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The Stabilizing Effect of the ERM on Exchange Rates and Interest Rates: An Empirical Investigation

Prepared by Michael J. Artis and Mark P. Taylor 1/

Authorized for Distribution by Peter Clark

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Abstract

This paper applies nonparametric test procedures to test for a shift in the volatility of nominal and real exchange rates for ERM members and nonmembers. The results imply a reduction in volatility for the ERM members, especially during the second half of the period of operation of the ERM. We also demonstrate that this enhanced stability was not bought at the expense of increased interest rate volatility. The issue of interest rate volatility during sterling's participation in the ERM is also examined.

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F31, F42

1/ Michael J. Artis is Professor of Economics at the University of Manchester. This paper was completed while Professor Artis was a Visiting Scholar in the Research Department of the International Monetary Fund. Mark P. Taylor is a Senior Economist in the Economic Modeling and External Adjustment Division of the Fund's Research Department.

Table of Contents

List of Tables

Summary

This paper investigates the volatility of exchange rates and interest rates of member countries of the exchange rate mechanism (ERM) of the European Monetary System (EMS) by comparing it with that of a control group of non-ERM currencies before and after the inception of the ERM. Because there are doubts about the true distribution of exchange rate and interest rate changes, a nonparametric method is used. It also examines how volatility changes over time.

The essential findings are very clear. During the operation of the EMS, the volatility of intra-ERM (specifically bilateral-deutsche mark) exchange rates fell, whereas the volatility of non-ERM currencies has remained the same or increased. This effect was big enough to replicate itself for the ERM countries' overall effective exchange rates also. Similar conclusions, albeit not quite so striking, were obtained for real bilateral and real effective exchange rates. The general impression that the ERM had evolved over time in the direction of greater stability is also confirmed on this data set.

The same technique is applied to study the evolution of volatility in "offshore" or "Eurocurrency" interest rates. Again, volatility appears to be somewhat reduced for the ERM countries compared with the control group. This result is inconsistent with the "volatility transfer" hypothesis according to which reduced stability in exchange rates would imply added volatility in interest rates. Moreover, the high-frequency volatility of ERM interest rates did not shift significantly during the time the United Kingdom was participating in the ERM.

Drawing on earlier work by the present authors on the long-run credibility of the ERM and taking into account the distinction between short-run volatility and long-term misalignment, the paper argues that the very recent turbulence in the EMS is not inconsistent with the short-run, stabilizing influence of the ERM that is documented here.

I. Introduction

Recent events, since the so-called "Black Wednesday" of September 16, 1992, have placed a doubt in the minds of some observers over the future operation of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS). The speculative spasm that seized the markets in that period precipitated the floating of both the lira and the pound sterling (the former "inside" and the latter "outside" the ERM) and caused the first devaluation of the Spanish peseta. Since that time several other currencies, the Portuguese escudo, the Irish punt, the Danish kroner and the French franc have come under intermittent, and at times intense, speculative pressure. Whether and how the ERM might be reconstituted to secure its performance from such pressures is still a controversial issue. Although worries concerning substitutability between member currencies and possible misalignments within the ERM--and the implications for the long-run viability of the Mechanism--had been voiced earlier (e.g., Artis and Taylor, 1989), few are in doubt that the ERM had in the past been successful in stabilizing volatility in exchange rates between member countries. This paper provides empirical support for that presumption and goes further to examine some additional propositions where the presumption is less clear. Thus we examine whether what is true of intra-ERM exchange rates is also true of exchange rates between ERM member countries and non-members and we distinguish between real and nominal exchange rates to see whether the stabilizing effect of the ERM on the latter also holds for the former. In addition, because stability in exchange rates might be bought at the cost of a destabilization of interest rates, we explicitly examine whether this is true. Further, whilst we have referred so far to the EMS as if it were a chronologically homogeneous regime, it is apparent from casual observation that the system has evolved over time. In particular, it has been observed (Giavazzi and Spaventa, 1990) that in its later operation and before giving way to the trauma of 1992's disturbances, the system became exceptionally stable. We examine this proposition and confirm that the stabilizing effect of the ERM became more marked over this period of time. Given the recent intense pressures within the ERM which became apparent in September 1992, however, we also investigate whether these are reflected in increased volatility in member countries' interest rates during the United Kingdom's period of participation in the mechanism. The core of this paper is the application of a nonparametric method for testing whether the ERM had a stabilizing effect; this is in contrast to the large number of studies which employ parametric methods. There are good reasons, as we explain in Section III, for our preference for a nonparametric approach. However, we first describe in Section II the set-up and formal provisions of the EMS in the period under study.

II. Provisions of the EMS

The European Monetary System (EMS) was instituted in March 1979, largely as a reaction to the volatility of exchange rates among European countries during the years following the breakdown of the Bretton Woods system. At the heart of the EMS is the Exchange Rate Mechanism (ERM). Countries participating in the ERM undertake to maintain their bilateral exchange rates within bilateral bands of ±2.25 percent around an agreed central rate. Exceptionally, Italy negotiated a temporarily wider band of ±6 percent at the outset of the system (relinquished for the narrow band in January 1990), an example subsequently followed by the United Kingdom, Spain, and Portugal when these countries entered the Mechanism. (Spain and Portugal are still working within this broader band whilst the U.K. is now floating.) Spain entered the Mechanism in June 1989, the United Kingdom in October 1990 and Portugal in April 1992. Maintenance of the bilateral rates within the bands is formally a symmetrical obligation as the strong currency country is equally obliged to prevent its currency going through the ceiling as the weak currency country is to prevent it falling through the floor. Intervention resources to support these obligations are made available through credit lines, notably through the Very Short Term Financing Facility. The Basle-Nyborg agreements arrived at in 1987 strengthened the Mechanism by expanding these credit lines, lengthening the repayment period associated with them and establishing the "presumption" that credit would be supplied to intervention operations within the band (so-called "intramarginal intervention") where the previous provisions formally pertained only to intervention at the limits of the band ("marginal intervention"). 1/ The Basle-Nyborg Agreement also called for a strengthening of cooperation and coordination in monetary policy.

The central rates in each bilateral band can be changed in a realignment. Table 1 shows the timing and extent of such realignments through to the last realignment before the speculative surge of last September. 2/ As can be seen, the frequency and extent of realignments of central rates declined rapidly after the first half of the decade.

Although the center of the Mechanism is the set of provisions concerning bilateral rates, the system is formally organized around a composite currency, the European Currency Unit (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 in the EMS, the divergence indicator and threshold positions. According to these provisions, when a currency triggers its divergence indicator threshold (calculated as the ECU value of a departure of its bilateral rates against all the other countries up to

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1/ Although this presumption was established, the financing central bank could still, in principle, object. Other special conditions were also attached to intra-marginal interventions under the Basle-Nyborg agreements, relating to credit limits and currency of repayment.

2/ The lira was formally devalued (by 7 percent) on September 12, 1992, but commenced a float soon afterwards on September 17, following the example of sterling which was floated from September 16. The peseta was devalued on September 17, by 5 percent and again, by a further 6 percent, on November 22, at which time the escudo was devalued by a similar amount. The punt was devalued by 10 percent on January 30, 1993; on May 13 the peseta was devalued by a further 8 percent with a parallel devaluation of the escudo, of 6.5 percent.

Table 1. Changes in EMS Central Rates prior to September 1992

	Dates of Realignments											
	9/24 1979	11/30 1979	3/22 1981	10/5 1981	2/22 1982	6/14 1982	3/21 1983	7/21 1985	4/7 1986	8/4 1986	1/12 1987	1/8 1990
Percentage change in parity:												
Belgian Franc	0.0	0.0	0.0	0.0	-8.5	0.0	+1.5	+2.0	+1.0	0.0	+2.0	0.0
Danish Kroner	-2.9	-4.8	0.0	0.0	-3.0	0.0	+2.5	+2.0	+1.0	0.0	0.0	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	0.0
French Franc	0.0	0.0	0.0	-3.0	0.0	-5.75	-2.5	+2.0	-3.0	0.0	0.0	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	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	-3.7
Dutch Guilder	0.0	0.0	0.0	+5.5	0.0	+4.25	+3.5	+2.0	+3.0	0.0	+3.0	0.0

75 percent of the band limit), a presumption is created that the country concerned should take corrective action (involving monetary and fiscal policy or taking the initiative for a realignment). This technical provision was designed both to provide an early warning of bilateral limit contacts and, more important, to isolate an errant currency--the one standing out against all the others.

There seems to have been little doubt in the minds of those who constructed these provisions that the errant currency was going to be the strong deutsche mark. 1/ It is one of the curiosities of the history of the system that in fact the mark has not often been at the higher end of its permitted range and that, for the major period of operation of the ERM, the inflation policy priority has been so strong that it was not desired to single it out (Padoa-Schioppa, 1983), and the mark naturally evolved as the anchor currency of the system.

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 (although these countries abolished remaining restrictions on capital movements in January and May 1990 respectively, ahead of the deadline of July 1 imposed by EC directive). Artis and Taylor (1988) provide evidence--in the form of the volatility of the offshore-onshore interest rate differential for mark and lira post-March 1979--that these controls were used substantially. They 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.

The immediate objective, then, of the ERM has clearly been the stabilization of the bilateral nominal exchange rates among its members. Moreover it is well known that whilst the ERM in its early phase of operation was used as a means of restraining exchange rate "overshooting," preserving the competitiveness of participant countries through frequent realignment, the system subsequently evolved as a counter-inflationary framework. Nominal exchange rate stabilization and counter-inflationary policy commitment to fixed nominal rates are clearly not consistent with real rate (competitiveness) stabilization unless inflation rates are convergent. Yet it can be argued that, as the exchange rate expression of a customs union, the EMS must have an "inner rationale" of maintaining broadly stable conditions of competitiveness. Otherwise, the achievements of reducing protection will be called into question. It is just as important,

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1/ Ludlow (1982) gives a detailed and informative account of the negotiations leading to the institution of the EMS. Van Ypersele (1985) provides a more detailed account of the institutional features of the System.

therefore, to explore whether real exchange rates have been stabilized as it is to test for nominal rate stabilization.

A further important issue arises with respect to the stability of EMS exchange rates vis-à-vis outside currencies. To the extent that the ERM succeeds in forcing greater coherence on the partner currencies it is inevitable that the characteristics of the individual currencies vis-à-vis third currencies will become more homogeneous. To take an example which is not entirely fanciful, if the dollar-mark rate is exceptionally volatile, the growing association of the franc with the mark will impart some of the mark's exceptional volatility against the dollar to the franc. (Indeed, to the extent to which this does not happen, tensions within the ERM will be caused by shifts of sentiment about the dollar, which would exert pressure on the mark-franc exchange rate.) Thus, an important issue to explore is whether volatility reduction for intra-EMS parities has been offset, partially, wholly or even more-than-wholly by volatility increases in extra-EMS parities for some European currencies.

III. Studies of Volatility in the EMS

As already noted, before the events of September 1992, there had been twelve realignments of the currencies participating in the EMS. This, together with the fact that quite wide variations are allowed by the parity grid margins, and that there has been, to date, less than full convergence of inflation among ERM members (Masson and Taylor, 1992), 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 (however defined) over a protracted period of time. In fact, in a world of risk-neutral producers and consumers, it can be shown that higher exchange volatility will actually enhance overall welfare (see e.g., De Grauwe, 1992, pp. 64-67); but this conclusion becomes more equivocal when allowance is made for risk-aversion and incomplete forward markets. A related question concerns the effect of ERM membership on interest rates. If the union is successful in generating a convergence of interest rates toward the lower level of those of the low-inflation anchor currency, there may be positive welfare gains since higher interest rates may generate important principal-agent problems in domestic capital markets (Stiglitz and Weiss, 1981). Also, some authors (Baldwin, 1989, EC Commission, 1990) have argued--using an endogenous growth model framework--

that such lower interest rate effects may generate permanently higher growth paths for GDP. 1/

With respect to the effects of exchange rate volatility on trade flows, the evidence is mixed. While a study by Akhtar and Hilton (1984) found evidence of a negative correlation between exchange rate volatility and U.S.-German trade flows, comparable studies by the Bank of England (1984) and the International Monetary Fund (1983) failed to confirm this finding for alternative trade flows, time period and volatility measures. Cushman (1986), however, finds evidence of volatility effects on trade when "third country" effects are controlled (e.g., dollar-mark volatility may affect U.S.-U.K. trade).

Despite these caveats, 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, 1987, 1990), the European Commission (1982), Padoa-Schioppa (1983), Rogoff (1985), and Artis and Taylor (1988). 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, and 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 behavior 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, although the improvement is less marked for effective rates.

IV. Some Non-Parametric Volatility Tests

Many 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 assess scientifically 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 parameterization of the volatility and testing for a structural shift 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 stylized 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

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1/ In fact, these authors apply these arguments to the prospect of a single European currency, but similar arguments apply in the present case.

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 behavior is provided by Boothe and Glassman (1987) who find that mixtures of normal distributions provide some of the best fits to their data.

We wish to stress the importance of attempting to capture the correct distributional properties of exchange rate changes in any volatility study. Studies which rely on simple variance measures implicitly invoke 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 is conceivable that exchange rate changes at a certain frequency have a Cauchy distribution, for which no finite moments of any order exist.

In order to circumvent some of these problems, we apply nonparametric 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:

$$\Delta e_t = \mu + \sigma_t \epsilon_t \tag{1}$$

$$\sigma_t = \exp(\alpha + \beta z_t) \tag{2}$$

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 hypothesized shift in volatility at time N+1:

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

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

$$H_0 : \beta = 0 \qquad (3)$$

Hajek and Sidak (1967) (henceforth HS) develop a number of nonparametric 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:

$$\zeta = \sum_{t=1}^{T} (z_t - \bar{z})\, \alpha(u_t) \qquad (4)$$

where $\bar{z}$ is the arithmetic mean of the z_t sequence of T observations and u_t is defined as follows. Let r() be the rank of Δe_i; i.e., $r(\Delta e_i)$ is the $r(\Delta e_i)$-th smallest absolute 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 (4) is a score function defined in HS (page 70), depending upon the assumed density of ϵ_t. (i.e., 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:

$$F(x) = \int_{-\infty}^{x} f(u)\, du \qquad (5)$$

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

$$F^{-1}(u) = \text{Infimum } \{x \mid F(x) \geq u\} \qquad (6)$$

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

$$\psi : (0,1) \rightarrow \mathbb{R} \qquad (7)$$

$$\psi(u) = - F^{-1}(u) \left[\frac{f'(F^{-1}(u))}{f(F^{-1}(u))} \right] - 1.0 \qquad (8)$$

Under the maintained hypothesis (1), the statistic

$$\eta = \sum_{t=1}^{T} (z_t - \bar{z})\, \psi(u_t) \tag{9}$$

(i.e., as in (4) with $\alpha(.)$ replaced by $\psi(.)$) will be asymptotically normally distributed.

Under the null hypothesis (3), η will have mean zero and variance ρ^2 given by (HS, pp. 159-160):

$$\rho^2 = \left\{ \sum_{t=1}^{T} (z_t - \bar{z})^2 \right\} \int_0^1 \left\{ \psi(u) - \bar{\psi} \right\}^2 du \tag{10}$$

where

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

Thus, for a given choice of f, the statistic (η/ρ) will be asymptotically standard normal under the null hypothesis of no shift in volatility. Significantly negative values of η reflect a negative value for β in (2)--i.e., an increase in volatility after the shift point--whilst significantly positive values of η imply a reduction in volatility.

Note that although the test procedure just outlined is nonparametric in the sense that no volatility measures are actually estimated, in implementing the procedure we cannot avoid choosing an appropriate distribution for ϵ_t. In order to try and minimize the damage due to choosing an inappropriate distribution we selected four well-known ones in the belief that the true distribution will be close to one of them. If qualitatively similar nonparametric results are obtained for a range of assumed distributions, then the results may be said to be robust to this uncertainty. The densities used correspond to the normal, logistic, double exponential and Cauchy distributions. The density and asymptotic score functions (as defined in (8)) 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. 1/

V. Data

The data we use are monthly (end-month) data on bilateral U.S. dollar exchange rates and on nominal effective exchange rates, taken from the IFS data tape for the period January 1973 through October 1990 and on Eurocurrency interest rates (three-month maturity) for the period January 1975 through February 1993. The end-point of the exchange rate sample coincides with Britain's entry into the ERM: this choice of sample allows us to use sterling as a representative non-ERM currency. Bilateral rates against the German mark and U.K. sterling were also constructed by assuming a triangular arbitrage condition. Real exchange rates were constructed by deflating by the wholesale price relatives (data also from the IFS tape). 2/ The currencies used included those of three ERM members--German mark, French franc, and Italian lira and three non-ERM members--U.S. dollar, U.K. sterling, and Japanese yen. We also obtained monthly data on three-month maturity Eurodeposit interest rates in order to investigate the hypothesis that exchange rate fixity may impart interest rate volatility. All results reported are for shifts in the volatility of monthly changes.

VI. The Overall ERM Effect

In the first set of tests, we looked for a shift in exchange rate volatility post-March 1979.

1. Nominal exchange rates

As would be expected, the results of applying the nonparametric volatility shift tests show a significant reduction, after March 1979, in the volatility of the ERM currencies against the mark (Table 2.A), whilst the volatility of the mark against sterling, yen, and dollar appears unchanged. Table 2.B shows that whilst there may have been some increase in the volatility of the dollar-lira exchange rate post March 1979, this is not the case for dollar-franc and dollar-mark exchange rates (although the test statistics are uniformly negative, suggesting a tendency towards increased volatility). The volatility of the dollar-sterling and dollar-yen exchange

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1/ Another relevant distribution would have been Student's t. However, the score function (8) 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 (e.g., shifted from normal to Cauchy). Tests for this kind of behavior could conceivably be based on likelihood ratios, although one might suspect that the discriminatory power of such procedures would be low.

2/ Wholesale prices were used as a proxy for tradeable goods prices.

Table 2. Test Statistics for a Shift in Nominal Exchange Rate Volatility
Period 1973:1 - 1979:3 vs. 1979:4 - 1990:10

Exchange Rate	Normal		Logistic		Double Exponential		Cauchy	
A. DMK Nominal Exchange Rate								
DMK - FFR	6.405	(0.000)	5.396	(0.000)	5.272	(0.000)	5.399	(0.000)
DMK - ILI	7.563	(0.000)	6.118	(0.000)	5.942	(0.000)	5.093	(0.000)
DMK - UK£	0.222	(0.824)	0.135	(0.893)	0.103	(0.918)	-0.159	(0.874)
DMK - JYE	-0.498	(0.619)	-0.444	(0.657)	-0.451	(0.652)	-0.546	(0.585)
DMK - US$	-0.502	(0.616)	-0.685	(0.493)	-0.644	(0.520)	-1.310	(0.190)
B. US$ Nominal Exchange Rate								
US$ - FFR	-0.935	(0.350)	-1.098	(0.272)	-1.323	(0.186)	-2.869	(0.004)
US$ - ILI	-1.835	(0.067)	-1.929	(0.054)	-2.058	(0.040)	-3.770	(0.000)
US$ - DMK	-0.604	(0.546)	-0.755	(0.450)	-0.720	(0.471)	-1.361	(0.173)
US$ - UK£	-2.625	(0.009)	-2.171	(0.030)	-2.189	(0.029)	-2.830	(0.017)
US$ - JYE	-1.956	(0.050)	-2.088	(0.037)	-2.179	(0.029)	-4.286	(0.000)
C. Nominal Effective Exchange Rate								
French Franc	2.720	(0.007)	2.099	(0.036)	1.941	(0.052)	1.148	(0.251)
Italian Lira	3.143	(0.002)	2.225	(0.026)	2.144	(0.032)	0.637	(0.524)
Deutsche Mark	3.077	(0.022)	2.356	(0.018)	2.294	(0.022)	1.419	(0.156)
U.K. Sterling	-1.694	(0.090)	-1.635	(0.102)	-1.717	(0.086)	-2.634	(0.008)
Japanese Yen	-1.531	(0.126)	-1.120	(0.263	-1.101	(0.271)	-0.458	(0.647)
U.S. Dollar	-3.006	(0.003)	-2.670	(0.008)	-2.738	(0.006)	-3.652	(0.000)

Note: Figures in parenthesis denote marginal, two-sided significance levels. All test statistics are distributed as standard normal under the null hypothesis of no shift in volatility. Significantly positive test statistics indicate a reduction in volatility after the break point; significantly negative statistics indicate the converse.

rates has risen significantly in the post March 1979 period (Table 2.B), however.

Table 2.C reveals that there has been an unequivocal reduction in the volatility of nominal effective ERM exchange rates post March 1979, whilst exactly the converse is true of the U.S. dollar nominal effective rate. The results for the effective sterling and yen rates, whilst significant in only one case, are nevertheless uniformly negative and large in absolute magnitude, indicating a tendency towards increased volatility.

2. Real exchange rates

Table 3.A shows a marked, significant reduction in the volatility of the mark-lira rate post March 1979, and a similar--albeit statistically insignificant--reduction is indicated by the large, positive values of the test statistics for the mark-franc rate. For the three real exchange rates between the mark and the non-ERM countries, an insignificant shift is indicated (Table 3.A).

Table 3.B shows results of the tests applied to real effective exchange rates. Strong and significant reductions in volatility are indicated for the franc and the lira, and positive statistics were also recorded for the mark. For sterling and the yen, the test statistics are negative but insignificant, whilst for the dollar real effective rate a strongly significant rise in volatility post March 1979 is indicated.

3. An overall ERM effect?

Overall, the results reported in this section indicate that the ERM has been successful in reducing exchange rate volatility--both real and nominal--since March 1979. This is particularly impressive in light of evidence that the volatility of non-ERM exchange rates--particularly the dollar--has risen over the same period.

VII. A New EMS?

A number of commentators (e.g., Giavazzi and Spaventa, 1990), have noted a shift over time in the nature of the EMS, towards less frequent realignments (Table 1) and more concerted action towards internal adjustment. It is not entirely clear when this shift should be dated from and, accordingly, we tested for a shift in volatility for two different sub-periods within the period of operation of the ERM. We first tested for a shift in exchange rate volatility after the realignment of March 1983 (Tables 4 and 5). The results do, indeed, indicate a downward shift in the volatility of ERM exchange rates--real and nominal, bilateral and effective. For the dollar and sterling, however, there is little sign of a shift in volatility, although yen exchange rates do appear to have become more stable over this period. The second sub-period begins after the realignment of April 1986. The results of testing for a shift in volatility after this realignment (Tables 6 and 7) are broadly comparable to those reported for the first subsample--although there is less sign of reduced yen volatility.

We therefore conclude that these results confirm the hypothesis of a "new," harder EMS for the period after 1982, in which greater emphasis was given to harmonizing EMS-wide, internal macro-policy objectives (Giavazzi and Spaventa, 1990).

Table 3. Test Statistics for a Shift in Real Exchange Rate Volatility
Period 1973:1 - 1979:3 vs. 1979:4 - 1990:10

Exchange Rate	Normal		Logistic		Double Exponential		Cauchy	
A. DMK Real Exchange Rate								
DMK - FFR	1.652	(0.099)	1.469	(0.142)	1.492	(0.136)	1.993	(0.046)
DMK - ILI	7.390	(0.000)	6.159	(0.000)	6.088	(0.000)	6.170	(0.000)
DMK - UK£	0.502	(0.615)	0.313	(0.754)	0.287	(0.774)	-0.154	(0.877)
DMK - JYE	0.006	(0.996)	-0.023	(0.981)	-0.017	(0.986)	0.030	(0.976)
DMK - US$	0.314	(0.754)	-0.041	(0.967)	-0.005	(0.996)	-0.914	(0.361)
B. Real Effective Exchange Rate								
French Franc	3.543	(0.000)	2.916	(0.004)	2.860	(0.004)	2.563	(0.010)
Italian Lira	4.780	(0.000)	3.872	(0.000)	3.814	(0.000)	3.573	(0.000)
Deutsche Mark	1.232	(0.218)	1.019	(0.308)	0.985	(0.325)	1.001	(0.317)
U.K. Sterling	-.808	(0.419)	-0.773	(0.440)	-0.830	(0.407)	-1.200	(0.230)
Japanese Yen	-1.390	(0.164)	-1.017	(0.309)	-0.948	(0.343)	-0.365	(0.715)
U.S. Dollar	-4.273	(0.000)	-3.703	(0.000)	-3.735	(0.000)	-4.641	(0.000)

Note: Figures in parenthesis denote marginal, two-sided significance levels. All test statistics are distributed as standard normal under the null hypothesis of no shift in volatility. Significantly positive test statistics indicate a reduction in volatility after the break point; significantly negative statistics indicate the converse.

Table 4. Test Statistics for a Shift in Nominal Exchange Rate Volatility

Period 1979:4 - 1983:3 vs. 1983:4 - 1990:10

Exchange Rate	Normal		Logistic		Double Exponential		Cauchy	
A. DMK Nominal Exchange Rate								
DMK - FFR	2.200	(0.028)	1.694	(0.090)	1.688	(0.091)	1.139	(0.255)
DMK - ILI	2.326	(0.020)	1.934	(0.053)	1.969	(0.049)	2.087	(0.037)
DMK - UK£	1.671	(0.095)	1.339	(0.818)	1.337	(0.818)	1.203	(0.229)
DMK - JYE	3.224	(0.001)	2.636	(0.008)	2.648	(0.008)	2.626	(0.009)
DMK - US$	-0.564	(0.573)	-0.500	(0.617)	-0.481	(0.631)	-0.528	(0.598)
B. US$ Nominal Exchange Rate								
US$ - FFR	0.755	(0.450)	0.572	(0.567)	0.623	(0.533)	0.706	(0.480)
US$ - ILI	0.165	(0.869)	0.027	(0.978)	0.107	(0.915)	-0.005	(0.996)
US$ - DMK	-0.228	(0.819)	-0.292	(0.771)	-0.255	(0.799)	-0.467	(0.640)
US$ - UK£	0.037	(0.970)	-0.026	(0.979)	-0.038	(0.970)	-0.439	(0.661)
US$ - JYE	1.899	(0.058)	1.582	(0.114)	1.594	(0.111)	1.512	(0.131)
C. Nominal Effective Exchange Rate								
French Franc	0.951	(0.341)	0.748	(0.455)	0.797	(0.425)	0.760	(0.448)
Italian Lira	1.340	(0.180)	1.074	(0.283)	1.025	(0.306)	0.859	(0.390)
Deutsche Mark	1.740	(0.082)	1.196	(0.232)	1.152	(0.249)	0.201	(0.841)
U.K. Sterling	0.696	(0.486)	0.473	(0.636)	0.407	(0.684)	0.027	(0.978)
Japanese Yen	1.460	(0.144)	1.241	(0.215)	1.269	(0.204)	1.552	(0.121)
U.S. Dollar	0.294	(0.769)	0.158	(0.875)	0.152	(0.879)	-0.258	(0.796)

Note: Figures in parenthesis denote marginal, two-sided significance levels. All test statistics are distributed as standard normal under the null hypothesis of no shift in volatility. Significantly positive test statistics indicate a reduction in volatility after the break point; significantly negative statistics indicate the converse.

Table 5. Test Statistics for a Shift in Real Exchange Rate Volatility

Period 1979:4 - 1983:3 vs. 1983:4 - 1990:10

Exchange Rate	Normal		Logistic		Double Exponential		Cauchy	
A. DMK Real Exchange Rate								
DMK - FFR	1.731	(0.083)	1.337	(0.181)	1.283	(0.200)	0.658	(0.511)
DMK - ILI	3.976	(0.000)	3.453	(0.001)	3.388	(0.001)	3.923	(0.000)
DMK - SPE	3.751	(0.000)	2.854	(0.004)	2.699	(0.007)	1.414	(0.157)
DMK - UK£	1.809	(0.070)	1.426	(0.154)	1.407	(0.160)	1.209	(0.227)
DMK - JYE	3.397	(0.001)	2.790	(0.005)	2.820	(0.005)	2.703	(0.007)
DMK - US$	-0.417	(0.679)	-0.404	(0.687)	-0.394	(0.693)	-0.536	(0.592)
B. Real Effective Exchange Rate								
French Franc	2.636	(0.008)	2.177	(0.029)	2.169	(0.030)	2.269	(0.023)
Italian Lira	3.985	(0.000)	3.433	(0.001)	3.313	(0.001)	3.489	(0.001)
Deutsche Mark	3.185	(0.001)	2.611	(0.009)	2.569	(0.010)	2.562	(0.010)
U.K. Sterling	1.143	(0.253)	0.849	(0.396)	0.823	(0.410)	0.432	(0.666)
Japanese Yen	2.350	(0.019)	1.947	(0.052)	1.977	(0.048)	2.155	(0.031)
U.S. Dollar	0.362	(0.717)	0.261	(0.794	0.273	(0.784)	0.028	(0.978)

Note: Figures in parenthesis denote marginal, two-sided significance levels. All test statistics are distributed as standard normal under the null hypothesis of no shift in volatility. Significantly positive test statistics indicate a reduction in volatility after the break point; significantly negative statistics indicate the converse.

Table 6. Test Statistics for a Shift in Nominal Exchange Rate Volatility
Period: 1979:4 - 1986:5 vs 1986:6 - 1990:10

Exchange Rate	Normal		Logistic		Double Exponential		Cauchy	
A. <u>DMK Nominal Exchange Rate</u>								
DMK - FFR	0.248	(0.804)	0.105	(0.917)	0.083	(0.934)	-0.362	(0.717)
DMK - ILI	1.575	(0.115)	1.201	(0.230)	1.312	(0.190)	1.067	(0.286)
DMK - UK£	1.474	(0.140)	1.179	(0.238)	1.064	(0.288)	0.691	(0.489)
DMK - JYE	1.431	(0.153)	1.034	(0.301)	1.035	(0.301)	0.471	(0.638)
DMK - US$	-0.175	(0.861)	-0.306	(0.759)	-0.295	(0.768)	-0.698	(0.485)
B. <u>US$ Nominal Exchange Rate</u>								
US$ - FFR	0.912	(0.362)	0.647	(0.517)	0.695	(0.487)	0.466	(0.641)
US$ - ILI	-0.156	(0.876)	-0.266	(0.790)	-0.252	(0.801)	-0.559	(0.576)
US$ - DMK	-0.177	(0.860)	-0.277	(0.782)	-0.276	(0.782)	-0.587	(0.557)
US$ - UK£	-0.119	(0.905)	-0.119	(0.905)	-0.096	(0.924)	-0.209	(0.834)
US$ - JYE	-0.456	(0.649)	-0.467	(0.641)	-0.428	(0.669)	-0.927	(0.354)
C. <u>Nominal Effective Exchange Rate</u>								
French Franc	2.200	(0.028)	1.829	(0.067)	1.868	(0.062)	2.104	(0.035)
Italian Lira	0.974	(0.330)	0.798	(0.425)	0.767	(0.443)	0.721	(0.471)
Deutsche Mark	2.388	(0.017)	2.025	(0.043)	2.021	(0.043)	2.349	(0.019)
U.K. Sterling	0.818	(0.413)	0.569	(0.569)	0.463	(0.643)	-0.076	(0.939)
Japanese Yen	-0.811	(0.417)	-0.789	(0.430)	-0.782	(0.434)	-1.282	(0.200)
U.S. Dollar	1.041	(0.298)	0.777	(0.437)	0.775	(0.438)	0.433	(0.665)

Note: Figures in parenthesis denote marginal, two-sided significance levels. All test statistics are distributed as standard normal under the null hypothesis of no shift in volatility. Significantly positive test statistics indicate a reduction in volatility after the break point; significantly negative statistics indicate the converse.

Table 7. Test Statistics for a Shift in Real Exchange Rate Volatility
Period 1979:4 - 1986:5 vs. 1986:6 - 1990:10

Exchange Rate	Normal		Logistic		Double Exponential		Cauchy	
A. DMK Real Exchange Rate								
DMK - FFR	1.290	(0.197)	1.070	(0.285)	1.102	(0.270)	1.093	(0.274)
DMK - ILI	2.096	(0.036)	1.728	(0.084)	1.679	(0.093)	1.612	(0.107)
DMK - UK£	1.442	(0.149)	1.111	(0.267)	1.032	(0.302)	0.596	(0.551)
DMK - JYE	1.751	(0.080)	1.359	(0.174)	1.437	(0.151)	1.144	(0.253)
DMK - US$	-0.400	(0.689)	-0.532	(0.595)	-0.521	(0.602)	-1.177	(0.239)
B. Real Effective Exchange Rate								
French Franc	2.706	(0.007)	2.231	(0.026)	2.193	(0.028)	2.176	(0.030)
Italian Lira	4.720	(0.000)	3.975	(0.000)	3.892	(0.000)	3.857	(0.000)
Deutsche Mark	2.415	(0.016)	1.996	(0.046)	1.900	(0.057)	1.767	(0.077)
U.K. Sterling	1.472	(0.141)	1.157	(0.247)	1.121	(0.262)	0.889	(0.374)
Japanese Yen	-0.016	(0.987)	-0.182	(0.855)	-0.236	(0.814)	-0.968	(0.333)
U.S. Dollar	0.826	(0.409)	0.563	(0.574)	0.588	(0.556)	0.104	(0.918)

Note: Figures in parenthesis denote marginal, two-sided significance levels. All test statistics are distributed as standard normal under the null hypothesis of no shift in volatility. Significantly positive test statistics indicate a reduction in volatility after the break point; significantly negative statistics indicate the converse.

VIII. Volatility Transfer

It is sometimes argued 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 e.g., Bachelor, 1983, 1985). 1/ In particular, this suggests 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 reduction 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"). Such credibility arguments rest crucially on the assumption that the costs (to the authorities) of revaluation outweigh the costs of internal adjustment and, in particular, the costs of disinflation (see e.g., Giavazzi and Giovannini, 1989).

In an attempt to shed some light on these arguments we carried out the nonparametric volatility shift tests for monthly changes in Euro-currency short-term interest rates; the results are reported in Table 8.

Table 8.A reveals that the overall effect of the ERM has not been to increase interest rate volatility--if anything, the test statistics show a tendency towards reduced interest rate volatility for ERM members, which is strongly significant for lira interest rates. In contrast, dollar interest rates have seen a significant rise in volatility during the period of operation of the EMS.

Within the period of operation of the EMS, there seem to have been further reductions in interest rate volatility (less marked for the lira), although a specific ERM effect cannot be separated from a global effect, since significant reductions in volatility are also indicated for dollar, yen and sterling interest rates (Tables 8.B and 8.C).

1/ Many of the arguments relating to systemic macroeconomic risk can be traced to Poole (1970).

Table 8. Test Statistics for a Shift in Eurocurrency Interest Rate Volatility

Exchange Rate	Normal		Logistic		Double Exponential		Cauchy	
A. Period 1975:1 - 1979:3 vs 1979:4 - 1990:10								
French Franc	1.53	(0.126)	1.42	(0.155)	1.37	(0.171)	1.15	(0.250)
Italian Lira	2.04	(0.041)	2.19	(0.028)	2.13	(0.033)	2.41	(0.016)
Deutsche Mark	1.18	(0.238)	0.97	(0.332)	0.84	(0.401)	0.72	(0.472)
U.K. Sterling	1.14	(0.254)	1.67	(0.095)	1.43	(0.153)	1.37	(0.171)
Japanese Yen	1.13	(0.258)	0.93	(0.352)	1.13	(0.258)	1.18	(0.238)
U.S. Dollar	-2.18	(0.029)	-2.13	(0.033)	-2.26	(0.024)	-2.19	(0.028)
B. Period: 1979:4 - 1983:3 vs 1983:4 - 1990:10								
French Franc	4.892	(0.000)	4.231	(0.000)	4.191	(0.000)	4.779	(0.000)
Italian Lira	1.994	(0.046)	1.585	(0.113)	1.592	(0.111)	1.349	(0.177)
Deutsche Mark	6.051	(0.000)	5.001	(0.000)	4.945	(0.000)	4.826	(0.000)
U.K. Sterling	3.857	(0.000)	3.266	(0.001)	3.326	(0.001)	3.892	(0.000)
Japanese Yen	5.213	(0.000)	4.293	(0.000)	4.232	(0.000)	4.068	(0.000)
U.S. Dollar	7.642	(0.000)	6.385	(0.000)	6.204	(0.000)	5.994	(0.000)
C. Period: 1979:4 - 1986:5 vs 1986:6 - 1990:10								
French Franc	4.542	(0.000)	3.924	(0.000)	3.915	(0.000)	4.575	(0.000)
Italian Lira	-0.062	(0.950)	-0.153	(0.879)	-0.220	(0.826)	-0.768	(0.442)
Deutsche Mark	3.639	(0.000)	3.084	(0.002)	3.150	(0.001)	3.651	(0.000)
U.K. Sterling	3.009	(0.003)	2.545	(0.011)	2.585	(0.010)	3.054	(0.002)
Japanese Yen	3.553	(0.000)	2.907	(0.004)	2.829	(0.005)	2.606	(0.009)
U.S. Dollar	5.072	(0.999)	4.301	(0.000)	4.198	(0.000)	4.347	(0.000)
D. Period: 1987:2 - 1990:10 vs 1990:11 - 1992:9								
French Franc	1.314	(0.189)	0.913	(0.361)	0.714	(0.475)	0.398	(0.691)
Italian Lira	-0.331	(0.741)	-0.183	(0.855)	-0.043	(0.966)	0.577	(0.564)
Deutsche Mark	0.699	(0.485)	0.588	(0.556)	0.674	(0.500)	0.763	(0.445)
U.K. Sterling	1.223	(0.221)	0.821	(0.411)	0.638	(0.523)	-0.532	(0.595)
Japanese Yen	-0.307	(0.759)	-0.235	(0.814)	-0.225	(0.822)	-0.191	(0.848)
U.S. Dollar	-0.277	(0.821)	-0.299	(0.765)	-0.215	(0.830)	-0.652	(0.515)

Note: Figures in parenthesis denote marginal, two-sided significance levels. All test statistics are distributed as standard normal under the null hypothesis of no shift in volatility. Significantly positive test statistics indicate a reduction in volatility after the break point; significantly negative statistics indicate the converse.

Overall, therefore, the results of this section indicate that the stability of nominal and real ERM exchange rates was not bought at the expense of increased interest rate volatility.

IX. Sterling's Participation in the ERM

Given the comparatively brief duration of the U.K.'s membership of the ERM (October 1990-September 1992) and the growing tensions inside the system during this period it is interesting to examine whether our nonparametric test procedures can be employed to reflect these tensions. While this period--less than two years--is arguably too short to yield any reliable conclusions, it does seem a reasonable hypothesis that the apparent loss in credibility of the system should have been reflected in increased interest rate volatility of member countries. Thus, in Table 8.D we report results of the nonparametric procedures applied to interest rate data for the period following the January 1987 realignment until the exit of sterling from the ERM in September 1992, with a hypothesized shift point in volatility after sterling's entry in October 1990. The results reveal, in fact, no significant shift in interest rate volatility after October 1990 either for sterling or for any other of the currencies examined.

These findings may be explained by again returning to the distinction between misalignment and volatility. It seems apparent that some of the tensions within the system reflected cumulative currency misalignments, particularly in the case of the high inflation currencies; in the case of the U.K., some commentators have argued that sterling joined at too high a rate vis-à-vis the mark (e.g., Wren-Lewis et al., 1991). Given sterling's rapid devaluation since leaving the ERM, this hypothesis has some empirical support. If, then, a primary cause of the tensions within the System was currency misalignment--a low-frequency concept--we should not necessarily expect to see this reflected in the volatility of interest rates--a high-frequency concept.

More generally, the present authors have argued elsewhere (Artis and Taylor, 1989) that the ERM had not rendered member currencies perfect substitutes in international portfolios, as required of a fully credible exchange rate union (Canzoneri, 1982), and did not exhibit a convincing capacity for correcting cumulative misalignments over time. It seems plausible that market concentration on these longer-run issues was heightened by the Danish rejection of the Maastricht Treaty in the referendum of 1992 and the less-than-overwhelming ("petit oui") support for the Agreement in the French Referendum a few months later.

X. Conclusions

In this study we investigated the volatility of the exchange rates of the ERM countries over the period up to October 1990, before the accession of the U.K. to the Mechanism, and in the volatility of interest rates during sub-samples of a data period extending through sterling's participation in the ERM. Because there are doubts about the true distribution of exchange rate and interest rate changes, a nonparametric statistical method was used. The volatility of ERM exchange rates and interest rates was compared with that of a control group of non-ERM currencies before and after the inception of the ERM and their behavior through time was also examined.

The essential findings are very clear. In the period of operation of the ERM, the volatility of intra-ERM (specifically bilateral-German Mark) exchange rates fell whilst the volatility of non-ERM currencies remained the same or increased. This effect was big enough to replicate itself for ERM countries' overall effective exchange rates also. Similar conclusions, albeit not quite so striking, were obtained for real bilateral and real effective exchange rates. The general impression that the ERM evolved over time in the direction of greater stability is also confirmed on this data set. The same technique was applied to study the evolution of volatility in "off-shore" or "Euro-currency" interest rates: here also it appears that volatility has been somewhat reduced for the ERM countries compared to the control group. This is inconsistent with the "volatility transfer" hypothesis according to which reduced stability in exchange rates would imply added volatility in interest rates. There is no significant shift in interest rate volatility during the period of sterling's participation in the ERM.

Given the recent instability displayed by currencies participating in the ERM, the conclusion that the Mechanism has exerted an unequivocally stabilizing influence on its member currencies may seem at first sight surprising. We would again refer to the distinction made throughout this paper between the short-run ("high frequency") concept of volatility and the longer-term ("low frequency") concept of misalignment. In earlier work (Artis and Taylor, 1989), we showed that the ERM was not entirely successful either in correcting long-term misalignments of real exchange rates between member currencies or in terms of rendering member currencies perfect substitutes in international portfolios as would be expected in a fully credible exchange rate union (Canzoneri, 1982): "Both these findings are worrying since it is easy to imagine the stock of credibility which the EMS has earned being dissipated as sophisticated and forward-looking international capital markets begin to focus on the longer-run stability properties..." (Artis and Taylor, 1989, p. 305). Given the added instabilities which arise naturally in the transition to monetary union (Masson and Taylor, 1992), the recent abolition of exchange controls which had previously been extensively used by France and Italy (Artis and Taylor, 1988), and the uncertainty occasioned by the sequence of national referenda on the Maastricht Treaty during 1992, the "events of '92" are neither surprising nor inconsistent with the short-run stabilizing influence of the ERM documented in this paper.

Density and Asymptotic Score Function
for the Non-Parametric Tests

Distribution	Density Function, f(x)	Asymptotic Score Function, $\psi(u)$
Normal	$(2\pi)^{-½} \exp(-½ x^2)$	$\{\Phi^{-1}(u)\}^2 - 1$
Logistic	$e^{-x}(1 + e^{-x})^{-2}$	$(2u - 1)\ln\{u/(1-u)\} - 1$
Double Exponential	$½ \exp(-\vert x \vert)^2$	$-\ln(1 - \vert 2u - 1 \vert) - 1$
Cauchy	$\pi^{-1}(1 + x^2)^{-1}$	$2 \tan^2\{\pi(u-½)\} [1 + \tan^2\{\pi(u-½)\}]^{-1} - 1$

Notes: The Asymptotic score function is defined in relation (8) in the text. $\Phi(.)$ denotes the standard normal distribution function, i.e.,

$$\Phi(u) = \int_{-\infty}^{u} (2\pi)^{-½} \exp(-½ u^2)\, du$$

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