-1} & & 0 & & 0 & & 0 \\ \hline
\gamma_1 & \gamma_2 \ \ldots\ldots & \gamma_{n-1} & \gamma_n & \delta_1 & \delta_2 \ \ldots\ldots & \delta_{n-1} & \delta_n \\ \hline
 & 0 & & 0 & & I_{n-1} & & 0
\end{array}\right]$$

---

5 Note that the vector autoregressive representation (10) implicitly assumes that the moving average representation has zero deterministic part. In all the empirical work, the data was transformed to mean deviation form, which is equivalent to including constants in the vector autoregressions.

6 Note that this formulation does not directly contradict our earlier reasoning that the exchange rate approximates a random walk - the coefficient matrix may be sparse. Also, although we do not allow for heteroscedastic disturbances in this section, results obtained using the heteroscedastic - robust vector autoregressive tests developed in Taylor 1987c yielded qualitatively identical results to those reported below.

$$Z_t = (\Delta e_t, \ldots \Delta e_{t-n+1}, (i - i^*)_t, \ldots, (i - i^*)_{t-n+1})'$$

$$\nu_t = (\epsilon_t \; 0 \ldots 0 \; \eta_t \; 0 \ldots 0)'$$

Using the first-order formulation, (11), it is then easily shown that:

$$E(e_{t+n} - e_t \mid \Lambda_{t-1}) - E(i_t - i_t^* \mid \Lambda_{t-1})$$

$$= (h' \sum_{k=1}^{n} \Phi^{k+1} - g' \Phi) Z_{t-1} \qquad (12)$$

where Λ_{t-1} is an information set consisting of only lagged values of the rate of depreciation and the interest differential and h and g are 2n dimensional selection vectors with unity in the first and (n+1)th element respectively, and zeros elsewhere. However, taking expectations of the uncovered interest parity condition under perfect substitutability, (8), with respect to Λ_{t-1} implies that (12) should be identically equal to zero. Hence, the zero risk premium restrictions are:

$$h' \sum_{k=1}^{n} \Phi^{k+1} - g' \Phi = 0 \qquad (13)$$

One way of testing these restrictions is to estimate the unrestricted system by ordinary least squares and construct a Wald test statistic. Since this is an asymptotic test, however, we also computed likelihood ratio and lagrange multiplier statistics for the restrictions as a cross-check (see Taylor 1987b for details on the construction of these statistics).

5.2 Empirical Results

Monthly (end-month) data on six-month Eurodeposit interest rates were taken from the Financial Times. In order to ensure compatability, the exchange rate data used in this section were also taken from this source. The ERM currencies considered were the German mark, French franc, Italian lira and Dutch guilder; the non-ERM currencies were the US dollar, UK sterling and Japanese yen.

The order of the vector autoregressions were chosen using the method outlined in Taylor 1987b. Basically, this involves balancing criteria such as whiteness of residuals, likelihood ratio tests on lag restrictions and minimisation of the Akaike Information Criterion (Akaike 1973).

Table 6 (see page 35) gives the results of testing for zero risk premia between the mark and the other currencies examined during the period of operation of the EMS. Whatever test statistic is used, the results are qualitatively identical. As one might have expected, the simple UIP condition (zero risk premium) cannot be rejected for dollar-mark. On the other hand, there are massive rejections of simple UIP between the mark and both the yen and sterling. Perhaps the most striking finding, however, is the strong evidence of non-zero risk premia between the mark and the other ERM currencies. In particular, the simple UIP condition is rejected for the Dutch guilder-mark exchange rate, which is perhaps slightly surprising since the dollar-mark and the dollar-guilder exchange rates are often seen as moving in tandem.

Given that the assumption of rational expectations formed part of the maintained hypothesis in the tests outlined and applied above, one possible interpretation of these findings is that market participants do not in fact efficiently process and act upon all available information. However, since typical participants in foreign exchange and asset markets are highly motivated professionals with access to potentially vast information sets literally at the touch of a button, this might appear a rather unattractive option. Indeed, many economists who would demur at the rational expectations hypothesis in general would accept it as a useful working hypothesis when applied to foreign exchange or asset markets - such a view forms the basis, for example, of the 'partly rational' models of, eg, Dornbusch (1976) or Blanchard (1981).

Given that a non-zero risk premium is a necessary but not a sufficient condition for the assets of two currencies to be perfect substitutes, our findings can at most be taken as circumstantial evidence of perfect substitutability between the mark and the US dollar. By denying this necessary condition for all other currencies against the mark, our results do however, imply that the EMS has not been successful in rendering all member currencies perfect substitutes. Thus, the results of this section suggest that the EMS has not been successful in eliminating the vulnerability of the cross rates of its members vis-à-vis the mark to swings in sentiment against the dollar.[7]

6 REAL EXCHANGE RATES AND THE EMS: RANDOM WALK OR DRAGGING ANCHOR?

As we noted in the introductory section, arguments for joining the ERM may hinge on the targeting of either the real or the nominal exchange rate. Although EMS realignments have probably made less than full adjustment for price level differences, one would expect the longer-run consequences of ERM membership to entail convergence on some form of purchasing power parity (PPP), at least against other ERM currencies; indeed this can be viewed as a measure of policy convergence. Indeed, as we noted in our introductory section, the long-run survival of the system would seem to depend upon long-run preservation of competitiveness, so that member countries are not continually tempted to try and restore their terms of trade.

In fact, however, there exists a whole literature which suggests that deviations from PPP, as measured by the real exchange rate, can generally be characterised to martingale or, more particularly, random walk behaviour. Seminal papers in this context are those of Roll (1979), who proposed a martingale PPP hypothesis based on efficient international goods arbitrage, and Adler and Lehmann (1983), who derive similar conclusions based on considerations of efficient cross-border bond arbitrage. Indeed, if the expected exchange rate depreciation over a given period is just equal to the expected inflation differential, the real exchange rate must follow a random walk.

---

7 Radaelli (1987) provides corroborating evidence of a non-zero risk premium between the franc and the mark over this period by estimating a particular parameterisation of the risk premium suggested by Frankel (1982). From an examination of movements in the onshore-offshore differential, Radaelli also suggests that market participants may have been reasonably accurate in forecasting the timing of realignments. This is quite important in the present context since otherwise our results may suffer from the 'peso problem' (Krasker, 1980). In order to be absolutely sure that our results are not dominated on the peso problem, we are currently engaged in research which seperates the data into 'turbulent' and 'non-turbulent' periods.

This returns us to the distinction we made earlier (and which has been stressed by Williamson (1985)) between volatility and misalignment. We believe that the results reported above constitute quite unequivocal evidence that the ERM has reduced exchange rate volatility, both real and nominal. In this section we want to investigate whether this volatility reduction has been coincident with a reduction in longer-term misalignment.

We propose to examine the long-run implications of the EMS by testing for unit roots in real exchange rates. Since the real exchange rate can be viewed as the deviation from PPP, if some form of (relative or absolute) PPP is to hold in the long run, the real exchange rate must be characterised by a stationary process. If the real exchange rate is non-stationary, there is no tendency for it to settle down at any particular level, even in the long run. Thus, PPP deviations - the degree of misalignment - will tend to get larger and larger over time.

6.1 Testing for unit roots in real exchange rates

The specific hypothesis under examination is that the real exchange rate is characterised by a stochastic process with a unit root. Denote the real exchange rate c, and suppose it is generated in discrete time according to:

$$c_t = c_{t-1} + u_t \tag{14}$$

where the error sequence (u_t) may be weakly dependent and heterogeneously distributed but satisfies certain weak regularity conditions (see Phillips 1987 or Taylor 1987d). This assumption concerning the error process is quite important for two reasons. Much previous empirical work on this topic may be confounded because of implicit assumptions made concerning the error process in the random walk specification - ie that it is independently and identically distributed (iid). As noted above, a number of authors, notably Cumby and Obstfeld (1984), and Domowitz and Hakkio (1985), have noted the presence of conditional heteroscedasticity (more particularly autoregressive conditional heteroscedasticity) in exchange rate innovations. In addition, the 'peso problem' (Krasker, 1980), suggests that a perceived small probability of a large, discrete change in the exchange rate (such as an expected devaluation), which does not materialise in-sample, will induce serial dependence into the forecast errors. In the present paper we therefore apply unit root test which are non-parametric with respect to nuisance parameters and which therefore allow for weakly dependent and heterogeneously distributed forecast errors. Secondly, it may well be that the real exchange rate follows some general ARMA process with a unit root, rather than a pure random walk:

$$(1 - L)\ A(L)\ c_t = B(L)v_t$$

(where A(.) and B(.) are scalar polynomials in the lag operator, L) which can be written in the form (14) with

$$u_t = A^{-1}\ (L)\ B(L)\ v_t$$

Thus, although we apparently test for a pure random walk, the results may in fact detect non-stationarity in higher-order processes.

In order to test the unit root hypothesis with independent and identically distributed (iid) errors, Dickey and Fuller (1981) and Fuller (1976) propose tests based on the ordinary least squares (OLS) regression:

$$c_t = \mu + \beta\ (t - T/2) + \alpha\ c_{t-1} + u_t \tag{15}$$

Where T is the sample size and the null hypothesis is

$$Ho:\ \ (\mu,\ \beta,\ \alpha) = (0,\ 0,\ 1) \tag{16}$$

Under the maintained hypothesis that the error sequence is iid, Fuller (1976) and Dickey and Fuller (1981) derive the limiting distributions of the standard 't-statistics' for the individual null hypotheses $\alpha = 1$, $\mu = 0$, $\beta = 0$ (these statistics will not be distributed as t under the null because of the presence of a unit root) and use Monte Carlo methods to construct estimates of their finite sample empirical distributions. We denote these Dickey-Fuller statistics as t_α, t_μ and t_β respectively. Phillips and Perron (1986) propose amending these statistics to allow for weakly dependent and heterogenously distributed errors (see Phillips and Perron 1986 or Taylor 1987d for details). We denote these amended statistics t^*_α, t^*_μ and t^*_β respectively.

If the error sequence is in fact iid, then the Dickey-Fuller and Phillips-Perron procedures will be asymptotically equivalent. Phillips and Perron show that the tables of critical values tabulated in Fuller 1976 and Dickey and Fuller 1981 can be used for the Phillips-Perron statistics. At a significance level of 5%, the approximate rejection regions for both the Dickey-Fuller and Phillips-Perron statistics are (for a sample size of around 100):

t_α, t^*_α: $\{t \mid t < -3.45\}$

t_μ, t^*_μ: $\{t \mid |t| < 3.42\}$

t_β, t^*_β: $\{t \mid |t| < 3.14\}$

Although these statistics test the individual hypotheses $\alpha = 1$, $\mu = 0$, $\beta = 0$ respectively, since they are constructed under the joint null hypothesis (16), they should reflect <u>any</u> departure from the joint null.

6.2 Empirical Results

Using the same exchange rate and price series data as in our volatility tests, we tested for unit roots in real exchange rates against the mark, pre- and post-EMS.[8] The results are given in Table 7 (see page 36). Interestingly, in no case, either pre- or post-EMS, can the null hypothesis of a pure random walk with zero drift be rejected at standard levels of significance.

There are, however, a number of remarks which should be made concerning these results. Firstly, the results reported in Section 3 show a very definite reduction in intra-ERM exchange rate volatility post-March 1979. In terms of the present section, this can be interpreted as a reduction in the (average) variance of the disturbance term, u_t, in (14). Thus, one interpretation of the present results is that although the ERM has not been able to put a halt to the tendency for exchange rates to become misaligned, it has been successful in reducing the rate at which the degree of misalignment grows. Put another way, the ERM appears to have increased exchange rate predictability, as also evidenced by our analysis in sub-section 3.4. Secondly, it might be argued that the data period over which the ERM has been observed is too short to enable one to infer the very long-run properties of the system: in spectral analysis terms, it may be the case that the low-

8 In each case, the logarithm of the real rate was normalised to zero at the beginning of each test period.

frequency components are not particularly evident in the data collected to date.[9]

7 CONCLUSIONS

The EMS has defied predictions of its imminent demise and thereby built up a stock of credibility with the market - as also with governments. Thus, we found unequivocal evidence that the ERM has brought about a reduction in both the conditional and unconditional variance of exchange rate changes and, far from having purchased this reduction at the cost of increased interest rate volatility, there is also some evidence of a reduction in the volatility of interest rates for ERM members. We attribute this to the enhanced credibility of the exchange rate policies of these countries.

In detail, however, the operation of the EMS has clearly owed something, at times, to the controls over capital flows by France and Italy. The present phase of liberalisation in these countries has highlighted the need for changes. Indeed, it is now recognised by ERM member countries that there is a need for constant monitoring of the system and changes in its mode of operation from time to time. In addition, it has also become more accepted that more explicit co-ordination of monetary, particularly interest rate, policy may be necessary.

Two other findings are of interest. The ERM has not, apparently, been successful in rendering member countries' currencies perfect substitutes or in establishing long-run convergence on some form of purchasing power parity. These findings are probably as much indicative of the system's comparative infancy as of any intrinsic weakness, but they do suggest that the longer-term properties of the system might reward further research.

---

9 A closely allied point relates to the possibly poor power characteristics of the extent tests for random walk behaviour of exchange rates (see eg Hakkio, 1986). Monte Carlo evidence presented in Taylor, 1986 does, however, suggest that a certain class of tests closely related to those used here (the augmented Dickey-Fuller test) may have very high power to reject a false null against a whole range of stationary local alternatives.

Appendix: Density and Asymptotic Score Functions for the Non-Parametric Tests[a]

Distribution	Density Function, $f(x)$	Asymptotic Score Function, $\psi(u)$
Normal	$(2\pi)^{-\frac{1}{2}} \exp(-\frac{1}{2} x^2)$	$\{\Phi^{-1}(u)\}^2 - 1$
Logistic	$e^{-x} (1 + e^{-x})^{-2}$	$(2u - 1) \ln (u/(1-u)) - 1$
Double Exponential	$\frac{1}{2} \exp(- \mid x \mid)$	$-\ln (1 - \mid 2u - 1 \mid) - 1$
Cauchy	$\pi^{-1} (1 + x^2)^{-1}$	$2 \tan^2 (\pi(u-\frac{1}{2}))[1+\tan^2(\pi(u-\frac{1}{2}))]^{-1} - 1$

a The Asympototic score function is defined in relation (4) in the text. $\Phi(.)$ denotes the standard normal distribution function, ie

$$\Phi(u) = \int_{-\infty}^{u} (2\pi)^{-\frac{1}{2}} \exp(-\frac{1}{2} u^2) \, du$$

TABLE 1: CHANGES IN EMS CENTRAL RATES

	Dates of realignments										
	24/9 1979	30/11 1979	22/3 1981	5/10 1981	22/2 1982	14/6 1982	21/3 1983	21/7 1985	7/4 1986	4/8 1986	12/1 1987
Belgian Franc	0.0	0.0	0.0	0.0	-8.5	0.0	+1.5	+2.0	+1.0	0.0	+2.0
Danish Kroner	-2.9	-4.8	0.0	0.0	-3.0	0.0	+2.5	+2.0	+1.0	0.0	0.0
German Mark	+2.0	0.0	0.0	+5.5	0.0	+4.25	+5.5	+2.0	+3.0	0.0	+3.0
French Franc	0.0	0.0	0.0	-3.0	0.0	-5.75	-2.5	+2.0	-3.0	0.0	0.0
Irish Punt	0.0	0.0	0.0	0.0	0.0	0.0	-3.5	+2.0	0.0	-8.0	0.0
Italian Lira	0.0	0.0	-6.0	-3.0	0.0	-2.75	-2.5	-6.0	0.0	0.0	0.0
Dutch Guilder	0.0	0.0	0.0	+5.5	0.0	+4.25	+3.5	+2.0	+3.0	0.0	+3.0

TABLE 2

TEST STATISTICS FOR A SHIFT IN EXCHANGE RATE VOLATILITY AFTER MARCH 1979[a]

TABLE 2a: GERMAN MARK REAL RATES

Exchange Rate	Normal	Logistic	Double exponential	Cauchy
DMK-DKR	3.21 (0.65 E-3)	2.72 (0.32 E-2)	2.71 (0.34 E-2)	2.88 (0.20 E-2)
DMK-BFR	1.39 (0.08)	1.14 (0.12)	1.17 (0.12)	1.08 (0.14)
DMK-FFR	4.53 (0.30 E-5)	3.75 (0.90 E-4)	3.68 (0.12 E-3)	3.67 (0.12 E-3)
DMK-ITL	6.03 (0.80 E-9)	5.08 (0.18 E-6)	5.04 (0.24 E-6)	5.52 (0.17 E-7)
DMK-NGL	3.45 (0.23 E-3)	2.86 (0.20 E-2)	2.98 (0.14 E-2)	3.28 (0.50 E-3)
DMK-US$	0.17 (0.43)	-0.05 (0.48)	-0.10 (0.46)	-0.88 (0.19)
DMK-CN$	1.01 (0.15)	0.55 (0.29)	0.58 (0.28)	-0.50 (0.31)
DMK-JPY	0.96 (0.17)	0.55 (0.29)	0.47 (0.32)	-0.63 (0.26)
DMK-UK£	-0.16 (0.43)	-0.33 (0.37)	-0.25 (0.40)	-1.00 (0.16)

a All statistics are standard normal variates under the null hypothesis of no shift in volatility. Figures in parentheses are marginal (two-sided) significance levels. Significantly positive statistics indicate a reduction in volatility post-March 1979; significantly negative statistics indicate an increase in volatility.

TABLE 2b: **NOMINAL EFFECTIVE RATES**

Currency	Normal	Logisitic	Double exponential	Cauchy
Danish Kroner	-0.59 (0.28)	-0.48 (0.31)	-0.60 (0.27)	-0.95 (0.17)
Belgian Franc	1.59 (0.06)	1.28 (0.10)	1.26 (0.10)	1.01 (0.16)
French Franc	1.33 (0.09)	0.99 (0.16)	0.88 (0.19)	0.23 (0.41)
Italian Lire	3.35 (0.4 E-3)	2.51 (0.60 E-2)	2.45 (0.71 E-2)	1.32 (0.09)
Dutch Guilder	0.66 (0.25)	0.39 (0.34)	0.33 (0.37)	-0.40 (0.34)
German Mark	2.09 (0.02)	1.55 (0.06)	1.46 (0.07)	0.57 (0.28)
US Dollar	-2.62 (0.43 E-2)	-2.25 (0.01)	-2.31 (0.01)	-2.92 (0.17 E-2)
Canadian Dollar	2.03 (0.02)	1.74 (0.04)	1.76 (0.04)	2.05 (0.02)
Japanese Yen	-0.94 (0.17)	-0.62 (0.27)	-0.66 (0.25)	-0.12 (0.49)
UK Sterling	-1.84 (0.03)	-1.62 (0.05)	-1.66 (0.05)	-2.06 (0.02)

TABLE 2c: **REAL EFFECTIVE RATES**

Currency	Normal	Logisitic	Double exponential	Cauchy
Danish Kroner	4.36 (0.65 E-5)	3.61 (0.15 E-3)	3.57 (0.18 E-3)	3.45 (0.27 E-3)
Belgian Franc	1.92 (0.03)	1.61 (0.05)	1.62 (0.05)	1.95 (0.03)
French Franc	2.17 (0.01)	1.78 (0.03)	1.81 (0.03)	1.72 (0.04)
Italian Lire	3.14 (0.85 E-3)	2.45 (0.71 E-2)	2.49 (0.63 E-2)	2.09 (0.02)
Dutch Guilder	1.78 (0.03)	1.45 (0.07)	1.41 (0.08)	1.81 (0.12)
German Mark	3.35 (0.41 E-3)	2.54 (0.50 E-2)	2.49 (0.63 E-2)	1.32 (0.09)
US Dollar	-1.31 (0.09)	-1.32 (0.09)	-1.36 (0.08)	-2.48 (0.65 E-2)
Canadian Dollar	1.39 (0.08)	1.17 (0.12)	1.11 (0.13)	1.11 (0.13)
Japanese Yen	0.10 (0.46)	0.11 (0.45)	0.11 (0.45)	0.22 (0.41)
UK Sterling	-1.44 (0.07)	-1.12 (0.13)	-1.10 (0.13)	-0.91 (0.18)

TABLE 3: **MAXIMUM LIKELIHOOD ARCH ESTIMATES**[a]

$e_t = e_{t-1} + u_t$

$h_t = E(u_t \; I_{t-1}) = \alpha_0 + \alpha_1 u^2_{t-1}$

TABLE 3a: GERMAN MARK NOMINAL RATES

Exchange rate	Pre-ERM $\hat{\alpha}_0$	Pre-ERM $\hat{\alpha}_1$	Pre-ERM mean $h_t^{1/2}$	Post-ERM $\hat{\alpha}_0$	Post-ERM $\hat{\alpha}_1$	Post-ERM mean $h_t^{1/2}$	Likelihood Ratio
DMK-DKR	0.27 E-8 (4.18)	0.33 (1.52)	1.07	0.32 E-4 (4.11)	0.86 (2.48)	0.97	7.00 (0.03)
DMK-BFR	0.42 E-4 (4.55)	0.38 (1.70)	0.85	0.24 E-4 (4.23)	0.97 (2.56)	1.16	5.33 (0.07)
DMK-FFR	0.36 E-3 (5.01)	0.23 E-1 (0.20)	1.92	0.76 E-4 (5.84)	0.13 (1.01)	0.94	30.09 (0.00)
DMK-ITL	0.39 E-3 (4.13)	0.56 (2.13)	2.93	0.91 E-4 (5.15)	0.28 (1.50)	1.11	28.12 (0.00)
DMK-NGL	0.38 E-4 (4.01)	0.70 (2.47)	1.04	0.13 E-4 (5.17)	0.21 (1.50)	0.41	18.71 (0.87 E-4)
DMK-US$	0.57 E-3 (4.44)	0.26 (1.38)	2.80	0.10 E-2 (5.64)	0.14 (1.96)	3.03	6.87 (0.03)
DMK-CN$	0.76 E-3 (4.38)	0.22 (1.22)	3.12	0.85 E-3 (5.64)	0.12 (1.63)	2.76	4.18 (0.12)
DMK-JPY	0.43 E-3 (4.12)	0.34 (1.62)	2.57	0.47 E-3 (4.13)	0.33 (1.69)	2.63	0.09 (0.96)
DMK-UK£	0.38 E-3 (4.26)	0.49 (1.95)	2.70	0.49 E-3 (4.83)	0.09 (0.63)	2.32	2.61 (0.27)

TABLE 3b: US DOLLAR NOMINAL RATES

Exchange Rate	Pre-ERM $\hat{\alpha}_0$	Pre-ERM $\hat{\alpha}_1$	Pre-ERM mean $h_t^{1/2}$	Post-ERM $\hat{\alpha}_0$	Post-ERM $\hat{\alpha}_1$	Post-ERM mean $h_t^{1/2}$	Likelihood Ratio
US$-DKR	0.37E-3 (4.15)	0.34 (1.67)	2.39	0.10E-2 (5.77)	0.15 (2.55)	2.99	13.53 (0.11 E-2)
US$-BFR	0.42E-3 (4.27)	0.31 (1.63)	2.48	0.11E-2 (5.63)	0.13 (1.74)	3.11	10.82 (0.45 E-2)
US$-FFR	0.33 (4.03)	0.52 (2.13)	2.54	0.98E-3 (5.31)	0.11E-1 (0.17)	3.11	8.42 (0.01)
US$-ITL	0.19E-3 (4.10)	0.73 (2.48)	2.40	0.88E-3 (5.58)	0.12 (1.63)	2.80	19.14 (0.70 E-4)
US$-NGL	0.41 (4.02)	0.36 (1.73)	2.55	0.10E-2 (5.52)	0.12 (1.48)	3.00	9.60 (0.81 E-2)
US$-CN$	0.75E-4 (4.17)	0.35 (1.58)	1.05	0.89E-4 (4.84)	0.15 (0.97)	1.02	0.47 (0.79)
US$-JPY	0.32E-3 (4.43)	0.42 (1.95)	2.34	0.89E-3 (5.46)	0.34E-1 (0.31)	3.03	12.07 (0.24 E-2)
US$-UK£	0.28E-3 (3.87)	0.39 (1.81)	2.13	0.94E-3 (6.30)	0.82E-1 (5.78)	2.95	13.54 (0.11 E-2)

a Figures in parentheses below coefficient estimates are t-ratios; those below test statistics are marginal significance levels. The likelihood ratio statistic tests for a shift in the coefficients post-March 1979.

TABLE 4: TEST STATISTICS FOR A SHIFT IN INTEREST RATE VOLATILITY AFTER MARCH 1979: ONSHORE DIFFERENTIAL[a]

Rates	Normal	Logistic	Double exponential	Cauchy
French Franc	-2.70 (0.49)	-2.71 (0.47)	-1.98 (0.54)	-2.01 (0.36)
Italian Lire	-2.55 (0.12)	-2.46 (0.14)	-2.43 (0.14)	-2.20 (0.03)
Dutch Guilder	2.73 (0.64 x 10^{-2})	2.26 (0.02)	2.15 (0.03)	1.86 (0.06)
German Mark	2.41 (0.02)	1.89 (0.06)	1.84 (0.06)	1.30 (0.19)
US Dollar	-1.56 (0.12)	-1.18 (0.24)	-1.13 (0.26)	-0.79 (0.43)
Canadian Dollar	-1.43 (0.15)	-1.10 (0.27)	-1.07 (0.29)	-0.59 (0.56)
Japanese Yen	3.67 (0.24 E-3)	3.27 (0.10 E-2)	3.38 (0.72 E-3)	4.71 (0.25 E-5)
UK Sterling	5.71 (0.11 E-7)	4.74 (0.22 E-5)	4.75 (0.20 E-5)	4.93 (0.84 E-6)

a See note to Table 2.

TABLE 5a: TEST STATISTICS FOR A SHIFT IN INTEREST RATE VOLATILITY AFTER MARCH 1979: ONSHORE SHORT RATES[a]

Rate	Normal	Logistic	Double exponential	Cauchy
French Franc	1.05 (0.29)	0.81 (0.42)	0.75 (0.46)	0.51 (0.61)
Italian Lire	4.56 (0.51E-5)	3.69 (0.22E-3)	3.51 (0.45E-3)	2.87 (0.41E-2)
Dutch Guilder	2.91 (0.36E-2)	2.37 (0.02)	2.25 (0.02)	1.85 (0.06)
German Mark	0.81 (0.42)	0.41 (0.68)	0.38 (0.71)	-0.84 (0.40)
US Dollar	-3.29 (0.10E-2)	-2.60 (0.92E-2)	-2.53 (0.01)	-2.01 (0.04)
Canadian Dollar	-2.77 (0.56E-2)	-2.17 (0.03)	-2.11 (0.03)	-1.42 (0.15)
Japanese Yen	1.15 (0.25)	0.92 (0.36)	0.96 (0.34)	0.88 (0.38)
UK Sterling	6.10 (0.11E-8)	5.10 (0.34E-6)	5.10 (0.35E-6)	5.49 (0.41E-7)

a See note to Table 2.

TABLE 5b: TEST STATISTICS FOR A SHIFT IN INTEREST RATE VOLATILITY AFTER MARCH 1979: OFFSHORE SHORT RATES[a]

Rate	Normal	Logistic	Double exponential	Cauchy
French Franc	1.37 (0.17)	1.30 (0.19)	1.21 (0.23)	1.09 (0.28)
Italian Lire	2.01 (0.44 E-1)	2.11 (0.35 E-1)	2.09 (0.37 E-1)	2.31 (0.21 E-1)
Dutch Guilder	3.00 (0.27 E-2)	2.87 (0.41 E-2)	2.61 (0.91 E-2)	2.09 (0.37 E-1)
German Mark	1.00 (0.32)	0.83 (0.41)	0.77 (0.44)	0.61 (0.54)
US Dollar	-2.17 (0.3 E-1)	-2.09 (0.37 E-1)	-2.31 (0.21 E-1)	-2.11 (0.35 E-1)
Canadian Dollar	-2.08 (0.38 E-1)	-2.14 (0.32 E-1)	-2.05 (0.4 E-1)	-2.21 (0.27 E-1)
Japanese Yen	1.08 (0.28)	0.99 (0.32)	1.07 (0.29)	1.21 (0.23)
UK Sterling	1.11 (0.27)	1.48 (0.14)	1.57 (0.12)	1.42 (0.16)

a See note to Table 2.

TABLE 6

WALD, LIKELIHOOD RATIO AND LAGRANGE MULTIPLIER TESTS FOR THE ZERO RISK PREMIUM RESTRICTIONS: SIX MONTHS MATURITY[a]

Exchange Rate	Chosen of n	R_1	R_2	Q_1	Q_2	L(n-1)	L(n+1)	Wald Statistic	Likelihood Ratio Statistic	Lagrange Multiplier Statistic
Franc-Mark	1	0.10	0.71	26.16	22.77	-	5.48	13.96	12.94	11.03
				(0.45)	(0.65)		(0.24)	(0.001)	(0.0015)	(0.004)
Lire-Mark	1	0.01	0.66	34.87	28.65	-	6.91	88.15	60.13	52.31
				(0.11)	(0.33)		(0.14)	(0.00)	(0.00)	(0.00)
Guilder-Mark	3	0.36	0.64	5.25	30.47	8.49	6.97	268.70	135.83	116.68
				(0.99)	(0.17)	(0.07)	(0.14)	(0.00)	(0.00)	(0.00)
Dollar-Mark	2	0.09	0.66	19.21	26.10	18.26	3.55	5.99	5.84	5.64
				(0.79)	(0.40)	(0.001)	(0.47)	(0.20)	(0.21)	(0.23)
Sterling-Mark	1	0.16	0.80	20.79	19.43	-	1.61	595.85	249.85	138.71
				(0.75)	(0.82)		(0.00)	(0.00)	(0.00)	(0.00)
Yen-Mark	2	0.08	0.87	12.53	33.63	14.51	5.67	506.54	427.03	310.16
				(0.98)	(0.12)	(0.006)	(0.22)	(0.00)	(0.00)	(0.00)

a Period of estimation is July 1979 to December 1986, truncated as necessary because of lags. R_1 and R_2 denote the coefficients of determination for the rate of depreciation and interest differential regressions respectively, Q_1 and Q_2 are the corresponding Ljung-Box statistics, evaluated at 27 autocorrelations and are asymptotically central chi-square variates under the null of white noise residuals, with (27-n) degrees of freedom; L(n-1) in a likelihood ratio statistic for a vector autoregression of order (n-1) (VAR(n-1)) against the alternative VAR(n), whilst L(n+1) tests VAR(n) against VAR(n+1): each is an asymptotically central chi-square variate with four degrees of freedom, and was constructed with a finite sample correction for degrees of freedom as suggested in Sims 1980; the Wald, likelihood ratio and Lagrange multiplier statistics for the zero risk premium restrictions are each asymptotically central chi-square under the null with 2n degrees of freedom; figures in parentheses denote marginal significance levels in all cases.

TABLE 7

TESTING FOR UNIT ROOT IN REAL EXCHANGE RATES[a]

$c_t = \mu + \beta (t-T/2) + \alpha c_{t-1} + u_t$

Exchange Rate	Period	t*	t*	t*
DMK-DKR	Pre-EMS	2.55	-0.81	-2.70
	Post-EMS	1.01	-0.23	-0.26
DMK-BFR	Pre-EMS	2.64	-0.78	-2.72
	Post-EMS	0.98	-0.24	-0.30
DMK-FFR	Pre-EMS	2.75	-0.86	-2.68
	Post-EMS	0.97	-0.21	-0.25
DMK-ITL	Pre-EMS	2.66	-0.84	-2.69
	Post-EMS	0.98	0.25	-0.26
DMK-NGL	Pre-EMS	2.61	-0.83	-2.71
	Post-EMS	0.98	-0.22	-0.26
DMK-US$	Pre-EMS	2.81	-0.77	-2.11
	Post-EMS	1.04	-0.27	-0.31
DMK-CN$	Pre-EMS	2.59	-0.84	-2.65
	Post-EMS	0.97	-0.26	-0.25
DMK-JPY	Pre-EMS	2.63	-0.83	-2.70
	Post-EMS	0.99	-0.24	-0.26
DMK-UK£	Pre-EMS	2.65	-0.82	-2.72
	Post-EMS	1.08	-0.29	-0.30

a t*, t*, t* are the Phillips-Perron's test statistics for the null hypotheses Ha: $\alpha = 1$, Hb: $\mu = 0$, Hc: $\beta = 0$.

Aproximate rejection regions at the 5% level

are $(t^*_\alpha \mid t^*_\alpha < -3.45)$, $(t^*_\mu \mid |t^*_\mu| < 3.42)$

and $(t^*_\beta \mid |t^*_\beta| < 3.14)$ respectively.

References

Adler, M and Lehmann, B, (1983), 'Deviations from Purchasing Power Parity in the Long Run', Journal of Finance, 38, 1471-1487.

Akaike, H, (1973), 'Information Theory and an Extension of the Maximum Likelihood Principle', in B N Petrov and F Csaki (eds), Second International Symposium on Information Theory, Budapest: Akademiai Kiado.

Akhtar, M A, and Hilton, R S (1984), 'Exchange Rate Uncertainty and International Trade: Some Conceptual Issues and New Estimates for Germany and the United States, Federal Reserve Bank of New York Research Paper No 8403, May.

Baillie, R T, Lippens, R E and McMahon, P C (1983), 'Testing Rational Expectations and Efficiency in the Foreign Exchange Market', Econometrica, 51, pp 553-563.

Batchelor, R A (1983) Evidence to House of Commons Select Committee, (op cit).

Batchelor, R A (1985) Evidence to House of Lords Select Committee, (op cit).

Belsley, D (1979) 'On the Efficient Computation of the Non-Linear Full-Information Maximum Likelihood Estimator', paper presented to the European meeting of the Econometric Society, Athens.

Blanchard, O J (1981), 'Output, the Stock Market, and Interest Rates', American Economic Review, 71, pp 132-143.

Boothe, P and Glassman, A (1987), 'The Statistical Distribution of Exchange Rates: Some Empirical Evidences', Journal of International Economics.

Canzoneri, M (1982) 'Exchange Intervention Policy in a Mulitple Country World, Journal of International Economics 13(3/4).

Cumby, R E and Obstfeld, M (1984), 'International Interest Rate and Price Level Linkages under Flexible Exchange Rates: A Review of Recent Evidence', in Bilson, J F O and Marston, R C (eds) Exchange Rate Theory and Practice, Chicago: University of Chicago Press.

Cushman, D O (1986) 'Has Exchange Risk Depressed International Trade? The Impact of Third Country Exchange Risk' Journal of International Money and Finance.

Dickey, D A and Fuller, W A (1981), 'The Likelihood Ratio Statistic for Autoregressive Time Series with a Unit Root', Econometrica, 49, pp1057-72.

Domowitz, I and Hakkio, C S (1985), 'Conditional Variance and the Risk Premium in the Foreign Exchange Market', Journal of International Economics, 18, pp47-66.

Dornbusch, R (1976), 'Expectations and Exchange Rate Dynamics', Journal of Political Economy, 84, pp 1161-76.

Dornbusch, R (1986), 'Exchange Rate Economics, 1986. Royal Economic Society Conference, July.

Engle, R F (1982), 'Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of UK Inflation', Econometrica, 50, pp 987-1007.

European Commission (1982), 'Documents Relating to the European Monetary System', European Economy (Jul).

European Economy (1987), Symposium on Capital Exchange Controls, November.

Frankel, J A (1982), 'A Test of Perfect Substitutability in the Foreign Exchange Market', Southern Economic Journal, October, pp 406-416.

Frenkel, J A (1981), 'Flexible Exchange Rates, Prices and the Role of "News": Lessons from the 1970s', Journal of Political Economy, 89, pp665-705.

Fuller, W A (1976), Introduction to Statistical Time Series, New York: John Wiley.

Giavazzi, F and Giovannini, A (1986), 'The EMS and the Dollar', Economic Policy 2 (Apr).

Giavazzi, F and Pagano, M (1985), 'Capital Controls and Foreign Exchange Legislation', Occasional Paper, Euromobiliare, June.

Goodhart, C A E, (1986), 'Should the UK Join the EMS?', Mimeo, London School of Economics.

Goodhart, C A E, (1987), 'The Foreign Exchange Market: A Random Walk with a Dragging Anchor', LSE Financial Markets Group Discussion Paper.

Goodhart, C A E, and Taylor, M P, (1987), 'Why Don't Individuals Speculate in the Forward Foreign Exchange Market?', London School of Economics Financial Markets Group Discussion Paper No 17.

Hajek, J and Sidak, Z (1967), Theory of Rank Tests, New York and Prague: Academic Press.

Hakkio, C S, (1981), 'Expectations and the Forward Exchange Rate', International Economic Review, 22, pp 663-678.

Hakkio, C S, (1986), 'Does the Exchange Rate Follow a Random Walk? A Monte Carlo Study of Four Tests for a Random Walk', Journal of International Money and Finance, 5, pp 221-230.

Hannan, E J, (1970), Multiple Time Series, New York: John Wiley.

Hansen, L P and Hodrick, R J, (1980), 'Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis', Journal of Political Economy, 88, pp829-853.

House of Commons Select Committee (1985) 'The European Monetary System, 13th Report from the Treasury and Civil Service Committee, and Evidence.

House of Lords Select Committee (1983), European Monetary System, 5th Report and Evidence.

International Monetary Fund (1983), Exchange Rate Volatility and World Trade, IMF Occasional Paper No 28, July.

Krasker, W S, (1980), 'The "Peso Problem" in Testing the Efficiency of Forward Exchange Markets', Journal of Monetary Economics, 6, pp296-276.

Lucas, R E (1976), 'Econometric Policy Evaluation: A Critique', in Brunner, K and Meltzer, A H, (eds), The Phillips Curve and Labour Markets, Carnegie-Rochester Conference Series No 1, New York: North-Holland.

Ludlow, P, (1982) The Making of the European Monetary System, London: Butterworths.

Melitz, J (1985), Evidence to the House of Commons Select Committee (op cit).

Mussa, M (1984), 'The Theory of Exchange Rate Determination', in Bilson, J F O, and Marston, R C (eds) Exchange Rate Theory and Practice, Chicago: University of Chicago Press.

Padoa-Schioppa, T (1983) 'Evidence to the House of Lords Select Committee (op cit).

Pagan, A and Ullah, A (1986) The Econometric Analysis of Models with Risk Terms, Centre for Economic Policy Research Discussion Paper No 127.

Phillips, P C B (1987), 'Time Series Regression with a Unit Root', Econometrica, 55, pp 277-302.

Phillips, P C B and Perron, P (1986), 'Testing for a Unit Root in Time Series Regression' Cowles Foundation Discussion Paper No 795.

Radaelli, G (1987), 'EMS Stability, Capital Controls and Foreign Exchange Market Intervention', Chase Manhattan Bank Working Paper in Financial Economics No2, Chase Manhattan Bank, NA, London.

Rogalski, R J and Vinso, J D (1977), 'Price Level Variations as Predictors of Flexible Exchange Rates', Journal of International Business Studies, Spring/Summer, pp71-81.

Rogoff, K (1985), 'Can Exchange Rate Predictability be Achieved without Monetary Convergence'. European Economic Review.

Roll, R (1979), 'Violations of Purchasing Power Parity and their Implications for Efficient International Commodity Markets' in Sarnat, M and Szego, G P (eds) International Finance and Trade, Vol 1, ch 6, Cambridge Mass, Ballinger.

Sargent, T J, (1979), 'A Note on Maximum Likelihood Estimation of the Rational Expectations Model of the Term Structure', Journal of Monetary Economics, 5, pp 133-143.

Taylor, M P (1986), 'On Unit Roots and Real Exchange Rates: Empirical Evidence and Monte Carlo Analysis', Bank of England, Mimeo.

Taylor, M P (1987a), 'Covered Interest Parity: A High-Frequency, High-Quality Data Study', Economica, 54, pp429-438.

Taylor, M P (1987b), 'Risk Premia and Foreign Exchange: A Multiple Time series Approach to Testing Uncovered Interest Parity', Weltwirtschaftliches Archiv, forthcoming.

Taylor, M P (1987c), 'Testing Ex Ante Purchasing Power Parity Using Vector Autoregressions in the Time Domain', Bank of England, Mimeo.

Taylor, M P (1987d), 'Exchange Rates, Random Walks and News: Some Robust Tests on High-Frequency Data', mimeo, Bank of England.

Taylor, M P (1988), 'A DYMIMIC Model of Forward Foreign Exchange Risk, With Estimates for Three Major Exchange Rates' The Manchester School of Economic and Social Studies, forthcoming March.

Tobin, J, (1982), 'A Proposal for International Monetary Reform'. In Essays in Economics: Theory and Policy, Cambridge: MIT Press.

Ungerer, H, Evans O, and Nyberg, P, (1983), 'The European Monetary System: the Experience 1979-1982, IMF Occasional Paper No 19, May.

Ungerer, H, Evans, O, Mayer, T, and Young, P (1987), The European Monetary System: Recent Developments, mimeo, International Monetary Fund.

Westerfield, J M (1977), 'Empirical Properties of Foreign Exchange Rates under Fixed and Floating Rate Regimes' Journal of International Economics, 7, pp 181-200.

Williamson, J, (1985), The Exchange Rate System, rev ed, Policy Analyses in International Economics, 5, Institute for International Economics, June.

Bank of England Discussion Papers

	Title	Author
1-5,8, 11-14 16-17, 20-23	*These papers are now out of print, but photocopies can be obtained from University Microfilms International (see below).*	
6	'Real' national saving and its sectoral composition	C T Taylor A R Threadgold
7	The direction of causality between the exchange rate, prices and money	C A Enoch
9	The sterling/dollar rate in the floating rate period: the role of money, prices and intervention	I D Saville
10	Bank lending and the money supply	B J Moore A R Threadgold
15	Influences on the profitability of twenty-two industrial sectors	N P Williams
18	Two studies of commodity price behaviour: Interrelationships between commodity prices Short-run pricing behaviour in commodity markets	 Mrs J L Hedges C A Enoch
19	Unobserved components, signal extraction and relationships between macroeconomic time series	T C Mills
24	The importance of interest rates in five macroeconomic models	W W Easton
25	The effects of stamp duty on equity transactions and prices in the UK Stock Exchange	Mrs P D Jackson A T O'Donnell
26	An empirical model of company short-term financial decisions: evidence from company accounts data	Ms G Chowdhury C J Green D K Miles
27	Employment creation in the US and UK: an econometric comparison	I M Michael R A Urwin
28	An empirical model of companies' debt and dividend decisions: evidence from company accounts data	Ms G Chowdhury D K Miles
29	Expectations, risk and uncertainty in the foreign exchange market: some results based on survey data	M P Taylor
30	A model of UK non-oil ICCs' direct investment	E J Pentecost
31	What has the European Monetary System achieved?	M P Taylor M J Artis

Papers presented to the Panel of Academic Consultants[(a)]

	Title	Author
8	International monetary arrangements the limits to planning*	P M Oppenheimer
9	Institutions in the financial markets: questions, and some tentative answers*	M V Posner
10	The arguments for and against protectionism*	M Fg Scott The Hon W A H Godley
14	The usefulness of macroeconomic models*	Prof W H Buiter T F Cripps Prof Angus Deaton Prof A P L Minford M V Posner
15	Factors underlying the recent recession*	G D N Worswick Dr A Budd
17	Why do forecasts differ?*	Prof M J Artis
19	Bank lending, monetary control and funding policy*	Prof A D Bain
20	The economics of pension arrangements*	Prof Harold Rose J A Kay
22	Monetary trends in the United Kingdom	Prof A J Brown Prof D F Hendry and N R Ericsson
23	The UK economic recovery in the 1930s	G D N Worswick P N Sedgwick Prof Michael Beenstock Dr Forrest Capie Prof Brian Griffiths
24	Employment, real wages and unemployment in the United Kingdom*	Prof J R Sargent Sir Bryan Hopkin

Technical Series

	Title	Author
1-11	*These papers are now out of print, but photocopies can be obtained from University Microfilms International (see below).*	
12	The development of expectations generating schemes which are asymptotically rational	K D Patterson
13	The arch model as applied to the study of international asset market volatility	R R Dickens
14	Modelling the UK economy in a stock-flow consistent manner	E P Davis
15	International comparison of asset market volatility : a further application of the ARCH model	R R Dickens
16	A three sector model of earning behavior	D J Mackie
17	Integrated balance sheet and flow accounts for insurance companies and pension funds	Raymond Crossley

* These papers are no longer available from the Bank, but photocopies can be obtained from University Microfilms International, at White Swan House, Godstone, Surrey, RH9 8LW.

(a) Other papers in this series were not distributed.