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Effects of exchange rate fluctuations on international trade

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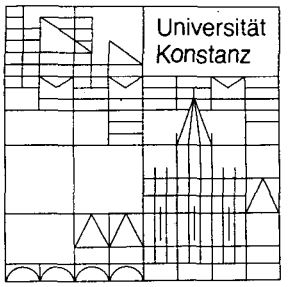
Diskussionsbeiträge



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Effects of Exchange Rate Fluctuations on International Trade

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EFFECTS OF EXCHANGE RATE FLUCTUATIONS ON INTERNATIONAL TRADE

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I. Introduction

The early enthusiasm which greeted the introduction of flexible exchange rates has been dampened by the violence and unpredictability of their subsequent movement. After well over a decade under the new regime, "a review of the experience with floating rates reveals an exchange rate system with a number of weaknesses, including a high sensitivity of real (inflation adjusted) exchange rates to purely nominal shocks, an absence of automatic constraints on international liquidity creation, substantial unexplained volatility of exchange rates in the short run and a tendency to allow protracted swings in competitiveness over the medium term" (Obstfeld, 1985). Equally, to the practitioners of international financial relations "/sind/ die unglaublichen Wechselbäder, die wir seit 1980 beim Dollarkurs erlebt haben ... ökonomisch funktionslos gewesen" (Pöhl, 1987)[1].

Even though it is generally recognized that a radical reform of the international currency system is not at present possible, joint efforts to achieve greater exchange rate stability have become more vigorous recently. It was possible to stabilize the major currencies following the Louvre Accord of April, 1987, even when the agreement was under severe pressure

[1] "the incredible shifts and reversals of the dollar exchange rate which we have experienced since 1980 were without economic purpose".

towards the end of the year. This stabilization effort was an important precondition for the continuation of the economic recovery: "ohne das Louvre-Abkommen und ohne die Stabilisierung der Wechselkurse hätten wir (in der BRD) heute sehr viel schlechtere Konjunkturdaten" (Pöhl, 1972)[1].

The hectic and erratic exchange rate fluctuations and, above all, the protracted swings in exchange rates gave rise to fears that with growing uncertainty international trade as well as private investment and production and maybe even growth and employment may have been impaired.

This report covers the following themes:

- the time paths of major currencies since 1973 (Section II);
- a survey of current empirical research on the effects of exchange rate risk after a theoretical discourse on the economic concept of risk in general (Section III);
- the problems of measuring exchange rate uncertainty and the definition of practical statistics suitable to both floating currencies and those bound in the quasi-peg of the EMS (Section IV);

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[1] "Were it not for the Louvre Accord and exchange rate stabilization we (in the F.R. Germany) would be facing much worse business cycle indicators".

- an econometric investigation of the influence of exchange rate risk on the foreign trade of the U.S.A., Great Britain, France and the Federal Republic of Germany. The volume of exports and imports on a global, bilateral and sectoral level, trade shares and the prices of tradeable goods are all examined (Section V).

The empirical work presented in this report is, of course, subject to the usual difficulties and limitations of any econometric analysis, which stem in part from the shortcomings of the available statistical data (detail and length of time series, measurement errors in composing, say, a price index for tradeable goods), and also in part from the pervasive and complex role of exchange rates in a highly integrated economy. The results, though, do let one say that exchange rate fluctuations and the concomitant uncertainty about foreign trade impact primarily on a bilateral and sectoral level and on prices rather than on aggregate trade volumes.

The connections between currency risk, trade, investment and insurance may become clearer if one has information on individual enterprises. Hence the IFO Institute conducted a survey of German businesses during the spring of 1987 on the theme of exchange rate uncertainty.

The crux of the partial equilibrium approach presented here is that exchange rates as the primary determinant and control factor also affect the price level, interest rates, stock market, investment volume and thus almost all macro-economic aggregates. Uncertainty regarding exchange rates will therefore create risks for the entrepreneur in all sectors concerned. It is to be feared that the micro-economic uncertainties for the entrepreneurs which stem from the unpredictability of currency relations, cannot be sufficiently captured by the statistical ex-post variances. The results to be presented in the following chapters must therefore be regarded as a subsection of a much greater and complex field of research.

The authors would like to thank their colleagues at the IFO Institute who helped them with data processing, above all Mr. Erich Langmantel, Ms Else Göpfert and Ms Ingetraut Lindloff. We must also express our gratitude to Ms Angela Ramsenthaler for the care and patience she displayed in preparing this text.

II. Exchange Rates Since 1970: An Overview

1. Long-run Shifts in Exchange Rate Relationships

The precipitating factor in the abandonment of fixed exchange rates in 1973 was a series of crises of confidence in the US dollar, which became more frequent and acute from the end of the 1960s. Several countries, including the Federal Republic of Germany, had gone over temporarily to floating in 1971. The new parities which were set in the Smithsonian Agreement at the end of 1971, allowing the first general realignment of the US dollar since 1949, were to have "saved" the system of pegged rates. Yet the new parities quickly came under pressure, confidence in the dollar waned, and Sterling also was weak. The D-mark along with the Swiss franc became the main refuge currencies. From January to July 1972 the Deutsche Bundesbank bought over DM 20 bn worth of foreign currency and again DM 18.5 bn in one seven-day period in February 1973. Between the end of 1971 and early March 1973 the industrial countries bought $ 20 bn to support the dollar. A further dollar devaluation of 10 % in February 1973 failed to calm the foreign exchange markets. The floating of exchange rates in March 1973 was unavoidable.

Already in the period from 1970 to 1973 the structure of currency relations had shifted drastically. Except for the pound Sterling and the Italian lira, the currencies of all major industrial countries had gained significantly in value against the US dollar. Changes in the effective rate - that is, the index of exchange rates against the currencies of major industrial countries, weighted by export shares for example - were greatest for Japan, the F.R. Germany, Switzerland and the U.S. These countries also experienced the largest shifts in their real exchange rates.

Since 1973 these tendencies have persisted for some currencies: Italy and Britain usually have had depreciating currencies, Switzerland and the F.R. Germany appreciating. Japan joined the latter group in 1976. The dollar resisted its tendency towards depreciation until 1977, when it came under renewed pressure (see Figure 1).

The first half of the 1980s were dominated by the strong rise in the dollar up to the beginning of 1985. That was the principal reason why the appreciation of the Swiss franc and the D-mark was halted. The nominal effective rate for the French franc, the lira and (after some gyrations) Sterling fell markedly. The tendency of the Yen to appreciate continued, and indeed its depreciation against the dollar was much less than that of most other currencies.

Table 1

Changes [a] in Nominal Effective Exchange Rates
(in %)

	1970-75	1975-80	1980-85
U.S.A.	- 15.5	- 7.9	+ 49.7
Great Britain	- 23.3	- 4.6	- 15.3
F.R. Germany	+ 25.2	+ 27.2	+ 1.9
France	+ 6.0	- 8.5	- 25.3
Japan	+ 8.2	+ 26.1	+ 30.1

a) Appreciation: +; Depreciation: -; calculated from annual averages.

Source: EC-Commission, DG II

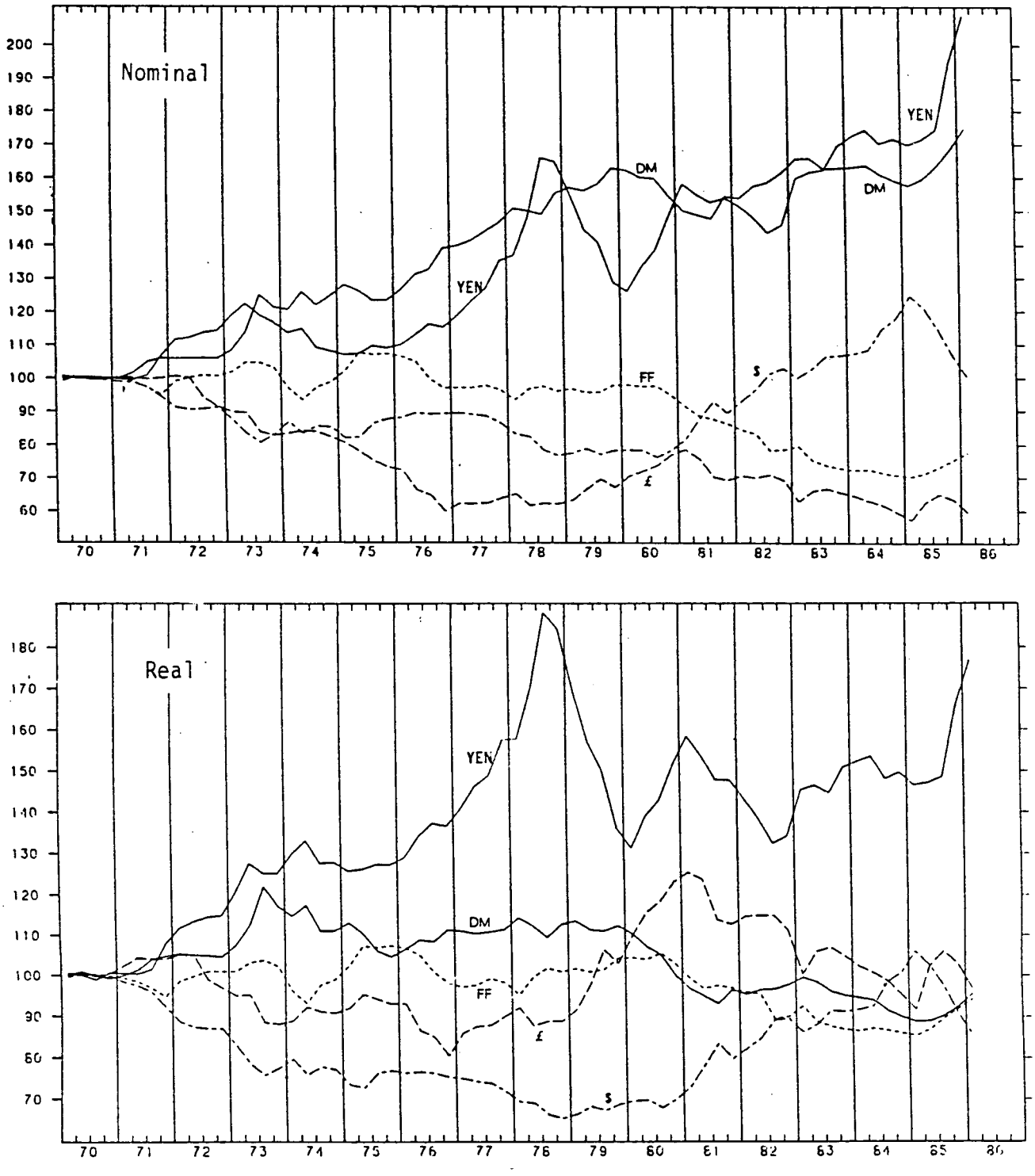

Figure 1 Nominal and Real Effective Exchange Rates

Source: EC-Commission, DG II

2. Intense Short-term Exchange Rate Fluctuations

The longer-term shifts in currency relationships were accompanied by large, indeed sometimes very large, exchange rate fluctuations. Advocates of the change to the floating regime at first regarded this as a temporary phenomenon which would disappear as market participants gained experience in dealing with flexible rates. This expectation has not been fulfilled for the currencies we investigate. In general there has been no tendency towards decreasing exchange rate volatility, with the possible exception of the nominal effective D-mark and franc rates. The other currencies were subject to large and at times seemingly self-reinforcing movements in the 13 years since the end of the Bretton Woods system (see Figure 2).

Of the five currencies considered, the nominal effective D-mark rate exhibited the lowest volatility during the period of floating. Its volatility peaked already in 1973 and then subsided considerably. There was a lenghty period, namely from 1977 to 1981, when volatility was not only relatively low but also fairly constant. In contrast, the variance of other currencies fluctuated considerably over time.

This phenomenon almost certainly reflects the membership of the D-mark in the European "Snake" and then the EMS since 1979. Variance against other member currencies was extremely low during years without major realignments, such as 1979, 1980, 1984 or 1985.

The history of the French franc, a member of the EMS from 1979, was rather different. Fluctuations, which were relatively mild in 1973, were greatest towards the end of 1975, diminished somewhat and then rose a bit in the early 1980s. Unlike Germany, France was only periodically a member of the European "Snake", which it twice had to leave amidst serious franc crises. The franc first withdrew in 1974, entered again in 1975 and had to leave one more in 1976. Membership in the EMS since 1979 has helped the effective franc rate to be about as stable as the

Table 2

Changes in Bilateral Exchange Rates
(in %)

	US dollar	Pound Sterling	French franc	D-mark
US dollar				
1970-75	-	8.2	- 22.5	- 32.6
1975-80	-	- 4.7	- 1.5	- 26.1
1980-85	-	88.2	+111.9	+ 61.4
1985-87(a)	-	- 20.9	- 32.0	- 38.0
Pound Sterling				
1970-75	- 7.5	-	- 28.3	- 37.6
1975-80	+ 4.9	-	+ 3.4	- 22.5
1980-85	- 44.5	-	+ 17.5	- 10.5
1985-87(a)	+ 26.4	-	- 13.7	- 21.6
French franc				
1970-75	+ 28.7	+ 38.2	-	- 13.0
1975-80	+ 1.7	- 2.9	-	- 25.1
1980-85	- 52.7	- 14.7	-	- 23.7
1985-87(a)	+ 47.3	+ 14.9	-	- 8.8
D-mark				
1970-75	+ 48.5	+ 61.4	+ 15.0	-
1975-80	+ 35.4	+ 28.8	+ 33.4	-
1980-85	- 38.1	+ 11.8	+ 31.3	-
1985-87(a)	+ 61.3	+ 27.2	+ 9.4	-

(a) June 1987. Calculated from annual averages.

Source: EC-Commission, DG II

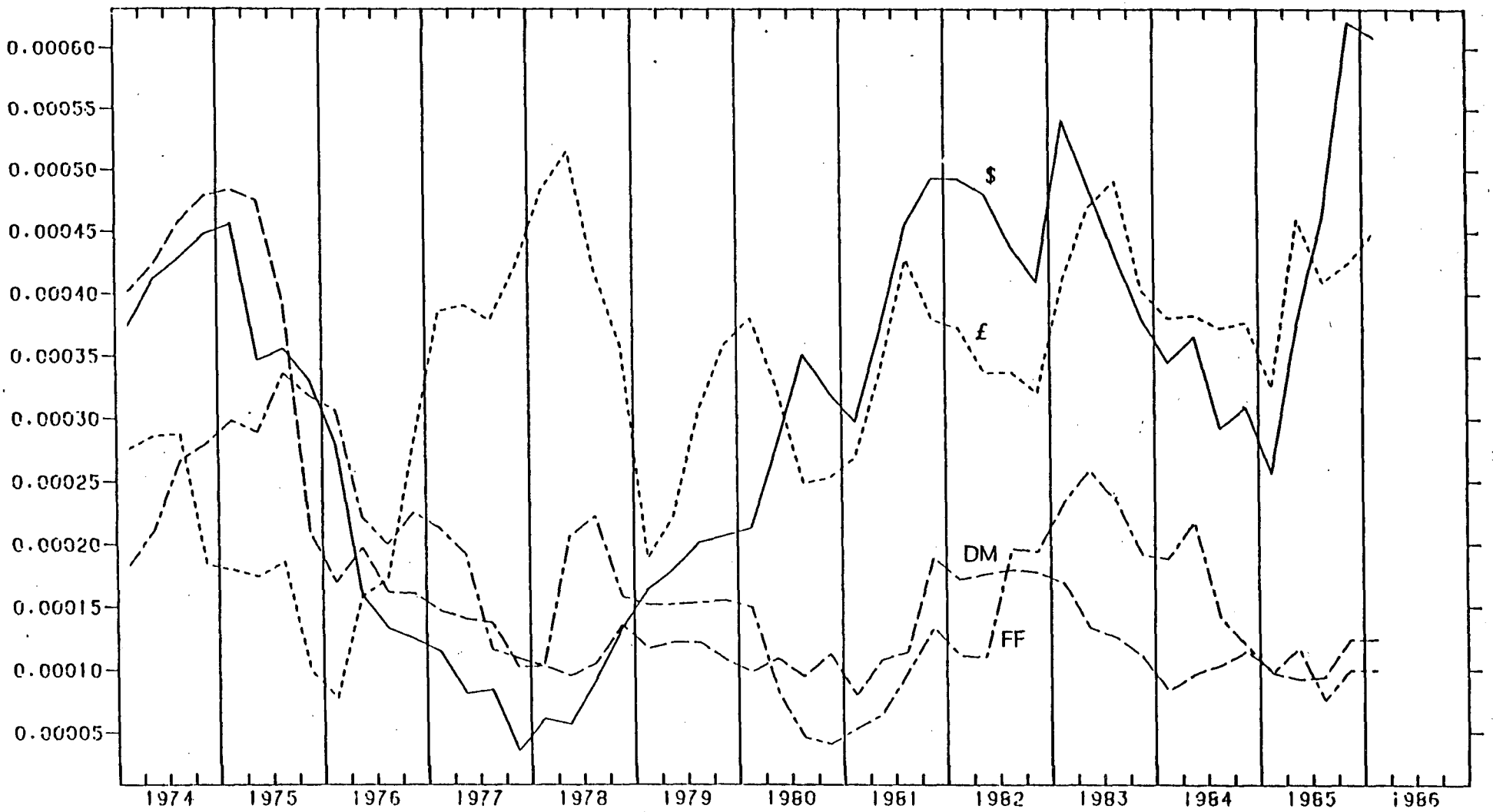

Figure 2 Variability (MV) of Effective Nominal Exchange Rates against 20 Industrialized Countries

(For definition of the variability measure MV see Section IV.1)

effective D-mark rate, but generally the fluctuations of the franc were somewhat more pronounced, in particular due to greater variance against the dollar.

The exchange rate movements of the pound Sterling, as measured by the nominal effective rate, were most unpredictable in the latter half of the 1970s, when its variance was much higher than that of other currencies. A dramatic decrease in confidence in Sterling, expressed in a rapid depreciation, was precipitated by an extremely high rate of inflation and deteriorating balance of payments. Calm was restored only temporarily; fluctuations became more pronounced again towards the end of the 1970s and were the largest of any currency except the Yen. Bilaterally, fluctuations against the dollar - as for most currencies - were most pronounced.

Unlike the other currencies, the Yen became exceptionally volatile in the late 1970s. Also in 1980 the fluctuations were absolutely and relatively large. During this period the Yen was subject to contradictory tendencies: a very large appreciation from 1976 to 1978 was followed by depreciation up to 1980 and a renewed rise almost to the levels of 1978. These frequent turnarounds contributed to the measured variance of the Yen during this period.

During the early 1970s the volatility of the nominal effective dollar exchange rate paralleled that of the D-mark, with dampening fluctuations after 1973. Unlike the D-mark, however, the dollar began to exhibit more volatility as the 1970s came to a close, and its variance itself tends to rise and fall a good deal from year to year. The variance of the dollar reached a peak during the phase of dollar appreciation and again in 1985, when the trend turned, the dollar fluctated greatly against all currencies.

In summary, it can be said that the nominal effective rates of the D-mark and the French franc suffered much lower short-term exchange rate variability than did the dollar, the pound, or the Yen.

3. Longer-term Fluctuations

Since the disintegration of the Bretton Woods system there have been not only considerable short-term exchange rate fluctuations but also persistent appreciations and depreciations. In particular, the dollar, after a long period of low valuation from 1977 to 1979, rose in the early 1980s to levels which surprised and baffled everyone. The reversal started in the first quarter of 1985 (see Figures 1 and 3).

One can also detect phases of appreciation and depreciation lasting several years for Sterling: a falling pound from 1972 to 1976 - with a hiatus in 1974 -, then a more or less fast appreciation until the beginning of 1981 followed by depreciation again for about four years. The longer-term swings of the franc and the mark were much milder.

These long-term exchange rate fluctuations in nominal exchange rates might be of little concern, were they not connected with movements in real rates, that is, if the ups and downs of nominal rates did not far excede changes in inflation differentials or other "real" factors (compare Figure 1 with Figures 3 to 6, and see below). This is not to say that changes in the real exchange rate are never desirable, for they may reflect durable changes in the real economy and ease adjustment to, for example, oil price shocks.[1] Persistent real exchange rate movements can, though, be undesired or undesirable insofar as they are reversed and unrelated to changes in the fundamentals of the real economy. Besides the wastage of adjustment costs, productive factors may be inefficiently allocated (see Williamson, 1983; Bank for International Settlements, 1983).

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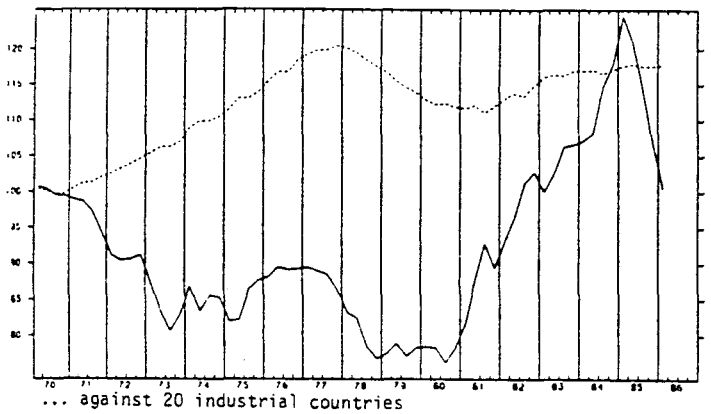
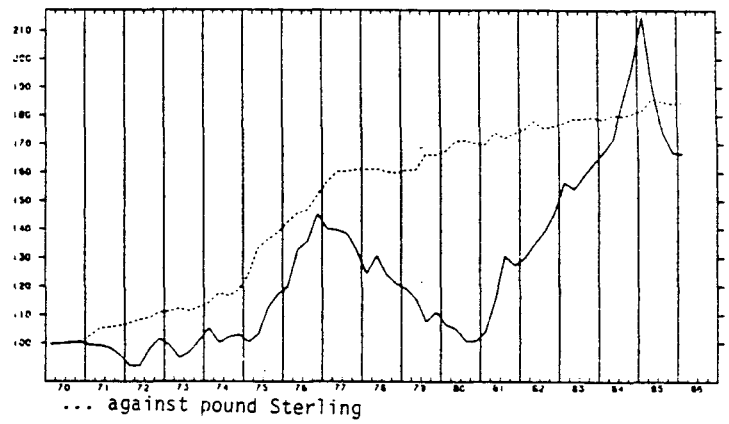
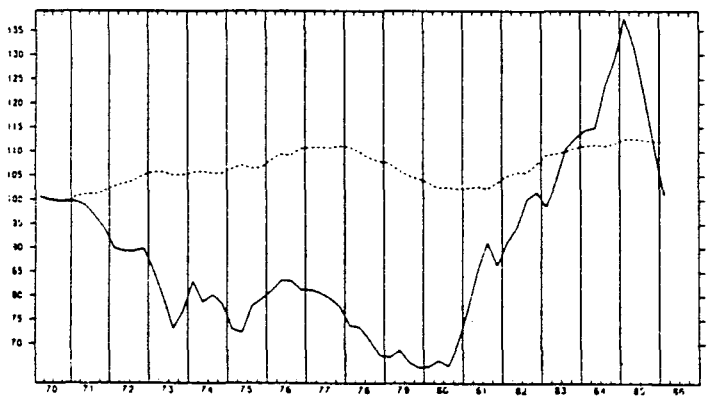
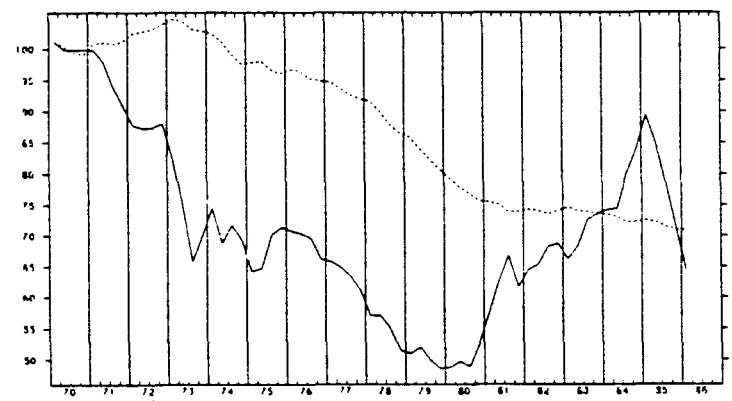
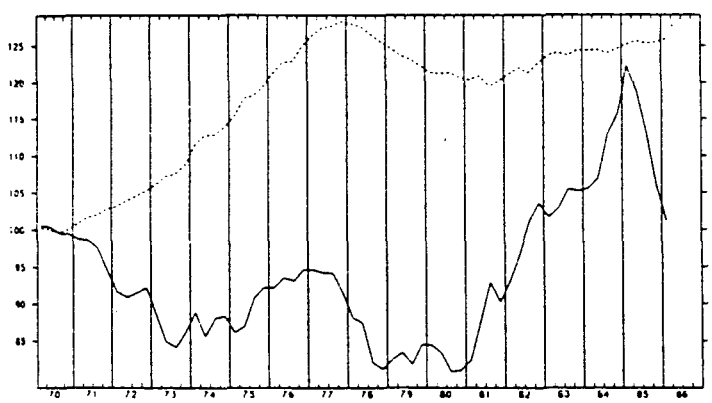
[1] The optimal distribution of adjustment between currency and internal changes depends on country-specific characteristics such as openness and domestic flexibility. For a discussion of the issues see Wegner (1985).











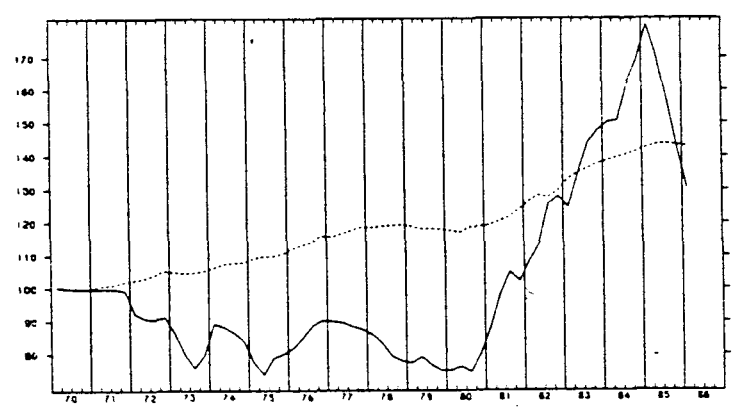
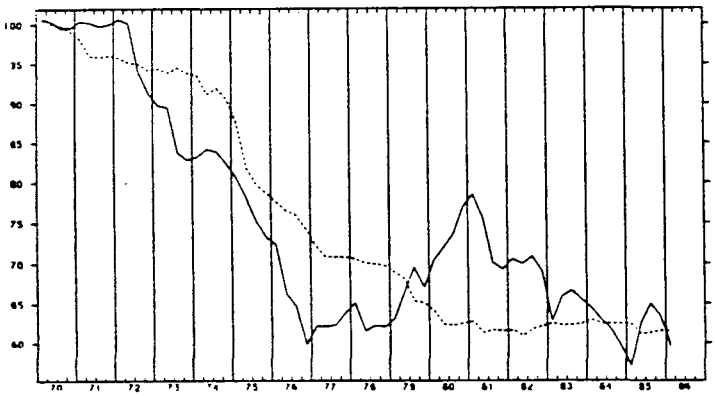


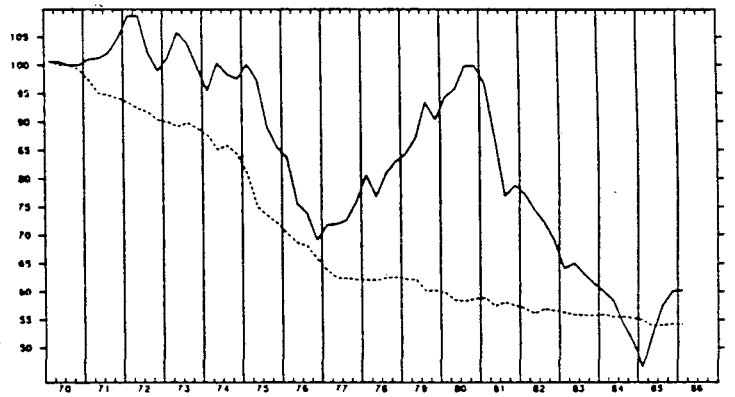
Figure 3 U.S.A.

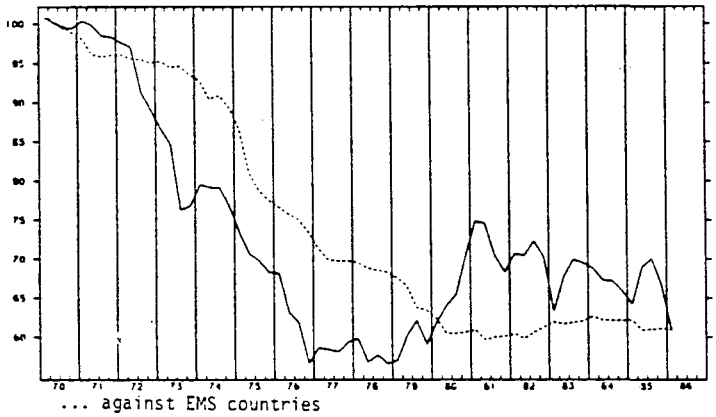
Nominal Effective and Bilateral Exchange Rates (—)
and Relative Consumer Prices (....) 1970=100

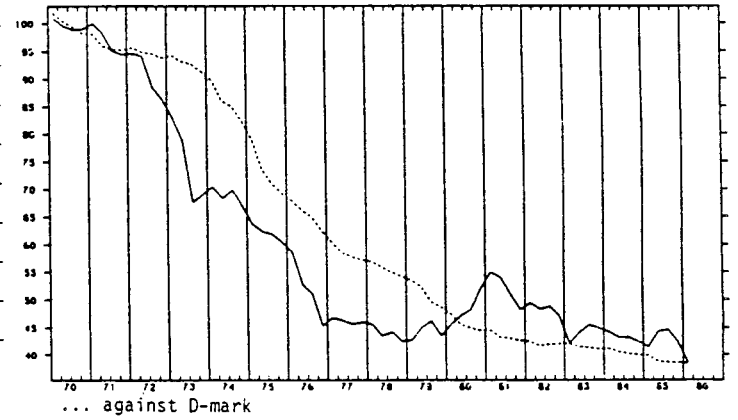
Exchange rates: foreign currency per dollar
Relative prices: foreign CPI divided by domestic CPI

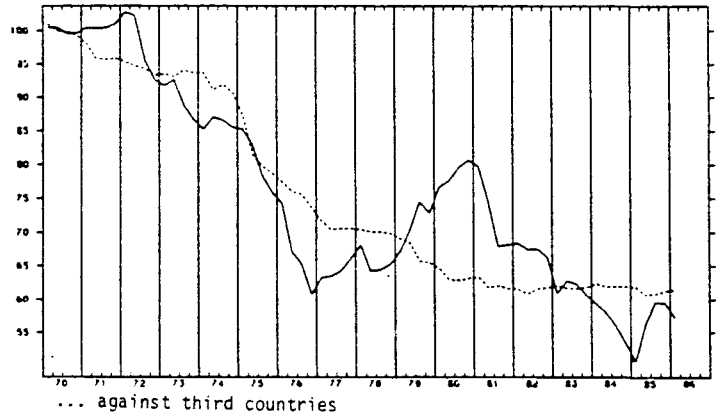
Source: EC-Commission, DG II











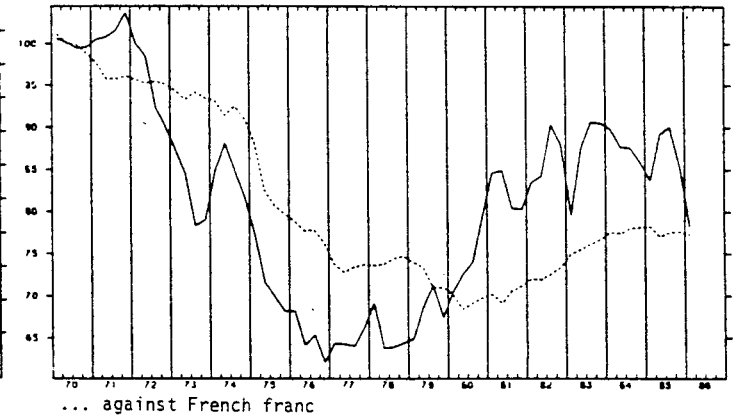


Figure 4 GREAT BRITAIN

Nominal Effective and Bilateral Exchange Rates (—) and Relative Consumer Prices (....) 1970=100

Exchange rates: foreign currency per pound
Relative prices: foreign CPI divided by domestic CPI

Source: EC-Commission, DG II

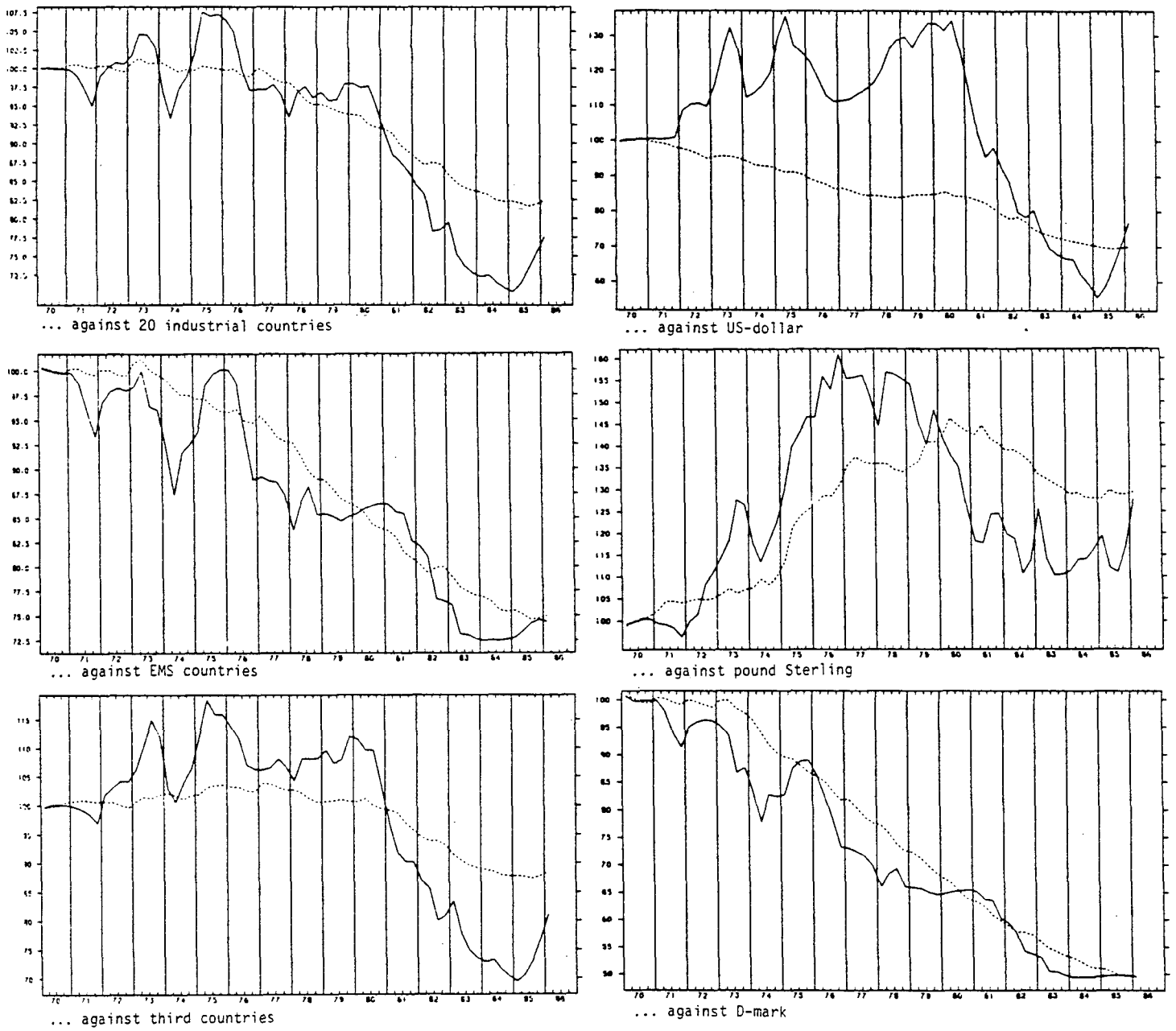
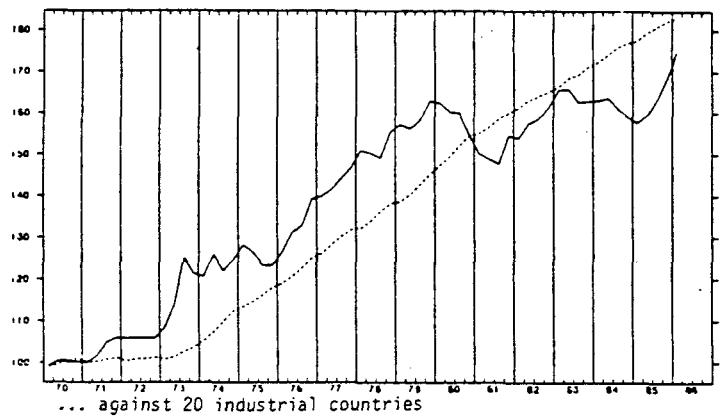


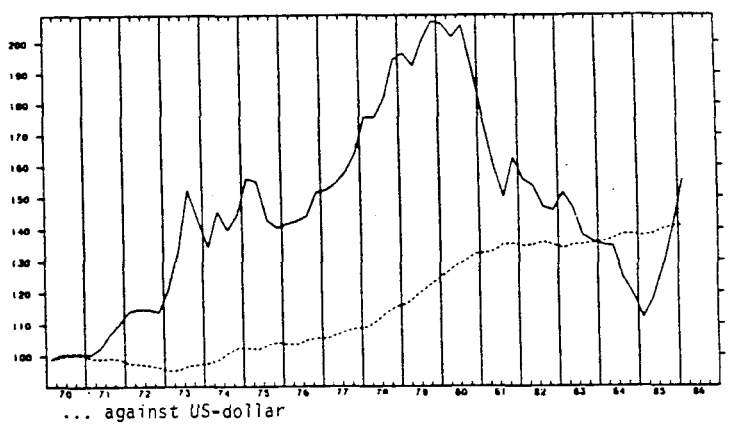
Figure 5 FRANCE

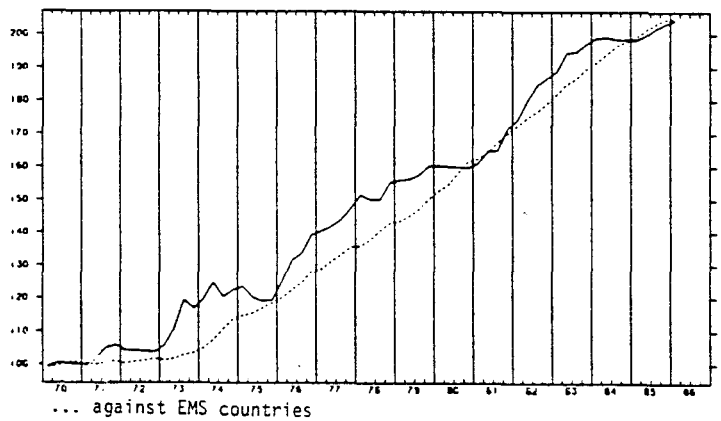
Nominal Effective and Bilateral Exchange Rates (—) and Relative Consumer Prices (....) 1970=100

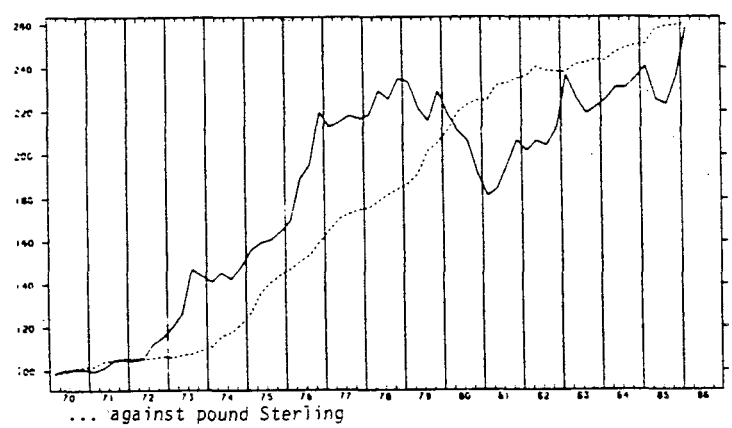
Exchange rates: foreign currency per franc
Relative prices: foreign CPI divided by domestic CPI

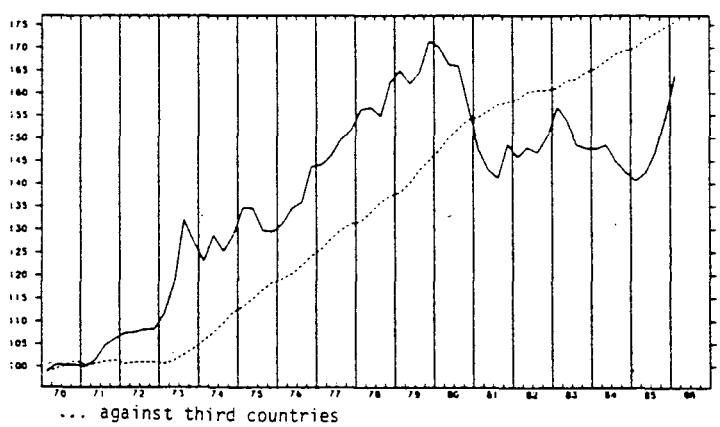
Source: EC-Commission, DG II











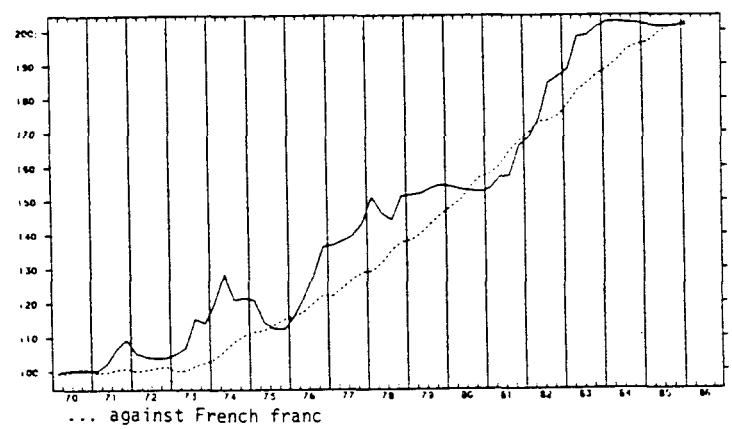


Figure 6 F.R. GERMANY

Nominal Effective and Bilateral Exchange Rates (—) and Relative Consumer Prices (....) 1970=100

Exchange rates: foreign currency per mark
Relative prices: foreign CPI divided by domestic CPI

Source: EC-Commission, DG II

4. Causes of Exchange Rate Movements

Economists have developed a good number of exchange rate models, but empirical testing has shown that a fully satisfactory and systematic explanation of currency movements is still lacking. Neither the older Keynesian or purchasing power parity approaches, nor the monetary theory or the portfolio balance approach in all its variants have been entirely successful. Combinations of these theories and their extentions dealing with the formation of expectations and the role of "news" have had only limited success.

Perhaps the origin of this difficulty lies in the general use of a partial and simplistic approach, which does not do full justice to exchange rates as the outcome of a complex and highly interactive system. Perhaps date problems and the specification of explanatory variables are also causes of trouble. The determinants of the paths of exchange rates come in ever new and changing combinations; the complexity of external linkages and exogenous shocks excludes monocausal explanations which are good for all times and all currencies.

4.1. Price and Cost Differentials

Exchange rates have followed relative price movements only in part or when, as in the case of Italy, there is a fairly steady trend in relative inflation over many years. Deviations in the US dollar were especially large and persistent (see Figure 3): the nominal effective dollar rate fell considerably from 1970 to 1973, yet price rises in the U.S. were more moderate than abroad at the time (though there may well have been a "catch-up" effect here). On the other hand, the rise of the dollar from 1980 to 1985 far exceeded any improvement in the relative U.S. price level - indeed, there was no noticeable improvement after 1983. For Britain the fall in the pound was halted in 1977/78 and turned into a major appreciation although inflation continued to be comparatively very high; Britain's new status as an oil producer

and anticipated deflation had the greater effect. The French franc during the 1970s was also subject to short but large deviations from purchasing power parity, and since the end of 1980 it has depreciated far more than its relative price level has risen. The D-mark exchange rate followed the trend in relative prices at least roughly until 1979, but the relationship was interrupted in 1980, 1981 and 1984.

Table 3

Changes [a] in Real Effective Exchange Rates [b]
(in %)

	1970-85	1975-80	1980-85
U.S.A.	- 25.1	- 7.5	+ 42.6
Great Britain	- 6.2	+ 24.3	- 13.9
F.R. Germany	+ 8.4	- 2.7	- 14.6
France	+ 6.1	- 1.6	- 14.3
Japan	+ 26.2	+ 11.5	+ 7.7

a) Appreciation: +; depreciation: -; calculated from annual averages.
b) Based on consumer price indices.

Source: EC-Commission, DG II

One can think of several extractions for the departure of exchange rates from purchasing power parities or relative costs. Not all price changes need have the same effect on exchange rates; so for instance if the price of non-tradeable goods rises, the demand for imports could fall if nominal income is fixed and price elasticities low. The result is a tendency towards appreciation rather than depreciation. Alternatively, cyclical movements in demand can account for shifts even in the long-run equilibrium exchange rate away from purchasing power parity. More immediately,

Table 4

Changes in Real Bilateral [a] Exchange Rates
(in %)

	US dollar	Pound Sterling	French franc	D-mark
US dollar				
1970-75	-	+ 23.1	+ 42.1	+ 44.0
1975-80	-	+ 34.1	+ 8.8	+ 7.8
1980-85	-	- 39.9	- 42.0	- 42.4
Pound Sterling				
1970-75	- 18.8	-	+ 15.4	+ 17.1
1975-80	- 25.4	-	- 18.8	- 19.6
1980-85	+ 66.3	-	- 3.6	- 4.1
French franc				
1970-75	- 29.6	- 13.3	-	+ 1.4
1975-80	- 8.1	+ 23.2	-	- 0.9
1980-85	+ 72.6	+ 3.8	-	- 0.6
D-mark				
1970-75	- 30.6	- 14.6	- 1.7	-
1975-80	- 7.2	+ 24.5	+ 0.9	-
1980-85	+ 73.6	+ 4.3	+ 0.6	-

a) Based on consumer price indices.

Source: EC-Commission, GD II

nominal exchange rates react to new statistics, the political situation, etc. with great speed, while real and price adjustments are hindered by many rigidities.

4.2. Does the Current Account Matter?

The balance on current account reflects not only price and cost differences but also other factors affecting the international competitiveness of a country, such as the quality and technological sophistication of its products and its ability to make structural adjustments to, say, the oil price shocks. Thus the current account could be an important determinant of the exchange rate in itself or vicariously. But the currencies seem as little linked to current accounts as to relative prices and costs (see Figure 7 and 8).

To start with the most obvious example, the dollar and the U.S. current account were on opposing paths from 1981 to the beginning of 1985; an appreciation of the nominal effective exchange rate of 44 % was accompanied by a deterioration of the current balance from + $ 1.9 bn to - $ 107 bn. The dollar depreciation began in 1985 but the U.S. external deficit (measured in nominal dollars) had if anything worsened by 1987. Also in the 1970s the dollar and the American current account balance seem to have been out of phase by about a year.

Nor can one find a consistent influence of the current account on the pound Sterling. For instance, Sterling was relatively strong in 1974, 1979 and 1986 despite a deterioration in the current account balance, whereas the relation was positive in 1980 and 1981.

For Germany trends in the current account and the exchange rate are in closer harmony, particularly in the period from 1975 to 1978 and 1985/86. The appearence of a deficit in the second quarter of 1979 and its elimination two years later were followed by the D-mark with a lag of two or three quarters.

Figure 7 The Current Account and Exchange Rates

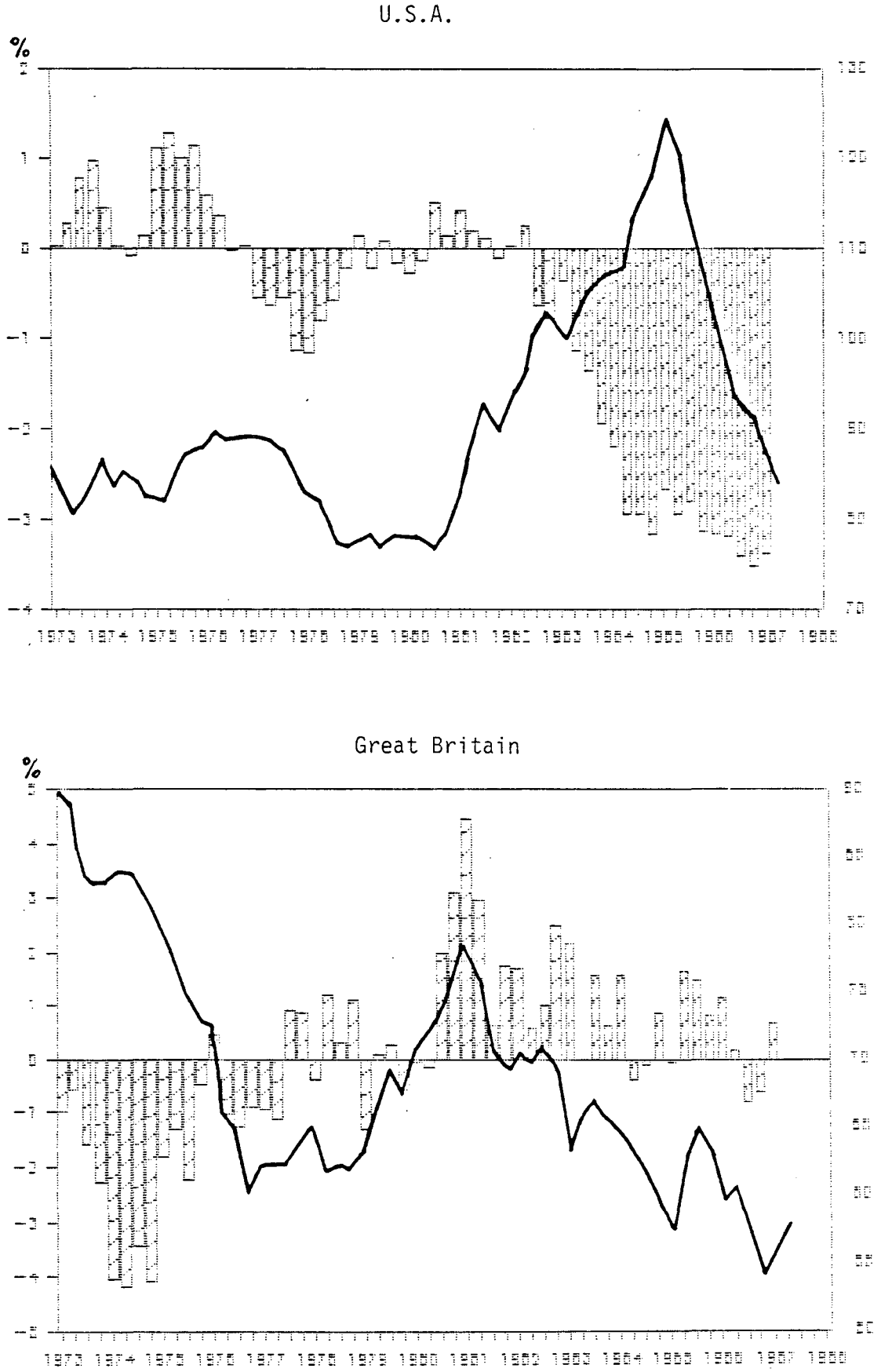
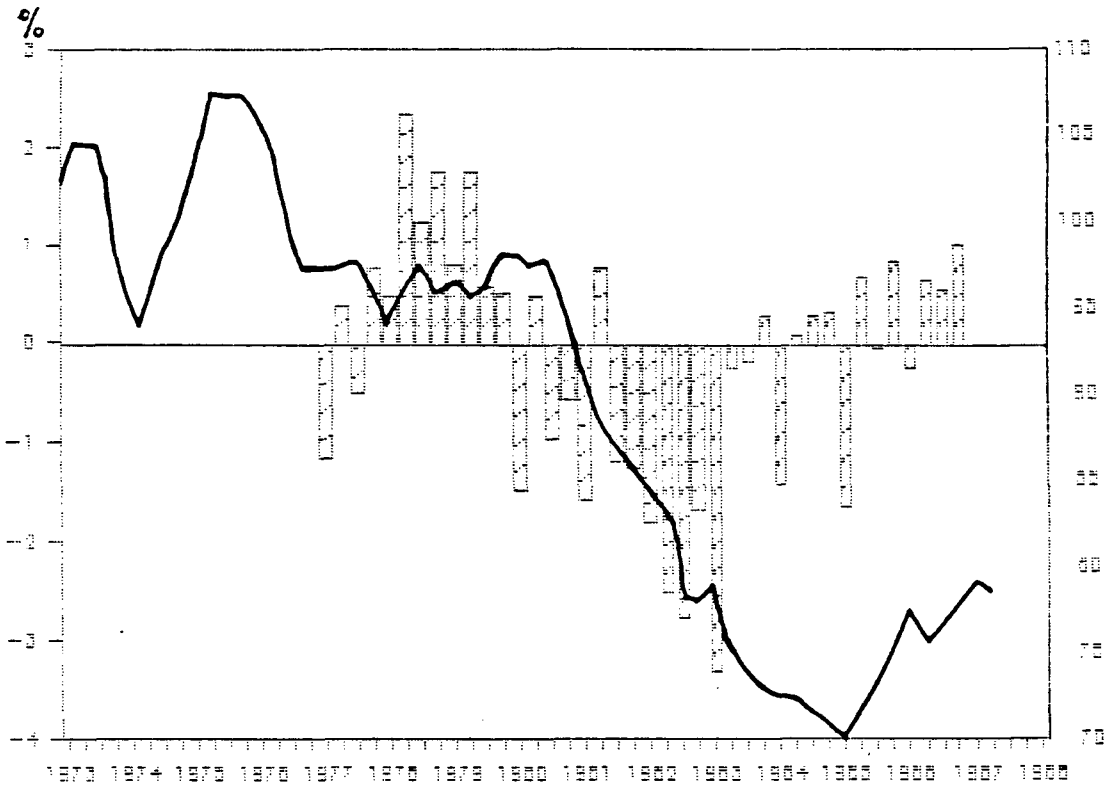
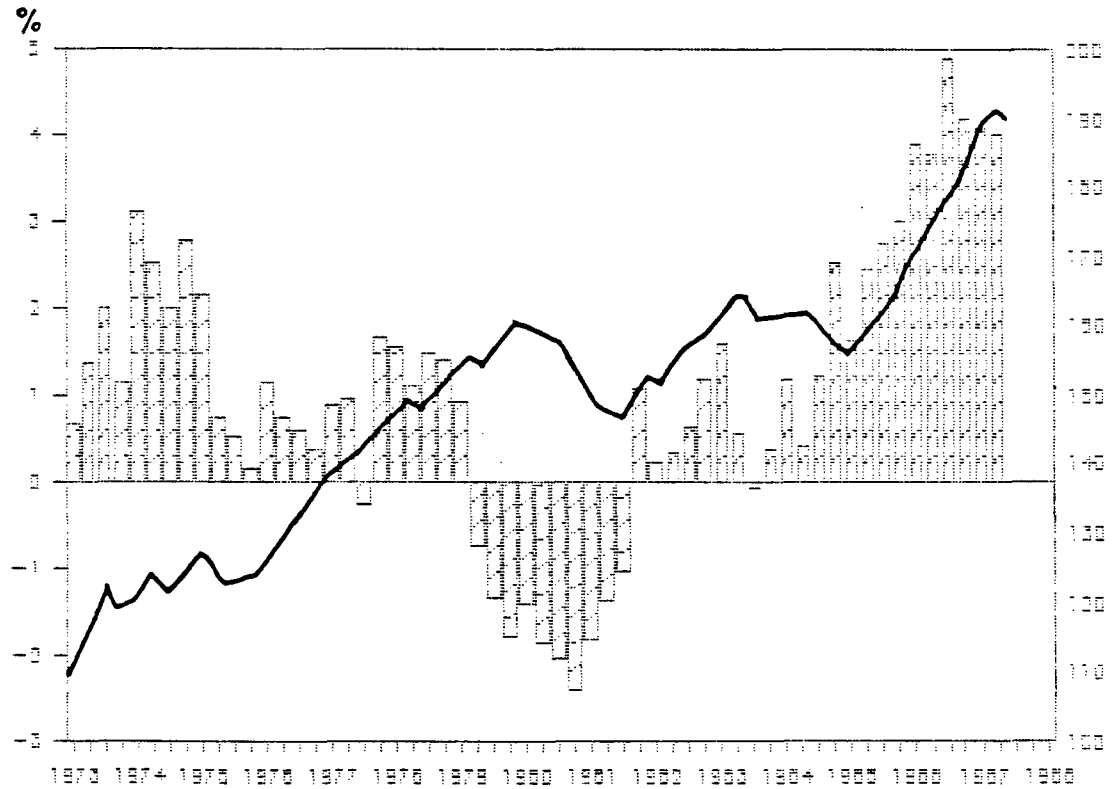


Figure 8 The Current Account and Exchange Rates

France



F.R. Germany



Current account balance as % of GNP

Nominal effective exchange rate, 1970=100

The weakness of the French franc in 1974, 1976 and 1981/82 coincided with large current account deficits, and the franc strengthened when the current account improved in 1975 and 1977/79. The slight appreciation of the franc since the spring of 1985 can, though, better be explained by the fall of the dollar than by the small improvement in the external account.

The looseness of the connection between current accounts and exchange rates is certainly to be explained in part by the interaction of the two as causality runs in both directions. The current account reacts with long lags of up to two years to changes in the exchange rate (the famous J curve), while the exchange rate will, ceteris paribus, react immediately to news about the current account.

At a further time horizon the current account balance does help determine our concept of long-term equilibrium exchange rates and has an influence via the international transfer of wealth and thus an portfolio allocation (see below Section 4.4).

4.3. Interest Rate Differentials

The influence of capital movements on exchange rates has grown with the increasing integration and internationalization of financial markets. The difference in adjustment speeds in financial and goods markets can lead to large exchange rate movements, so called overshooting (Dornbusch, 1976).

The determinants of capital movements are extremely complex, for not only interest differentials but also expected exchange rate movements and anticipated policies are important. One might expect a currency to appreciate with a rising domestic interest rate. However, as for relative prices and the current account, interest rates differences alone are not enough to explain exchange rate movements (IMF, 1983; Schadler, 1984).

In the case of the US dollar a quite contrary tendency stands out in the late 1970s: while interest rates in the U.S. rose significantly from the start of 1977 to the end of 1978, resulting in an interest differential in favour of the U.S., the effective dollar exchange rate fell considerably (OECD, 1984). Bilaterally also one finds many episodes where interest rates and the exchange rates of the D-mark, franc, the pound or the Yen against the dollar seem to have become uncoupled. Even during the period of long dollar appreciation in the early 1980s there were some, admittedly short, periods when the relationship between the exchange rate and nominal interest rate differentials seems to have broken down.

There may well be a closer connection between developments in real interest differentials and the exchange rates (see Pohl, 1987). However, the general validity of this theory could not be confirmed in a study by Coe and Golub (1986) of 18 OECD countries; for only seven currencies, which included the D-mark and the French franc, could a statistically significant relationship be found between real long-term interest rate differentials and the exchange rate against the US dollar. For the other currencies the relationship was either not statistically secured (e.g., for the Yen) or a negative sign appears (for Sterling). An influence of real interest differentials on the effective exchange rate could be found in just five cases, which included the U.S. and Germany. The relationship with the pound Sterling and the French franc was negative and insignificant respectively.

A negative correlation between real interest differentials and exchange rates is easily explainable in a monetary approach: a rise in domestic interest rates reduces real money demand; for given money supply money market equilibrium requires a higher price level. If purchasing power parity holds then the currency should fall, given the foreign price level. Dornbusch (1983) estimated his own model for the dollar/D-mark rate and corroberated the monetary hypothesis that the currency tends to depreciate when domestic rates rise. However, the monetary approach has in general been only partially successful in explaining exchange rate movements.

4.4 Portfolio Shifts

The failure to explain exchange rate movements by traditional theories led to the development of financial-market models, which regard the exchange rate as the relative price not of goods but of foreign and domestic financial assets. According to the so-called portfolio approach, exchange rates move in response to shifts in the portfolios of wealthholders at home and abroad. The strong fluctuations, the overshooting, is according to this approach inherent to the adjustment process in money, financial and real markets after, say, a monetary disturbance. The allocation of wealth by its owners depends on the returns expected from different investments, which in turn is a product not only of interest rates but also of exchange rate changes. Exchange rate movements can offset or enhance the interest payments on foreign investments. Furthermore, some account must be taken of risk along with interest rates and expected exchange rate changes in determining an optimal portfolio allocation, an allocation which, in aggregate, will determine the exchange rate.

This approach can account not only for volatility over the more or less short-term (as overshooting), but allows for the current account as the counterpart to changing net foreign asset positions. Likewise the public sector borrowing requirement is influencial by affecting the stock of outstanding government debt. To be more specific, in the "risk premium" approach (Dornbusch, 1983; Gaab, 1982) it is assumed that the risk of holding foreign assets rises as their portfolio share grows, but falls as the net foreign asset position of abroad improves. Put another way, if the home country runs a current account deficit, excess demand for foreign assets is created, resulting in a depreciation of the domestic currency.

For all its merits as a theory, the empirical testing of this approach has not been very successful (Dornbusch, 1983; Gaab, 1987; Dooley and Isard, 1983; Cézanne, 1985). One very serious practical problem is to obtain reliable data on the composition of private portfolios, especially with regard to foreign

assets. Dornbusch claims nevertheless to be able to explain the path of the D-mark from the beginning of 1976 to the middle of 1979 by portfolio shifts. With the new regime of floating asset holders desired greater international diversification; meanwhile the share of D-mark denominated assets in international portfolios was quite small to begin with. The new demand for claims in the relatively stable D-mark lead to the sustained D-mark appreciation.

4.5 Expectations and the Role of "News"

Portfolio composition is hard to measure; expectations and their formation, which are so important in determining financial allocations and the exchange rate, may be in principle unmeasurable. It is unclear just what information is used in forming expectations about the exchange rate: the current account, inflation rates, judgements on the economic efficiency of a country, policy switchs, the history of political stability and security, etc., are all likely candidates. One cannot say in advance which factor will dominate at any particular point.

Dornbusch (1983) and Dooley and Isard (1983) - besides many others - emphasize the role of unexpected changes in the important exchange rate determinants, specifically the "news" about major macro-economic variables. Dornbusch (1983) investigates the influence of new information about the current account, interest differentials and cyclical or other demand factors; in econometric tests on the nominal effective dollar exchange rate news about the current account and relative interest rates was important; the dominant influence on the dollar-Yen rate was information on the current account and cyclical factors, while the dollar-mark rate seems according to these tests to have been barely affected by news from these sources (Cézanne, 1985).

5. Exchange Rate Movements: A Random Walk?

The unsatisfactory empirical results of models based on economic fundamentals can lead to a view of the exchange rate as a random walk or as the product of many transient, almost arbitrary influences. "Bubbles" and "bandwagon" effects may arise, along with "safe haven" considerations and vague anticipation of future policy changes. Due to the close interlinkages of international financial markets and the speed with which information may be transmitted around the globe, a rumour or presumption can be greatly magnified. Every observer of currency markets can confirm that the mix of factors which influence expectations and suppositions can shift dramatically. Therefore it is perhaps not so surprising that a "random walk" model, whereby the current exchange rate equals the rate in the previous period plus a stochastic term, performs if anything slightly better than models incorporating systematic explanatory variables (Meese and Rogoff, 1983).

Must one then conclude, that exchange rates are determined by some shifting collection of volatile influences? In the short-term this description may be the best available. More basically and over a longer time-span, however, the economic "fundamentals" should set the direction; to give just one example, the path of the dollar did reach a turning point in February 1985. It is possible that the low power of economic variables in explaining exchange rate movements is due to the partial equilibrium approach which is usually taken, for then one cannot allow for the complexities of the interactions between variables. Isard (1987) considers that better descriptions of the paths of exchange rates can probably only be achieved within the framework of a full macroeconomic model.

III. Survey of Current Research

1. Uncertainty and Risk: some theoretical considerations

Economics starts from the assumption that each household attempts to maximize its expected utility over its lifetime, and that economic policy should aim to raise the weighted sum of expected utilities. Let it be emphasized that utility rather than consumption per se is of value, and that expected rather than perfectly foreseen utility is the objective. In almost every plausible situation we must commit ourselves now to actions leading to unpredictable outcomes without the benefit of full insurance. Economists speak of risk to denote the spread of outcomes around the mean or expected value; this concept can be formalized (see Rothschild and Stiglitz, 1970 and 1971). Thus risk is distinct from fluctuations, which can be perfectly deterministic, and risk can be present even when one obtains a long string of identical realizations. Agents are said to be risk averse if their expected utility is decreased by an increase in risk. Speaking roughly, we require that the indirect utility function be concave in income[1], so that by Jensen's inequality expected utility of income is less than the utility of expected income.

It turns out that the optimal response to increasing risk cannot in general be predicted a priori but depends on the exact shape of the utility function.[2] However, if we are prepared to presume a utility function with constant absolute risk aversion

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[1] Let U(I) be an indirect utility function. Then the Arrow-Pratt measure of absolute risk aversion is defined as

$$A = \frac{U''}{U'}$$

and relative risk aversion as

$$R = - \frac{IU''}{U'} .$$

Someone is risk averse if A or R is greater than zero (see Pratt, 1964).

[2] See Rothschild and Stiglitz (1970, 1971).

then expected utility is a function solely of the first two moments of the distribution of outcomes, i.e., agents maximize a linear combination of the mean and the variance. Then, when the variance of the payoff of some action increases, the less of that action is undertaken. Often in this essay constant risk aversion and mean-variance optimization will be assumed.

Those familiar with the mean-variance approach will know the importance of the covariance between outcomes. For example, Action A might in itself be unattractive due to the high variance of its payoff, and yet people are willing to undertake A for the sake of its negative correlation with the results of performing B. The whole variance-covariance matrix is involved.

The classic example to illustrate this point is of course insurance, where one pays premiums to receive money precisely in the unlikely event of suffering an accident. In and of itself buying insurance is very risky!

Much of the risk in financial markets might be described as zero-sum or distributional, for one man's gain is another man's loss. However, there is also real and economy-wide risks, of which war and natural desaster are only the most dramatic manifestations. These chance events cannot be diversified away in a closed economy, yet if they are small on a world scale a country can greatly benefit by international trade in goods and securities. For example, consider a world of one good endowed to two countries; the endowments are allocated stochastically. With only one good and no securities market, no trade can occur (for the one good cannot be exchanged except against itself) and each country must accept its (uncertain) endowment. Contrast this with a world with a securities market where claims to endowment shares are traded ex ante.[1] Then goods trade will also flow as claims are redeemed and each country will consume an amount be-

[1] See Goldstein and Khan (1985).

tween its realized endowment and its mean endowment. In some states a country might lose, but expected utility rises.[1]

In reality, of course, there are vaste numbers of sources of risk and incomplete and expensive securities markets. Therefore firms may have a good reason to behave in a risk averse manner as a means of providing indirect insurance to their shareholders.[2] On the one hand, a firm may have the resources and expertise to make better use of financial markets than an individual can, for example, to obtain foreign currency forward contracts. On the other hand, a firm can influence the probability distribution of its profit stream by its "real" decisions about inventories, production methods, location, etc. Note, though, that if a firm is providing insurance to shareholders then it cannot provide perfect insurance, because ex hypothese markets are incomplete.

Firms may also be risk averse due to the separation of ownership and control, in other words, because managers are risk averse and their rewards are tied to realized firm performance. In any case, firms say that they are risk averse (see Whitman, 1984, for instance) and that is what will be assumed here.

The points made in this rather long introduction should be borne in mind, both as an aid to understanding and as a critique, while the concept and implications of exchange rate risk are developed below.

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[1] More generally with many sources of uncertainty and very incomplete markets we cannot be so confident that adding one extra, unfettered securities market will improve utility; this is a variant on the familiar problem of the second best.

[2] Non-economists may be amazed that anyone questions whether firms are or should be risk averse. But each firm is small relative to the economy as a whole and the uncertainty attached to its returns is mostly firm-specific and thus diversifiable.

In this paper the effects of exchange rate risk are investigated, that is, the effects of the "spread" of the distribution of unforeseen changes in the exchange rate. Since a normal distribution is assumed (see below) at issue is the variance of the "innovation" or "surprise" or "error term" in the exchange rate. Exchange rate risk is thus distinct from any predictable swings in the exchange rate. However, it should be pointed out that in the, admittedly highly simplified, models of the exchange rate developed by economists the system is always stable and rarely exhibits deterministic oscillations (i.e. the model yields real eigenvalues at best some of which are smaller than unity in absolute value). For example, in Dornbusch's seminal work (Dornbusch, 1976) the exchange rate "overshoots" in response to monetary shocks in order to compensate for the slow adjustment in prices and preserve asset market equilibrium, that is, the exchange rate initially jumps beyond its long-term equilibrium and then slowly converges. The uncertainty in the system concerns the timing and magnitude of monetary (and other) shocks; once a shock has occurred the path of the exchange rate is quite deterministic. Uncertainty is above all the product of our ignorance, and so it is most important to be clear about who knows what when. In the Dornbuschian model, agents are unsure about what policy will be announced, while the drawn-out swings in the exchange rate for any given policy are well known.

Admittedly there may be "noise trading" or "speculative bubbles" in exchange markets (see Meese and Rogoff, 1983; Meese, 1986) which add greatly to risk, especially concerning the timing of the bursing of the bubble. There is, though, some evidence (Huang, 1981; Wadhwani, 1987; West, 1985) that exchange rates may be a only bit more volatile than can be accounted for by more than can be attributed to the usual regression errors. Certainly exchange rate volatility is much closer to what it "ought" to be than is stock market variance (see Schiller, 1981).

Thus the exchange rate is endogenous to the economic system, even if it is taken as parametric by individual firms and consumers, and not an independent source of risk. Agents will mind exchange rate risk and react to it insofar as it impinges on their final objectives (consumption for households, perhaps market valuation for firms). Therefore the covariance of the exchange rate and other variables should help determine their actions. One important and clear link is with the price level. For instance, if purchasing power parity (PPP) holds then there are only two distinct sources of risk because the exchange rate is always equal to the ratio of domestic to foreign prices. It follows that the variance of the logarithm of the exchange rate is equal simply to the sum of the variances of the logarithms of the two price indices, minus twice their covariance. Put more intuitively, neither firms nor households should mind exchange rate surprises which are exactly offset by a relative price change. In this spirit, one of the measures of exchange rate risk used in this paper is calculated from the "real" exchange rate, that is, the nominal rate multiplied by a foreign price index and deflated by a domestic price index. However, it seems that PPP does not hold (see Levich, 1985, to give just one example) and most of the unanticipated changes in the exchange rate are not matched quickly by price changes. Therefore, the variance of the nominal exchange rate is a pretty good proxy for real exchange rate variance.

In this paper the covariance between the exchange rate and all other economic variables is not treated explicitly. On the one hand, a full general equilibrium relating exchange rate variance to exogenous shocks with feedback from the behaviour of firms and households is beyond the scope of this exercise. On the other hand, if the correlation between the exchange rate and other variables is quite stable, exchange rate variance will be representative of risk in the economy as a whole; for example, by uncovered interest parity, an expected depreciation is matched by a relatively high nominal interest rate, so there are counter-

balancing influences on corporate profitability. Yet since uncovered interest parity is close to holding true all the time, the variance of the interest differential is a simple monotonic function of the variance of the exchange rate. The whole variance-covariance matrix may change drastically while the relative riskiness of the exchange rate is almost unchanged.

The examples below concentrate exclusively on exchange rate risk and its influence on behaviour. The hypothesis to be derived is that the more uncertain are exchange rates, the less firms wish to deal in tradeable goods in general and to export in particular, and likewise consumers prefer goods the relative price of which is comparatively invariant. The volume of trade is taken to mirror welfare: if high exchange rate variance is associated with low levels of trade, then risk constitutes a significant detriment to welfare. It must be argued, first, that exchange rate uncertainty reduces trade and, second, that less trade is a bad thing.

To take the second point first, it should be apparent from the above that a reduction in trade is not a necessary condition for exchange rate variance to harm welfare. By definition agents are risk averse precisely when their utility is reduced by risk for given mean consumption. Exchange rate uncertainty would be undesirable even if average trade flows were unaffected: exchange rate variation leads to variance in the price of imports relative to exports and tradeables relative to non-tradeables. Therefore exchange rate risk leads to variation in real income and in the composition of consumption, and both effects lower welfare. One may complain about uncertainty in the foreign exchange market without claiming that this uncertainty hinders trade on average.

Nevertheless, when uncertainty does discourage trade, usually the degree to which it does so is positively related to the accompanying reduction in expected utility; both are functions of risk aversion, market power, production functions, correlations, etc. as will be shown below. Put more formally, the derivative

of expected utility with resp t to exchange rate risk is a mono-
tonically increasing function f the derivative of export (or
import) supply with respect t exchange rate risk.

The latter will now be i estigated first by means of some
simple examples and then more enerally. The examples are no
more than "finger exercises" t illustrate some of the important
features of the partial equil rium theory of trade under un-
certainty.

Let utility functions an the distribution of shocks be such
that the firm's objective fun ion is

$$(1) \quad EU(\Pi) = E(\Pi) - \frac{A}{2} \text{Var}\ )$$

where Π are profits, E(.) is e expectations operator, Var(Π) is
the variance of profits and A s a positive coefficient capturing
risk aversion, assumed consta . Firms must choose output (x)
for export before the exchang rate ($\tilde{e}$) is known. The expected
exchange rate is $\bar{e}$ and its va ance σ_e^2. (For a more thorough
discussion of the theoretical ssues see Clark (1973) and de Grauwe
(1986) and Coes (1979).

Case one: Monopolistically co etitive firm

The firm operates in a foreig market with a constant elasticity
demand curve but producing at ome. For simplicity and with
little loss of generality assu constant returns to scale and
one input with marginal cost Then, ignoring constants, pro-
fits can be written as

$$(2) \quad \Pi = \tilde{e}x^{\beta} - cx \qquad \beta < 1$$

so that

$$E(\Pi) = \bar{e}x^{\beta} - cx, \quad V (\Pi) = \sigma_e^2 x^{2\beta}$$

Hence the firm chooses x to maximize

$$(3) \quad EU(\Pi) = \bar{e}x^{\beta} - cx - \frac{A}{2}\sigma_e^2 x^{2\beta}$$

according to the first order condition

$$(4) \quad \bar{e}\beta x^{\beta-1} - c - A\beta\sigma_e^2 x^{2\beta-1} = 0$$

and assuming that the second order condition is met:

$$(5) \quad \bar{e}\beta(\beta-1) x^{\beta-2} - A\beta(2\beta-1)\sigma_e^2 x^{2\beta-2} < 0$$

$$\rightarrow \bar{e}(\beta-1) - A(2\beta-1)\sigma_e^2 x^{\beta} < 0$$

Then it is easily shown that

$$\frac{\partial x}{\partial \sigma_e^2} = \frac{A\beta x^{2\beta-1}}{\bar{e}\beta(\beta-1)x^{\beta-2} - A\beta(2\beta-1)\sigma_e^2 x^{2\beta-2}}$$

$$= \frac{Ax^{\beta+1}}{\bar{e}(\beta-1) - A(2\beta-1)\sigma_e^2 x^{\beta}} < 0$$

which is negative because the numerator is positive and the denuminator must be negative from the second order condition.

The price charged by the firm (in foreign currency) is

$$p = x^{\beta-1},$$

and therefore

$$\frac{\partial p}{\partial \sigma_e^2} = (\beta-1)x^{\beta-2}\frac{\partial x}{\partial \sigma_e^2}$$

$$= \frac{A(\beta-1)x^{\beta-1}}{\bar{e}(\beta-1) - A(2\beta-1)\sigma_e^2 x^{\beta}} > 0$$

The firm with market power raises its price (recall that $\beta < 1$ and the denominator above is negative from the second order condition), corresponding to the reduction in output, but not enough to increase expected profits:

$$\frac{\partial E(\Pi)}{\partial \sigma_e^2} = \left[\bar{e}\beta\, x^{\beta-1} - c\right] \frac{\partial x}{\partial \sigma_e^2} < 0$$

(Compare with equation (4)) which is only to be expected because the firm is precisely not maximizing expected profits.)

Notice, also, that

$$\frac{\partial EU(\Pi)}{\partial \sigma_e^2} = -\frac{A}{2} x^{2\beta} < 0$$

$$= \left\{-\frac{x^{\beta-1}}{2}\left[\bar{e}(\beta-1) - A(2\beta-1)\sigma_e^2\, x^{\beta}\right]\right\}\frac{\partial x}{\partial \sigma_e^2};$$

the first term is positive, so the greater the reaction of output to variance the greater the reaction of expected utility from profits.

Case two: Price taking firm

A firm uses two inputs, L and K, in a production function exhibiting diminishing returns to scale:

$$(6) \qquad x = K^{\alpha}L^{\beta}, \qquad 0 < \alpha\beta < 1, \qquad \alpha + \beta < 1$$

The firm faces a perfectly elastic world demand with price p fixed in foreign currency terms. The unit cost of input L is ω, fixed in advance, and the unit cost of K is a random variable $\tilde{r}$ such that

$$E(\tilde{r}) = \bar{r} \quad Var(\tilde{r}) = \sigma_r^2 \quad Cor(\tilde{r},\tilde{e}) = \rho$$

Thus

$$(7a)\quad E(\Pi) = \bar{e}p\, K^{\alpha}L^{\beta} - \omega L - \bar{r}K$$

$$(7b)\quad Var(\Pi) = \sigma_e^{\,2}\, p^2K^{2\alpha}L^{2\beta} + \sigma_r^{\,2}K^2 - 2\,\rho pK^{\alpha+1}\,L^{\beta}$$

Using the objective function defined in equation (1) yields the first order conditions

$$(8a)\quad \bar{e}p\alpha K^{\alpha-1}\,L^{\beta} - \bar{r} - A\left[\sigma_e^{\,2}p^2\alpha K^{2\alpha-1}\,L^{2\beta} + \sigma_r^{\,2}\,K - \rho p(\alpha+1)\,K^{\alpha}L^{\beta}\right] = 0$$

$$(8b)\quad \bar{e}p\beta K^{\alpha}L^{\beta-1} - \omega - A\left[\sigma_e^{\,2}\,p^2\beta\,K^{2\alpha}L^{2\beta-1} - \rho p\beta K^{\alpha+1}\,L\beta^{-1}\right] = 0$$

Here again it is easy to show that

$$\frac{\partial K}{\partial \sigma_e^{\,2}} = \frac{Ap^2\alpha\,K^{2\alpha-1}\,L^{2\beta}}{\frac{\partial^2 EU(\Pi)}{\partial K^2}} < 0$$

$$\frac{\partial L}{\partial \sigma_e^{\,2}} = \frac{Ap^2\beta\,K^{2\alpha}\,L^{2\beta-1}}{\frac{\partial^2 EU(\Pi)}{\partial L^2}} < 0$$

by the second order conditions, so the firm will produce less and expect less utility when faced with more exchange rate uncertainty.

More interesting, perhaps, are the partial derivatives

$$\frac{\partial K}{\partial \rho} = \frac{-Ap(\alpha+1)\alpha\,K^{\alpha}L^{\beta}}{\frac{\partial^2 EU(\Pi)}{\partial^2 K}} > 0$$

$$\frac{\partial L}{\partial \rho} = \frac{-Ap\beta\,K^{\alpha+1}\,L^{\beta-1}}{\frac{\partial^2 EU(\Pi)}{\partial^2 L}} > 0$$

for they demonstrate that positive covariance between revenues and costs encourages trade. Indeed, it could be that the firm prefers to import the factor, buying it at the world market price in foreign currency[3], then to purchase it at a fixed domestic price ($\bar{r}$). If K is imported then expected utility from profits is

$$(9) \quad \bar{e}p\, K^{\alpha}L^{\beta} - \omega L - \bar{\bar{e}}\bar{s}K - \frac{A}{2}\sigma_e^2\left[p^2\, K^{2\alpha}L^{2\beta} + \bar{s}^2K^2 - 2\bar{s}p\, K^{\alpha+1}\, L^{\beta}\right]$$

whereas the alternative would be

$$(10) \quad \bar{e}p\, K^{\alpha}L^{\beta} - \omega L - \bar{r}K - \frac{A}{2}\sigma_e^2 p^2\, K^{2\alpha}\, L^{2\beta}.$$

Now, the optimal choice of K and L depends upon the circumstances, but there is no reason why the maximum of equation (9) should not be greater than the maximum of (10), even if $\overline{es} > \bar{r}$, that is, even if it is more expansive on average to import the factor. Typically, it will be optimal to meet part of the firm's demand for K from imports and part domestically. This example illustrates that exchange rate instability may promote trade, especially trade in intermediary goods, even though welfare is unambiguously lost compared to the no-uncertainty case.

Importing factors hedges against exchange rate risk because it effectively reduces the amount which has to be converted - out of foreign and into domestic currency - from total foreign revenue to foreign revenues minus purchases of inputs abroad. (Correspondingly, of course, importing factors increases risk if the firm sells to an isolated domestic market.) The most developed form of this strategy is direct foreign investment, whereby the only exposure is of profits to be remitted. Further, one can imagine gaining strategic advantage from distributing plant and suppliers across several countries (see Lessard and Lightstone, 1986; and more tangentally Dornbusch, 1986; Krugman, 1986; and Franke, 1985). This is exactly what Ford Europe claims as a prime motive for international diversification (Die Zeit, No. 27, 26 June 1987).

One should also mention here a result from Coes (1979) that under fairly general assumptions a firm operating in more than one market will always reduce the share of output going to some market when price risk rises in that market.

It can be shown (see Hey, 1979, Part IV) that a competitive, risk averse firm will produce less under price uncertainty than when output is chosen to suit a known price. However, that does not imply that an increase in risk, especially for a firm with some market power, will reduce output (see Rothschild and Stiglitz, 1971; de Grauwe, 1986), because one must allow for changes in the degree of risk aversion. In our two examples above the firm might wish to export more if A fell sufficiently as σ_e^2 rose.

There are two further qualifications to the hypotheses that exchange rate risk adversely affects trade flows. First, the strength of this influence is likely to be smaller in a general equilibrium setting because then there are more and more complex hedging methods; because there are other sources of risk; and because the possibility of "escaping" foreign exchange risk are less (volatility in the price of tradeables implies volatility in the relative prices of non-tradeables, factors, assets, etc.).

Second, firms may be able to take out insurance against movements in the exchange rate, so that the domestic currency price is known when output decisions are made. There is indeed a great number of such financial instruments, some of which (notably forward contracts) seem to be relatively inexpensive and easy to use. Perhaps the market for foreign exchange insurance is effectively complete as far as firms are concerned.

This critique, however, seems to take an excessively short-term and simplistic view of the firm. First, it is not clear whether or not, were markets so complete, firms ought to be risk averse; their owners could just as well take out their own desired level of insurance and diversify their portfolios. Second,

if markets for one form of risk are complete but not for others it will not in generally be optimal to obtain full insurance against the former. Third and most important, the financial instruments available are of relatively short maturity (up to one year) and are thus suited to and employed in hedging "transactions" and "translation" risk (the risk of an exchange rate change between the signing of a contract and payment and the risk in converting profits made abroad into the home currency, respectively). Yet decisions about new capacity, about product development, about marketing and so on must be taken years before they yield a return and long before one can have more than the vaguest inklings of what market conditions will be like when the project is completed. An extreme form of decision and implementation lags, and the interaction of exchange rate risk with other risks and with the strategic behaviour of firms, is manifest in the airliner industry: it takes maybe a decade to develop the product which will then be sold over the course of twenty years. The market is oligopolistic, thoroughly international and distorted by rivalrous governments. Does anyone claim that Airbus can take out full insurance against risks caused by exchange rate movements?

More generally, exchange rate risk can lead to a shift in capital allocation away from exposed industries and towards those which are relatively insulated. This risk is not wholly "diversifiable". Firms in the tradeables sector will have relatively more risky returns than those in non-tradeables, so that to attract capital they must offer on average higher profits, which in turn requires higher prices and less output. In a monopolistically competitive industry (and most industries in the tradeable sector seem to be so) net entry stops when expected profits are greater than zero. A shift of capital out of a sector appears to the firms involved as a rise in the cost of finance and a shift in the perceived demand curve such that industry output contracts and profits rise; this possibility contrasts with case 1 above, where only output (and thus price) of one firm is free to move and expected profits are negatively related to exchange rate risk.

2. Empirical Research

The great majority of empirical work which has been done on the effects and costs of flexible exchange rates on trade flows have concentrated on the consequences of short-term fluctuations. The longer-term movements have only more recently been investigated (Steinherr, 1985; de Grauwe and Bellefroid, 1986). This tendency may in part be accounted for by a new awareness that flexible rates are subject not only to immediate volatility but also to long swings (Williamson, 1983). Of course, both forms of exchange rate fluctuations are not independent of one another (see again Williamson, 1983; Shafer and Loopesko, 1983; and below Section IV), so that the effects of short-term variance can indicate something about the costs of longer-term periodic movements.

The influence of exchange rate volatility on international trade was first studied already in the 1970s. In these early research efforts a negative effect on the trade of developing countries could be shown (Coes, 1979; Diaz-Alejandro, 1976) but not in the case of industrialized nations (Hooper and Kohlhagen, 1978), with the exception of trade between Britain and the U.S. A GATT study from 1980 (Blackhurst and Tumlir, 1980) of the global trade of industrial countries came to the conclusion that the system of flexible rates had no marked effect on the international flow of goods. Specifically, the authors doubted the existence of an independent influence of exchange rate movements on other macro-economic variables because, in their view, exchange rate shifts are necessarily endogenous, the result of other inequalities in inflation or growth rates or in the amount account. A comparison of time series by visual inspection leads them to identify growth and a few other factors as having much more influence on trade flows then do exchange rates; the authors do not deny that there is feedback from currencies to trade, but merely emphasize the dominant role of other factors, notably growth differentials.

The International Monetary Fund (Goldstein, 1984) stated in a survey presented in spring, 1984, that no definite connection had been established between exchange rate fluctuations and weakening growth in world trade.

2.1 Global Trade Flows

Akhtar and Hilton (1984) attempted to estimate the influence of short-term exchange rate volatility on foreign trade in a partial equilibrium setting. Their tests were restricted to U.S. and German trade in manufactured goods. They looked at both the quantities of imports and exports and import and export prices. As a measure of uncertainty they used the standard deviation of the daily nominal effective exchange rate during each quarter.

The standard deviation S is defined as

$$S = \sqrt{\sum_{t=1}^{T} \frac{(E_t - \bar{E})^2}{T}}$$

The estimated equations had the specification

$$X = f(YF,\ PX\ (E/PF^f),\ SX^f)$$

X	=	quantity of industrial goods exported
YF	=	measure of real activity abroad
PX	=	export price in the domestic currency
PF^f	=	price of foreign competing goods in foreign currency
SX^f	=	exchange rate risk for the importer
E	=	exchange rate

$$PX = f(UCD, SX^d)$$

UCD = production costs in domestic currency
SX^d = exchange rate risk for the exporter

$$M = f(YD, PM/PD, SM^d)$$

M = quantity of industrial goods imported
YD = measure of real domestic demand
PM = import price in domestic currency
PD = price of domestic manufactured goods in domestic currency
SM^d = exchange rate risk for the importer

$$PM = f(UCF^f/r, SM^f)$$

UCF^f = foreign production costs in foreign currency
SM^f = exchange rate risk for foreign producer.

Using observations from 1974 to 1981 Akhtar and Hilton obtain significant estimates: exchange rate volatility seems noticeably to have reduced the exports of both countries and German imports (see Table 5). German import and export prices and American export prices did not show any influence of exchange risk, but U.S. import prices tended to rise. It seems that in this case exchange rate risk acts indirectly via prices rather than directly on quantities.

The authors suggest that the greater sensitivity of German exports and imports to exchange rate risk compared to U.S. trade is due to the greater openness of the former's economy when a relatively high share of turnover is subject to this risk and the cost involved, a latent preference for the domestic market may be enhanced. Furthermore, it would be important that in a relatively open economy the price elasticity of the demand for imports and exports tend to be higher than in an economy which is less closely linked to the world economy. Implicit is an

assumption that insurance costs associated with flexible exchange rates lead to higher prices.

Akhtar and Hilton believe that their results may be an underestimate, as their measure of very short-term exchange rate volatility does not take uncertainty about future currency movements fully into account. No allowance is made for the uncertainty occasioned by persistent deviations of exchange rates from the "fundamentals" (see also Sections III.1 and IV.2).

Gotur (1985) subjected the work of Akhtar and Hilton to a thorough reexamination. She tested for the generality of their results by including France, Britain and Japan using the same procedure and time period. She did not find significant effects of exchange rate variance on trade for any of the three. For Britain the estimated coefficient on the risk variable had the wrong sign, for France and Japan the estimates are not significant (see Table 5). For the last two countries the effects of uncertainty induced by exchange rate fluctuations are apparently felt only indirectly via prices.

Gotur modified Akhtar and Hilton's methodology in a number of ways: Lengthening the series of observations (1975-1983), enhancing the measure of uncertainty (using an effective exchange rate weighted against 18 currencies) and complicating the lag structure on the uncertainty and price variables.

As to her results for Germany and the U.S., the significant coefficients found by Akhtar and Hilton are found now only for export volumes and are of smaller magnitude. All other coefficients, in contrast to those in Akhtar and Hilton, were either of the wrong sign or insignificant. At the same time an effect on U.S. export prices would be discerned which was not present in Akhtar and Hilton. Similarly for the trade in goods by France, Britain and Japan Gotur could not establish a direct negative influence. For France an indirect effect of exchange rate risk was uncovered, namely through significant coefficients on import and export prices, as was the case for import prices in Japan (see

Table 6). One cannot, in sum, conclude from Gotur's investigation that there is a systematic, universally present, negative influence of exchange rate volatility on trade. The author suggests, however, that perhaps long-term currency swings discourage trade.

Justice (1983) looks at the impact of exchange rate uncertainty on the volume of global exports and export prices of Britain. Unlike Akhtar and Hilton or Gotur Justice does not use the standard deviation of the exchange rate as a measure of volatility. Instead he uses the Gini index (the median absolute change during some period) or the median absolute deviation from the period mean. Paying regard to the difficulties attached to calculating exchange rate uncertainty he tried estimating with no fewer than ten measures of risk. Justice also distinguishes between measures of variability and measures of risk, thus emphasizing that exchange rate fluctuations are not necessarily connected with higher risk, in particular insofar as they are foreseeable. The risk measure is either the average percentage deviation of the realized exchange rate from that predicted by a trend regression, or the difference between the spot price and the forward price one or two periods before. The measures of variability are calculated from the average change in the nominal exchange rate over the previous 12 months or 8 quarters. A variant is the deviation from a moving 7-period average. The measure of variability in the real exchange rate is derived from the average change over the previous 8 quarters.

Measures of variability and risk (Justice 1983)

Measure of variability

A1 Mean of the absolute percentage first differences of the 12 monthly observations over the past year (averaged over the current quarter)

$$\left[\sum_j w_j \sum_{i=o}^{n=11} \left|(S_{jt-i} - S_{jt-i-1})/S_{jt-i-1}\right| / n+1\right] * 100$$

A2 Mean of the absolute percentage first differences of the 8 quarterly observations over the past two years

As above (n = 7)

A3 Absolute percentage deviation of the current monthly observation from a 7 period centred moving average (averaged over current quarter)

$$\left[\sum_j w_j \left|(S_{jt} - \bar{S}_j)/\bar{S}_j\right| * 100\right]_{[n=3]}$$

where $\bar{S}_j = (\sum_{i=-3} S_{jt-i})/2n + 1$

A4 Absolute percentage deviation of the current quarterly observation from a 7 period centred moving average

As above

Measures of nominal exchange rate risk

B1 Ex ante forecast error. Average absolute percentage deviation of the monthly bilateral exchange rate observations 1, 2 and 3 periods ahead from an ex ante trend calculated over the past 9 monthly observations. The forecast errors for each period are then averaged and the resulting bilateral "risk" series weighted

$$\left[\sum_j w_j \left|\sum_{i=1}^{n=3} (S_{jt} - \bar{S}_{jt-i})/\bar{S}_{jt-i}\right|/3\right] * 100$$

where $\bar{S}_{jt} = (\sum_{i=o}^{8} S_{jt-i})/9$

together using MERM weights (and averaged over the quarter)

B2 Forward exchange rate risk (one month forward). The absolute percentage difference between the average observed spot exchange rate and the average quarterly $/£ forward exchange rates 30 days earlier

B3 Forward exchange rate risk (two months forward). The absolute percentage difference between the average observed spot exchange rate and the average quarterly $/£ forward exchange rates 60 days earlier

Measures of real exchange rate variability

C1 Relative costs. Mean of the absolute percentage first differences of the 8 quarterly observations over the past two years

$$\left[\sum_{i=0}^{n=7} \left|(R_{t-i} - R_{t-i-1}) / R_{t-i-1}\right|\right] / n + 1 \ * 100$$

C2 Relative wholesale prices. Mean of the absolute percentage first differences of the 8 quarterly observations over the past two years

As above

Measure of world currency variation

D1 Weighted average of the absolute percentage deviations of the current quarterly effective exchange rates of the major

$$\left[\sum_{j} v_j \left|(E_{jt} - \bar{E}_j)/\bar{E}_j\right|\right] * 100$$

where

$$\bar{E}_j = \left(\sum_{i=-n}^{i=n} E_{jt-i}\right)/(2n + 1)$$

(n=3)

manufacturing countries from a 7 period centred moving average (weighted together using 1975 world trade shares, V_j)

Justice uses the following equations for estimation:

$$\ln XGMA_t = a_0 + \sum_{i=0} a_{1i} \ln \frac{UXGM}{WPOM.ERUK_{t-i}} + \sum_{i=0} a_{2i} \ln TWIP_{t-i}$$

$$+ \sum_{i=0} a_{3i} \ln VAR_{t-i} + \sum_{i=0} a_{4i} \ln XGMA_{t-i-1} + u_t$$

XGMA = real exports of manufactured goods
UXGM = export unit values (export prices) in Sterling
WPJM.ERUK = competitors export prices in Sterling
TWIP = industrial production in OECD countries
VAR = measure of variability

$$\ln UXGM_t = b_0 + \sum_{i=0} b_{1i} \ln WPIM.ERUK_{t-i} + \sum_{i=0} b_{2i} \ln COST_{t-i}$$

$$+ \sum_{i=0} b_{3i} \ln POD_{t-i} + \sum_{i=0} b_{4i} \ln VAR_{t-i} + \sum_{i=0} b_{5i}$$

$$\ln UXGM_{t-i-1} + v_t$$

UXGM = export prices in Sterling
COST = domestic unit costs
POD = domestic capacity utilization.

Footnotes:

S_j: jth country's exchange rate against Sterling
E_j: jth country's effective exchange rate
R : appropriate real exchange rate
w_j: IMF MERM weights
v_j: 1975 world trade share weights

The equations were estimated in logarithms and with various lags for the period 1973 to 1981. Justice could not find any impact on the quantity of British exports for any measure used. To this, results for the influence on export prices are more complex and harder to interpret: prices displayed no statistically significant reaction to nominal exchange rate variability, but they did to real exchange rate volatility. The signs of coefficients are positive, suggesting an indirect effect on export volumes. Justice could also report a significant effect of exchange rate risk, but now the sign is negative, which would be consistent with the exporter bearing the risk (see Table 6).

Kenen and Rodrik (1984, 1986) investigate the influence of exchange rate risk on the global trade of 11 industrial countries from 1975.I to 1982.II. As risk measure they employ the fluctuations of the monthly real exchange rate over the previous 12 or 24 months. For both periods they calculate three measures: the standard deviation of the percentage changes, deviations from a trend and from an estimated autoregressive function.

The three proxies for variability are

$$(1) \quad {}_1J^x_{it} = \sqrt{\frac{1}{(N-1)} \sum_n (r^x_{in} - \bar{r}^x)^2}$$

$$r^x_{in} = \text{Log } R^x_{in+1} - \text{Log } R^x_{in}$$

$$\bar{r}^x_i = \text{mean } r^x_{in} \text{ in the relevant period}$$

$$(2) \quad {}_2J^x_{it} = \sqrt{\frac{1}{(N-2)} \sum_n (\log R^x_{in} - \log \hat{R}^x_{in})^2}$$

$$\text{Log } \hat{R}^x_{in} = a_o + a_1 T, \quad T = 1, \ldots N$$

(3) As for (2) but

$$\text{Log } \hat{R}^x_{in} = b_0 + b_1 \text{ Log } R^x_{in-1}$$

The estimated equations have the structure

$$\text{Log } V^x_t = \beta_0 + \beta_1 \text{ Log } R^x_{t-1} + \beta_2 \text{ Log } Q^x_t + \beta_3 T + \beta_4 A^x_t$$

V^x_t = quantity exported

R^x_{t-1} = real effective exchange rate, export weighted

Q^x_t = demand variable for the foreign market

T = trend

A^x_t = measure of exchange rate variability

$$\text{Log } V^m_t = \beta_0 + \beta_1 \text{ Log } R^m_{t-1} + \beta_2 \text{ Log } Y_t + \beta_3 T + \beta_4 A^m_t$$

V^m_t = quantity of industrial goods imported

R^m_{t-1} = real effective exchange rate, import weighted

Y_t = domestic industrial production

T = trend

A^x_t = measure of variability

Kenen and Rodrik, like other authors, come to mixed results (see Table 5). For eight countries negative coefficients on the uncertainty term were obtained in the import volume equations; in four cases (U.S.A., Canada, Belgium, France) the coefficients were large and very significant. Upon extending the time series to 1984 (Kenen and Rodrik, 1986), Germany and Britain also seemed very susceptible to exchange rate risk along with the U.S. and Canada. However, the negative impact on French imports is now no longer significant and for Belgium the sign has changed on the estimated coefficient, albeit now insignificant.

On the export side a negative effect of exchange rate volatility could be reported in only three cases, namely Japan, Canada and Italy. American and British exports were of anything encouraged. The other five countries (Belgium, France, Germany, the Netherlands and Sweden) displayed no significant effect at all. These countries, though, had especially low exchange rate instability - with the exception of Sweden - due to their membership in the European "Snake" and then the EMS. It is unfortunate that Kenen and Rodrik did not extend their investigation of exports to the longer period.

Kenen and Rodrik conclude that, on balance, their research shows that exchange rate volatility has hindered international trade, but not for all countries.

Bailey, Tavlas and Ulan (1986) examin the connexion between exchange rate variance and the real total exports of seven industrial countries (Canada, France, West Germany, Italy, Great Britain, the U.S. and Japan). Their estimates are based on quarterly data from 1973.I to 1983.III. They use the absolute percentage change (in the nominal effective exchange rate (E_{it}) from quarter to quarter as a measure of fluctuations (V_{it})):

$$V_{i,t} = \left| \left(E_{i,t} - E_{i,t-1} \right) \Big/ E_{i,t-1} \right|$$

The estimated equation for exports took the form

$$\log X_i = \log a_1 + a_2 \log Y + a_3 \log RP_i + a_4 \log OP + a_5 V_i + e_i$$

X_i = volume of exports

Y = importer's real GDP

RP_i = domestic relative to foreign prices

OP = real export earnings of oil producing countries

V = measure of variability

e = error term; conforms to the Gauss-Markov assumptions.

The influence of exchange rate fluctuations upon exports was tested either by incorporating the current variability measure into the estimated equation or by using an 8 period distributed lag. The authors do not find a significant negative impact on the exports of any of the 7 countries investigated. The estimated coefficients were negative but not significantly so for only Canada, France, Japan and Italy. The coefficient on variability was indeed positive for West Germany, the U.S.A. and Great Britain, although very small and again insignificant (see Table 5). Bailey et al. explain the differences between their results and those of others by the different specification of the export function; in particular, they take into account the real export earnings of oil producers as determinant of demand for total exports from industrial countries, an influence ignored by other authors. Their results may also have been influenced by the exclusion of dummies for, say, dockers' strikes, which Akhtar and Hilton and Cushman use.

2.2 Global and Bilateral Trade

Cushman (1983) concentrates his study on specific bilateral trade flows of the U.S.A. and West Germany. For the period 1965 to 1977 he looks for the consequences of exchange rate fluctuations on the goods trade between both countries and France and Britain, and on trade between the U.S.A. and Canada, Japan and West Germany. Cushman looks at two measures of uncertainty which, he argues, should enter the indirect utility functions of entrepreneurs. One is the so-called "expectations variable" (θ) relating to the forecast change in the exchange rate.

$$\theta_t = 100 \; (R_t \; / \; R_{t-1}) \qquad R = \text{real exchange rate}$$

If purchasing power parity holds at least in the long-term, then expectations concerning the future path of the exchange rate should depend upon its recent history: if θ has been consistently grater than unity over several quarters, then one's currency has been tending towards overvaluation and a reduction in θ is to be expected. This relationship is embodied by Cushman in the equation

$$E\theta = \frac{1}{M}$$

E = expectations operator

M = four-quarter moving average of real exchange rate changes

The other measure of uncertainty is the "risk variable", the standard deviation of the changes in the real exchange rate; again a four-quarter moving average is used in the estimated equation, which is of the form:

$$Q = a_0 + a_1 \; Y + a_2 \; CU + a_3 \; UC + a_4 \; UC^* + a_5 \; R$$

$$+ a_6 \; M + a_7 \; S + d$$

Q = export quantity
Y = importer's real GNP
CU = capacity utilization in the importing country
UC = real unit costs in the importing country
UC* = real unit costs in the exporting country
R = real exchange rate
M = "expectations variable" (see above)
S = "risk variable" (see above)
D = dummy for U.S. dockers strikes

The specification for export prices contains the same explanatory variables or that for export quantities with the exception of the dummy. Whereas the expected sign on the uncertainty variables in the export equations is unambiguously negative, there is no prior on sign of these variables in the price estimates. Cushman reports a series of significant, negative results, that is, a considerable reduction in bilateral trade stemming from exchange rate uncertainty, albeit with an important lag. Among the statistically significant variables the sign is the same on the "expectations" and the "risk" variables. Cushman can demonstrate a reduction through exchange rate uncertainty in the trade of the U.S.A. with France, Canada and Japan; the same holds for German exports to France and Britain. However, according to Cushman's estimates British exports to West Germany are actually stimulated by exchange rate uncertainty (see Table 7).

Steinherr (1985) studies the influence of exchange rate uncertainty on both bilateral and global trade flows, specifically, on the total exports of the U.S.A., Great Britain, Belgium and West Germany and on the exports of the last three to the U.S.A. As in de Grauwe and Bellefroid he starts from the position that long-term currency fluctuations are more detrimental to international trade than the short-run movements. He constructs a

measure of uncertainty which both contains the deviation of the actual exchange rate from a rate corresponding to purchasing power parity, and which incorporates the hypothesis, that exchange rate uncertainty is probably greater, the greater the spread between the maximum and the minimum rate during a period.

The equation is

$$V_t = \frac{X_{max(t)} - X_{min(t)}}{X_{min(t)}} + \left(1 + \left|\frac{X_t - \bar{X}_t}{\bar{X}_t}\right|^2\right) \equiv V_1 + V_2$$

X_t = nominal exchange rate at time t

$X_{max(t)}$, $X_{min(t)}$ = maximum and minimum nominal exchange rate from 1960 to time t

$\bar{X}_t$ = exchange rate corresponding to PPP

The estimated equation has the form

$$Q = f(WT \text{ or } USGNP, REEC, REEC_{-1}, V, PXPM, Q_{-1})$$

Q = exports
WT = world trade
USGNP = GNP of the United States
REEC = real effective exchange rate, CPI based
V = uncertainty measure
PXPM = terms of trade

All variables except V are in logarithms.

Using annual data for the period 1960-1984 Steinherr finds a significant negative influence on most of the trade flows tested. One exception were the total exports of Great Britain, for which a positively signed coefficient on V was found. For British, West German and Belgian exports to the U.S.A. exchange rate uncertainty had a negative influence in every case (see Table 7). It is unfortunate that Steinherr did not try splitting his sample between the fixed and floating rate periods. One may also ask whether his uncertainty measure does truely capture relevant uncertainty or just the level of the exchange rate.

De Grauwe and Bellefroid (1986) attempt a cross-sectional analysis. They investigate the effects of exchange rate fluctuations on the basis of bilateral trade flows between the ten largest industrial countries, which together conduct about 60 % of world commerce. The period 1960-1969 of fixed exchange rates is compared with the floating rate period 1973-1984. The measure of exchange rate uncertainty is either the standard deviation or the mean absolute deviation of the annual rates of change in the bilateral rates around their period averages. The latter (S_b) is defined as[1]

$$S_b = \frac{\sum_{i=1}^{n} \left| X_i - \bar{X} \right|}{n} \qquad X_i = \text{annual rate of change}$$

This measure, in contrast to the standard deviation, treats all observations including outliers equally. The two proxies are each calculated for both the nominal and the real exchange rates over the time periods 1960-1969 and 1973-1984. The use of annual exchange rate movements over the course of a long time span is meant to capture long-run aspects of the problem: it is supposed that it is not so much short-term exchange rate movements over days or months but rather the longer fluctuations which generate the relevant uncertainty and thus affect the allocation of resources.

[1] The equation for the standard deviation is given above on p. 42.

Table 5

Exchange Rate Uncertainty and Foreign Trade

- Results of econometric studies of total trade -

Estimated coefficients on the "currency fluctuations" variable

		Akhtar/Hilton (1984) 1974-81	Gotur (1985) 1975-83	Justice (1983) 1973-81	Kenen/Rodrik (1984, 86) 1975-82/2	Bailey/Tavlas/Ulan (1986) 1973-83/3	Steinherr (1985) 1960-84	Gashig (1986) 1977-85
F.R. Germany	EX	- 0.220	- 0.12	-	- 0.43 (n.s.)	+ 0.34 bis + 2,45 (n.s.)	- 0.047	-
	Im	- 0.125	- 0.05 (n.s.)	-	- 8.47	-	-	-
France	EX	-	- 0.01 (n.s.)	-	+ 0.19 (n.s.)	- 0.01 bis - 1.03 (n.s.)	-	-
	Im	-	+ 0.05 (n.s.)	-	(=)3.65 (n.s.)	-	-	-
Great Britain	EX	-	+ 0.04 (n.s.)	- 0.09 (n.s.)	+ 4.60	+ 0.20 bis + 1.0 (n.s.)	+ 0.055	+ 0.02 (n.s.)
	Im	-	+ 0.07 (n.s.)	-	- 8.84	-	-	-
U.S.A.	EX	- 0.040	+ 0.14	-	+14.43	+ 0.43 bis + 0.93	- 0.109	-
	Im	+ 0.005	- 0.02 (n.s.)	-	-14.9	-	-	-
Japan	EX	-	+ 0.03 (n.s.)	-	- 8.70	- 0.11 bis - 0.56 (n.s.)	-	-
	Im	-	+ 0.09	-	+ 3.0	-	-	-
Italy	EX	-	-	-	- 8.11	- 0.17 bis + 0.62 (n.s.)	-	-
	Im	-	-	-	+ 2.39 (n.s.)	-	-	-
Belgium	EX	-	-	-	+ 1.04 (n.s.)	-	- 0.053	-
	Im	-	-	-	(∓)1.46	-	-	-
Canada	EX	-	-	-	- 6.90	- 0.002 bis - 0.014	-	-
	Im	-	-	-	- 5.15	- (n.s.)	-	-
Switzerland	EX	-	-	-	- 6.02	-	-	-
	Im	-	-	-	+ 2.29 (n.s.)	-	-	-
Sweden	EX	-	-	-	+ 1.84 (n.s.)	-	-	-
	Im	-	-	-	- 3.78 (n.s.)	-	-	-
Netherlands	EX	-	-	-	+ 0.20 (n.s.)	-	-	-
	Im	-	-	-	- 5.94 (n.s.)	-	-	-

(n.s.) = not significant.- (∓) = sign change on extension of estimation period.-
(=) = no longer significant on extention of estimation period.

Table 6

Exchange Rate Uncertainty and the Prices of Traded Goods

- Results of econometric studies -

Estimated coefficients on the "currency fluctuations" variable

	Justice (1983) 1973-81		Akhtar/Hilton (1984) 1974-81	Gotur (1985) 1975-83
F.R. Germany				
Exports	-	-	+ 0,001 (n.s.)	+ 0,01 (n.s.)
Imports	-	-	+ 0,01 (n.s.)	- 0,02 (n.s.)
France				
Exports	-	-	+ 0,03	+ 0,04
Imports	-	-	+ 0,03	+ 0,03
Great Britain				
Exports	+ 0,018[a]	- 0,005[b]	- 0,03[c]	- 0,01 (n.s.)
Imports	-	-	- 0,005 (n.s.)[c]	- 0,01 (n.s.)
U.S.A.				
Exports	-	-	- 0,002 (n.s.)[c]	+ 0,10
Imports	-	-	+ 0,02 (n.s.)[c]	- 0,005 (n.s.)
Japan				
Exports	-	-	+ 0,05[c]	+ 0,00t (n.s.)
Imports	-	-	+ 0,05[c]	+ 0,06

a) Variability measure (C2).
b) Risk measure (B3).
c) Estimated by Gotur following the Akhtar and Hilton methodology.

n.s. = not significant.

Table 7

Exchange Rate Uncertainty and Foreign Trade

- Results of econometric studies of bilateral trade -

Estimated coefficients on the "currency fluctuations" variable

Exports	Hooper/Kohlhagen (1978) 1965-75	Cushman (1983) 1965-77	Steinherr (1985) 1960-84
F.R. Germany	--	--	- 0,0469
to France	- 7,29 (n.s.)[x]	- 54,68	
Great Britain	9,07 (n.s.)	- 31,61	--
U.S.A.	2,82 (n.s.)	--	- 0,3907
Japan	- 0,01 (n.s.)	8,87	--
Great Britain	--	--	0,0549
to F.R. Germany	- 0,97 (n.s.)	18,50	--
France	--	--	--
U.S.A.	4,24 (n.s.)	2,24 (n.s.)	- 0,1925
Japan	--	--	--
U.S.A.	--	--	- 1,094
to F.R. Germany	0.73 (n.s.)	3,92 (n.s.)	--
France	- 0,49 (n.s.)	- 8,75	--
Great Britain	- 31,9	11,16	--
Japan	- 0,02 (n.s.)	- 30,23	--
Japan	--	--	--
to F.R. Germany	149,7 (n.s.)	- 14,73 (n.s.)	--
France	--	--	--
Great Britain	--	--	--
U.S.A.	4425,0 (n.s.)	- 197,02	--

[x] n.s. = not significant

The estimated equation has the structure:

$$X_{i,j,t} = a + bT_{i,j,t} + cY_{jt} + eS_{i,j,t} + u_{i,j,t}$$

$$i,j = 1, \ldots n;$$
$$t = 1,2$$

$X_{i,j,t}$ = average annual growth rate of trade between countries i and j in period t

$T_{i,j,t}$ = dummy for the process of integration between certain groups of countries (EC(6), new entrants to the EC) or of development (Japan)

Y_{jt} = average annual growth rate of GNP

$S_{i,j,t}$ = measure of exchange rate uncertainty

De Grauwe and Bellefroid report the expected negative sign on all measures of variability, in six out of eight cases the coefficients being significant. Most pronounced is the negative influence of real exchange rate fluctuations (see Table 8). De Grauwe and Bellefroid suggest that the reason, why they found a dampening of export growth due to exchange rate uncertainty when others did not, lies first of all in their concentration on longer-term exchange rate movements which give rise to greater uncertainty than possible short-term fluctuations, against which insurance is more readily available. Estimation with measures of short-term volatility did not yield any significant negative coefficients. Further, de Grauwe and Bellefroid place great weight on their explicit treatment of integration effect in obtaining their results. This effect was especially noticeable on the six original members of the EC, whose bilateral trade decelerated markedly in the 1970s despite relatively low exchange rate variability.[1]

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[1] According to de Grauwe and Bellefroid the integration effect raised the annual growth rate of intra-EC trade by approximately 6 %; in the 1970s there seems indeed to have been a slight negative effect.

Table 8 Impact of Exchange Rate Variability on Growth of Trade

1960-1969 (S-60) 1973-1984 (S-70)

(Numbers in parentheses are t-statistics)

Explanatory Variables	Coefficients			
	Nominal Variability		Real Variability	
	Standard Deviation	Mean abs. change	Standard Deviation	Mean abs. change
Exchange Rate Variability				
S-60	-0.07 (-0.4)	-0.32 (-1.0)	-0.69 (-2.4)	-0.73 (-2.0)
S-70	-0.19 (-2.1)	-0.17 (-1.8)	-0.36 (-3.4)	-0.37 (-2.9)

Source: de Grauwe and Bellefroid (1986).

De Grauwe and Bellefroid look also at the fluctuations in annual growth rates of trade and test for possible causes. Their conclusion is that the integration effects play next to no role but that exchange rate fluctuations are important (see Table 9).

Table 9

Impact of Exchange Rate Variability on Variability of Trade Growth

(Numbers in parentheses are t-statistics)

Explanatory Variables	C o e f f i c i e n t s	
	Real Variability	
	Standard Deviation	Mean abs. change
Exchange Rate Variability		
S-60	2.67 (3.2)	2.77 (3.7)
S-70	0.59 (2.3)	0.39 (1.6)

Source: de Grauwe and Bellefroid (1986)

Thursby and Thursby (1985) investigate the influence of short-run exchange rate fluctuations, again by means of cross-sectional analysis. Twenty countries - mostly industrial countries - are included in the sample, and both their total exports and trade between the twenty is examined. The sample period extends from 1973 to 1977. Measures of variability were estimated on the basis of monthly data on nominal and real exchange rates, where the real rate is calculated using either consumer or the wholesale price indices. The following measures were employed:

$$AV = \frac{\sum_{i=1}^{n} |X_{i,t} - X_{i,t-1}|}{n} \qquad n = 12$$

= mean absolute percent changes during a year

$$SV = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})}{n}}$$

= standard deviation of per cent changes during a year

$$RV = \sqrt{\frac{\sum_{i=1}^{n} (u^2)}{n}}$$

= standard deviation of the residuals from a quadratic time-trend regression $R_t = a + bt + ct^2 + u_t$

Thus in total nine measures of exchange rate volatility were tested.

The estimated equation had the structure:

$$X_{ij} = a_1 + a_2 ADG_{ij} + a_3 V_{ij} + a_4 ME_{ij}$$

X_{ij} = value of exports from country i to country j, in US dollars, 1975 prices

ADG_{kj} = (GNP of i) - (GNP of j)

V_{ij} = measure of the variability of the exchange rate between the currencies of i and j

ME_{ij} = mean percentage change in the exchange rate ij.

X_{ij} and GNP data are annual while V_{ij} and ME_{ij} is based on monthly data for the relevant year.

Tests using the nine measures of variability do not lead to an unambiguous conclusion. Results vary by variability measure and currency. Among the significant coefficients some are positive and some negative, although the latter are more numerous. Fluctuations in the real, wholesale price index deflated exchange rate have significant effect in only very few countries, no matter which of the three measures is used.

The trade of about three quarters of the countries seems to react to the fluctuations in the nominal or CPI-based real exchange rate when "AV", that is the mean absolute percentage changes, is tested when the variability measure "SV", the standard deviation of percentage changes, is used in the specification, a noteworthy effect on trade flows could be found in about half of the countries. Nearly all significant coefficients were negative, implying a disincentive towards bilateral trade. When global trade is looked at Thursby and Thursby do not find a single, significant coefficient. The conclusion they draw from their investigation is that exchange rate uncertainty does not affect global trade flows but does have a marked impact on its regional structure.

Edwards (1987) also uses a cross section, this time of 23 developing countries in the periods 1965 to 1971 and 1978 to 1985. He considers not just trade but four time series where the effects of exchange rate instability might be apparent: mean GNP growth rates, real income per head, real exports and the average investment-output ratio.

The estimated equations are of the form:

$$X_n = a + bV_n + cZ_{ni} + u_n$$

X_n = the "performance" variable (GNP, GNP per head, exports, investment-output ratio)

V_n = measure of exchange rate volatility

Z_n = other explanatory variables as appropriate to the "performance" variable (e.g. the investment ratio and the variance of terms of trade for GNP; variance of the terms of trade for exports, etc.)

u_n = error term

The equations were estimated using untransformed data or in logarithms.

Edwards employs the coefficient of variation as his measure of variability, that is, the standard deviation of the residuals from a regression (S_x) divided by the arithmatic mean of the dependent variable (X):

$$V_x = \frac{S_x}{\bar{X}} \quad \text{where} \quad S_x = \sqrt{\frac{\sum (X - \hat{X})^2}{n-1}}$$

Specifically the influence of the variability of real effective exchange rates and of real rates against the dollar were tested for.

The cross-sectional analysis of the 23 developing countries led to the following results: during the Bretton Woods era (1965-1971) exchange rate fluctuations had as good as no effect on GNP or exports or on the investment-output ratio. The floating rate period 1978-1985 was different, as now a clear negative influence of exchange rate uncertainty on real GNP growth, on the growth in real GNP per head and also on the investment-output ratio was found. However, Edwards could not find a negative effect in the equation for exports, where indeed the coefficients were positive - the opposite of what one might expect - although not well secured. Edwards cautions against drawing too strong a conclusion, as the data series on exports is especially unreliable. Nevertheless, the contradiction between his results for domestic performance and for exports is disturbing since trade is presumably the transmission channel of exchange rate instability.

Table 10

Cross Country Regressions:
Export Growth and RER Variability,
1965-1971 and 1978-85 (OLS)*

(Numbers in parentheses are t-statistics)

Period	Constant	log of Variability Bilateral RER	log of Variability Effective REER	log of Variability T of T	R^2
1965-71	2.067 (1.715)	-	-0.121 (0.296)	-0.664 (-1.487)	0.147
1965-71	2.644 (6.488)	-0.333 (-1.615)	-	-0.145 (-0.953)	0.195
1978-85	1.353 (2.928)	0.326 (0.898)	-	0.099 (0.205)	0.067
1978-85	0.917 (1.207)	-	0.286 (0.789)	0.019 (0.093)	0.054

*The dependent variable is the log of the average rate of growth of real exports.

Source: Edwards (1987)

2.3. Sectoral Trade

The first and perhaps the best study of the effects of exchange rate risk on trade by sector was done by Coes (1979). He derives from theory a weighted index of moments of the distribution of exchange rate changes, which allow for the possible non-normality of this distribution. In contrast to other authors, Coes uses the export share in total production as his dependent variable, arguing that price uncertainty in one market will not just reduce total output but also draw resources away from that market. His data encompare 13 industrial and 9 primary sectors in Brazil and extend from 1959 to 1973; this period include a major regime shift, namely the introduction of a "crawling peg" for the Cruzeiro in 1968. In only two sectors does Coes find a coefficient on the risk variable with the wrong sign and very often his estimates are very significantly different from zero.

Maskus (1986) was the first in this field to undertake a sectoral disaggregation for an industrial country, restricting himself to the imports and exports of the U.S.A. He asserts that an investigation of individual branches is required, as the susceptibility of the different sectors to exchange rate uncertainty could vary greatly depending, for instance, upon the degree of integration into the world economy, on the regional structure of a sector's trade patterns, the market structure and the importance of multinational operations.

Maskus investigates the areas of agriculture, raw materials, total manufacturing industry, chemicals, machinery, motor vehicles and a group of "other manufactured goods". Besides the global imports and exports of these sectors he looks the bilateral trade flows of the U.S.A. with Japan, Great Britain, Canada and West Germany. The estimation period covers the years 1974 to 1984.

The measure of exchange rate risk comprises two parts, one to capture nominal exchange rate risk and the other proxying for price risk. An indicator of the former is the forward premium

(the difference between the spot and forward rates) while price risk is measured by the difference between the realized and the expected inflation differential between at home and abroad.

The expression of the exchange rate risk of sector i in trading with country j, for some quarter, is as follows:

$$RISK_{ij} = \frac{1}{3} \sum_{m=1}^{3} NRISK^{m_j} + USINFERR^{m_j} - INFERR^{m}_{i,j}$$

$NRISK^{m_j}$ = percentage difference between the spot rate and the 3-months forward rate at time t-3

$USINFERR^{m_j}$ = prediction error for the U.S. inflation rate

$INFERR^{m}_{i,j}$ = prediction error for the inflation rate in the partner country j

The risk measures are calculated using monthly data. The specification then estimated has the general form:

$$Q = a_0 + a_1 Y + a_2 CU + a_3 UC^* + a_4 UC + a_5 E + a_6 R + e$$

Q = real exports or imports in sector i

Y = real GNP of the importing country

CU = real capacity utilization in sector i of the importing country

UC = real unit labour costs in the importing country

UC^* = real unit labour costs in the exporting country

E = sectoral real exchange rate

R = real exchange rate risk

e = error term

All together Maskus estimated 64 equations. In 58 of them the coefficient on the risk variable was estimated to be negative, and in 26 cases the coefficients were statistically significant. The total diminution of trade due to exchange rate risk was small; for total trade (both exports and imports) of the U.S.A. over the period 1974-1984 the reduction was only about 3 % compared to the value which would have been achieved, had there been only so-called "unavoidable" exchange rate fluctuations.[1]

Trade in agricutlrual products (- 6 %) and in the output of manufacturing industry (- 5 %) suffered more than average. Commerce in chemicals (- 2.6 %), machinery (- 2 %), motor vehicles (- 2 %) and "other manufactures" (- 4 %) seem to have been much less affected. The small reduction of U.S. trade in chemical products, machinery and vehicles due to exchange rate risk is explained by the author by the high degree of concentration and the predominantly multinational character of production in these sectors. In such cases the means of insuring oneself are very extensive, so that any effect of higher exchange rate risk is more likely to show up in the price of tradeables. It is worth pointing out that trade with West Germany seems to be the most affected, while the effect on trade with Japan and Canada was much less. The exchange of goods between Great Britain and the U.S. seems as good as entirely unaffected, a result which in some other studies (for example, Steinherr, Kenen and Rodrik, Justice, Gotur) had already been noted (see also Table 11).

Gosling (1986) considers the influence of exchange rate fluctuations on selected branches of British industrial exports and on export prices between 1977 and 1985. Besides looking at manufacturing industry together she focuses on the following six industrial sectors: chemicals, clothing and footwear, textiles, scientific instruments, machinery and motor vehicles. The chemical,

[1] Maskus' results are hard to evaluate as he did not publish any estimated coefficients.

Table 11

Cumulative impact of real exchange rate risk on U.S. trade, 1974-84 (millions of 1980 dollars)

	Total				Agriculture			
	Imports		Exports		Imports		Exports	
Country	Volume	Percent	Volume	Percent	Volume	Percent	Volume	Percent
Japan	−11,395	−3.4	−2,184*	+1.2*	−158	−5.8	−703*	−2.1*
United Kingdom	−1,067*	−0.9*	−1,911*	−2.4*	−15*	−1.2*	−2*	−0.1*
Germany	−813*	−0.6*	−1,567	−2.2	−72	−4.3	−426	−6.6
Canada	−1,536*	−0.3*	−7,172*	−2.0*	−70*	−0.5*	−37*	−0.3*

	Imports plus exports		Imports plus exports	
	Volume	Percent	Volume	Percent
Total†	−12,962	−3.2	−656	−6.0

	Crude materials				Manufactured goods classified chiefly by material			
	Imports		Exports		Imports		Exports	
Country	Volume	Percent	Volume	Percent	Volume	Percent	Volume	Percent
Japan	−7*	−1.1*	−1,154*	−2.8*	−1,178*	−2.1*	−433	−4.1
United Kingdom	+51	+6.3	−450*	−8.1*	−699*	−4.9*	−65*	−0.8*
Germany	−72	−6.7	−574	−5.9	−836	−4.2	−151	−2.8
Canada	−2,324	−4.3	−604	−3.7	−291*	−0.4*	−2,239	−5.5

	Chemicals				Machinery			
	Imports		Exports		Imports		Exports	
Country	Volume	Percent	Volume	Percent	Volume	Percent	Volume	Percent
Japan	−364	−4.9	−233*	−1.3*	−1,465*	−1.6*	−414	−2.1
United Kingdom	−162*	−1.7*	−41*	−0.7*	−762*	−3.3*	−80*	−3.6*
Germany	−357	−3.2	−137*	−2.2*	−414	−1.2*	−185*	−1.1*
Canada	−2,723*	−13.0*	−338	−1.5	−914	−2.5	−215*	−0.3*

	Imports plus exports		Imports plus exports	
	Volume	Percent	Volume	Percent
Total†	−1,059	−2.6	−1,742	−1.9

	Transport equipment				Miscellaneous manufactures			
	Imports		Exports		Imports		Exports	
Country	Volume	Percent	Volume	Percent	Volume	Percent	Volume	Percent
Japan	−2,181	−2.1	−344*	−4.0*	−733	−2.4	−1,577	−16.3
United Kingdom	−84*	−0.8*	−181*	−2.7*	+315	+3.0	−437	−5.0
Germany	−1,510	−3.7	+144*	+2.5*	−68*	−0.7*	−211*	−3.0*
Canada	+2,433	+2.7	−4,451	−5.0	−431	−3.7	−19*	−0.1*

* Figures were computed from insignificant risk coefficients and should be considered unreliable. Risk coefficients were considered insignificant if the standard deviations of the coefficients were too large to indicate, at a 90 percent level of confidence, that a relationship exists between exchange rate risk and the associated trade volume.

Source: Maskus (1986)

machinery and motor vehicles sectors were further sub-divided: organic, inorganic chemicals and plastics; consumer goods, investment goods and intermediary products comprise machinery, and automobiles are included as a sub-section of motor vehicle manufacturing.

Following Akhtar and Hilton and Gotur, Gosling uses the standard deviation of daily nominal exchange rates during each quarter as a measure of uncertainty.

The estimated equations have the form:

For exports:

$$XV = f\ (CW,\ RGDPW,\ PXWF,\ ERVOL)$$

XV = volume index of exports of industrial goods

CW = capacity utilization in industrial countries

RGDPW = real GDP of OECD countries

PXWF = price of British exports relative to the price of industrial goods abroad, in pounds Sterling

ERVOL = measure of exchange rate volatility

and for export prices:

$$PX = g\ (PUK,\ PW,\ CUK,\ ERVOL)$$

PUK = British producer price index

PW = price of industrial goods abroad

CUK = British capacity utilization

Gosling, like several authors, finds no negative effect of exchange rate fluctuations on Britain's total exports of industrial goods, but does find an effect on most of the industrial sectors which she looked at. The exception is clothing and footwear (see Table 12). Significant, negative coefficients on the uncertainty variable were achieved for two sub-sections of

The Effects of Volatility on Export Volume and Prices
(United Kingdom)

Industry	Dependent Variable[1] Export Volume	Export Price
Manufactures	0.017 (0.45)	-0.004 (-0.38)
Chemicals	-0.23 (-4.54)**	0.016 (2.68)*
Clothing and footwear	0.07 (2.62)*	-0.09 (-4.60)**
Scientific Instruments	-0.17 (-3.69)**	0.02 (0.39)
Textiles	-0.091 (-2.40)*	-0.02 (-1.6)
Machinery	-0.06 (-2.42)*	-0.04 (-6.19)**
Road Vehicles	-0.11 (-1.89)	0.07 (2.19)*

The Effects of Volatility on Export Volumes and Prices of Sub-sectors

	Dependent Variable[1] Export Volume	Export Price
Organic chemicals	0.04 (2.87)**	0.04 (0.41)
Inorganic chemicals	-0.36 (-5.35)**	0.12 (3.36)**
plastics	-0.11 (-3.88)**	0.04 (3.13)**
passenger cars	-0.15 (-1.01)	0.03 (2.42)*
machinery (consumer goods)	-0.45 (-6.56)**	-0.12 (-1.77)
machinery (Intermediate goods)	-0.30 (-3.10)**	0.01 (5.48)**
machinery (capital goods)	0.04 (1.10)	-0.01 (-0.53)

[1] Note: figures in parentheses are t-statistics; * denotes significance at the 5 per cent level; ** denotes significance at the 1 per cent level.

Source: Gosling (1986)

the chemical industry, namely plastics and inorganic chemicals, and also for the two sub-sections of machinery intermediary products and consumer goods.

Turning to export prices, significant results were obtained in only four cases: chemicals, machinery, motor vehicles and clothing and footwear (see again Table 12). The direction of the influence of exchange rate volatility on export prices is though varied. The chemicals and motor vehicles sectors react to increased exchange rate uncertainty with higher prices, while the machinery and clothing and footwear sectors reduced theirs. Gosling explains the positive effect on prices in the chemicals and motor vehicles sectors by the apparently high share of their factoring conducted in foreign currency; consequently the exporter bears the exchange rate risk and passes on the cost of insurance to prices. The price-dampening effect of exchange rate uncertainty in the machinery sector can be explained by the reverse of this story: predominant factoring in pounds Sterling pushes the risk and costs of insurance onto foreign buyers. So competition among machinery manufacturers to mitigate this phenomenon will lower domestic export prices.

3. Summary and Conclusion

1. A systematic negative influence of short-term exchange rate fluctuations cannot be established from the available studies. For some countries a negative effect on trade seems to be present, but a positive effect can be found for other countries. There are also cases where it seems that exports are reduced by exchange rate uncertainty while imports are unaffected. The empirical results are very sensitive to the choice of a measure of uncertainty, the specification estimated and the length of the data series employed.

2. The various analyses of bilateral trade flows come to similarly diverse results. Only sometimes were negative effects apparent in these studies.

3. The evidence available to date is insufficient to establish, whether some countries are more vulnerable to exchange rate volatility than others, as different authors come to different conclusions about individual countries depending on their estimation procedure. Perhaps the clearest tendency which can be discerned is for West Germany: in four out of five investigations a negative effect on exports was found, though of varying magnitude and once not statistically significant. All three available studies of German imports reported a negative sign on the estimated coefficient of the uncertainty measure, in one case not significant. Exchange rate volatility seemed to have a predominantly positive effect on the exports of Great Britain.

4. The two sectorally disaggregated studies of industrial countries, namely those by Maskus for the U.S.A. and by Gosling for Great Britain, also come to mixed results. Maskus achieved a significant negative coefficient on his volatility measure for 26 of 64 sectors, as Gosling did for 9 of her 13 sectors. These last results are notable in that one normally finds positive effects on the total exports of Great Britain.

5. Two conclusions can be drawn from these results:

   - the effects of exchange rate uncertainty on the level of the firm or sector are very diverse and often cancel out or become indiscernable upon aggregation to the macroeconomic level;
   - an increase in exchange rate risk does not so much lead to a reduction in total exports and a diversion of resources towards the domestic market - the hypothesis which the studies surveyed here tend to concentrate on - as cause a redirection of exports towards zones of greater currency stability. The IFO's own investigations (see section V) point this way.

IV. Measurement and Methodology

The theoretical considerations and empirical investigations of other researchers presented in the last section suggest some solutions to the various practical difficulties in testing for effects of exchange rate uncertainty. The first requirement is for practical, meaningful measures of risk; it is useful to have several measures not only for corroberation but also to cover different conceptions of risk. The different time series properties of freely floating versus EMS currencies must be taken into account. Further, it is necessary to have a clear strategy on model selection, specification and estimation, and to be able to interpret results in the context of the assumptions made. These econometric and modelling issues are dealt with in section IV.2.

1. Measures of Exchange Rate Variance Reconsidered

A. It follows from the discussion in section III.1 that firms are more concerned about "long-term" exchange rate risk, that is, the uncertainty attached to predictions of the exchange rate over an extended horizon, then about the day to day or minute to minute movements which preoccupy foreign exchange dealers. What is at issue is "economic" risk affecting the lifetime profitability of projects. It may then be suggested that we need a measure of distinctively long-term exchange rate risk such as the variance of the error of three year ahead forecasts. Such a measure would, of course, use up many degrees of freedom, which is undesirable, especially when using quarterly or annual data since the start of floating in 1973. Further, it should not be forgotten that the "long run" is made up of a succession of "short runs", so that one's accuracy in predicting the exchange rate three years from now may be a monotonically increasing function of one's ability to predict the rate in three days time.

More formally, consider a simple autoregressive process (with mean zero for convenience):

$$e_t = be_{t-1} + \varepsilon_t,$$

$$E(\varepsilon_t) = 0 \qquad E(\varepsilon_t^2) = \sigma^2 \qquad E(\varepsilon_t \varepsilon_s) = 0 \quad t \neq s.$$

Then the prediction of e_t given information known at t-1 is

$$E(e_t | e_{t-1}) = be_{t-1},$$

and the variance of the prediction error is σ^2. By shifting the time subscripts forward and then substituting, we have

$$e_{t+1} = be_t + \varepsilon_{t+1}$$

$$= b^2 e_{t-1} + \varepsilon_{t+1} + b\varepsilon_t$$

and

$$\text{forcast error} = e_{t+1} - E(e_{t+1} \mid e_{t-1})$$

$$= e_{t+1} - b^2 e_{t-1}$$

$$= \varepsilon_{t+1} + b\varepsilon_t.$$

Since the disturbances are identically and independently distributed (i.i.d.)

$$\text{Var}\left[e_{t+1} - E(e_{t+1} \mid e_{t-1})\right] = (1 + b^2)\sigma^2,$$

that is, a scalar multiple of the variance of the forecast error across one period. In general

$$\text{Var}\left[e_{t+i} - E(e_{t+i} \mid e_{t-1})\right] = \sigma^2 \sum_{j=o}^{i} b^{2j}.$$

Therefore when it comes to estimation, whether σ^2 is used or $(1 + b^2)\sigma^2$ or $(1 + b^2 + \ldots b^{2n})\sigma^2$ will only affect the absolute magnitude of the estimated coefficient but not its sign or significance. The measures of exchange rate risk presented below and used in this study are based on day to day, month to month or quarter to quarter forecasting errors; nevertheless they should all reflect "long-term" exchange rate risk to some degree.

Although this conclusion remains approximately valid, complications arise if one allows for heteroskedasticity in the shocks, particularly autoregressive conditional heteroskedasticity (see Engle, 1982). If σ_t^2 denotes the variance of ε_t, then

$$\text{Var}\left[e_{t+i} - E(e_{t+i} \mid e_{t-1})\right] = \sum_{j=o}^{i} b^{2j}\, \sigma_j^2$$

and typically one cannot factor out one σ^2 as one could above. Furthermore, σ_t^2 and the autoregressive parameter "b" will in practice have to be estimated. One might then say that "long-term" risk differs qualitatively from short-term risk. In addition, over the longer term certain sources of risk gain in importance. So, for instance, if the exchange rate fluctuates about its PPP level, from day to day or month to month nominal and real exchange rate risk are almost equal, but over some time horizon unexpected changes in the rate of inflation become important.

We have calculated and employed four measures of exchange rate variance motivated by different approaches to exchange rate forecasting and constrained by data availability. It should be pointed out, however, that the measures for any one country are interrelated for, the longer time spans are, of course, composed of the shorter (see below). Further, the absolute magnitudes of the measures are not very important and are determined chiefly by the intervals between observations from which they are calculated. Thus, variance estimated from daily movements in exchange rates is going to be very much smaller than that derived from quarter to quarter changes. It is satisfying to note that when one scales up all the risk measures to a yearly basis one obtains very similar results (typically around 1 % on average for the freely floating currencies).

All the variance measures are economists' estimates and ipso facto imperfect. First, economists using only published time series must know less than market participants who can use all public information (say, about political developments). Therefore economists' forecasting errors will have a greater spread than those which affect economic decisions and our risk measures will overestimate true risk by an uncertain amount. Second, even if this bias were not present we can only estimate variance and estimates always contain random errors. If true risk is σ^2, an economist estimator $\hat{\sigma}^2$ can be described by

$$\hat{\sigma}^2 = \sigma^2 + \left(\begin{array}{c}\text{bias due to}\\ \text{economist's limited}\\ \text{information}\end{array}\right) + \left(\begin{array}{c}\text{estimation}\\ \text{error}\end{array}\right)$$

$$= \sigma^2 + (b + \varepsilon_1) + \varepsilon_2, \qquad b > 0.$$

The fixed component "b" of the bias is not very important when only $\hat{\sigma}^2$ is needed for subsequent regressions and when the absolute magnitude of the coefficient on $\hat{\sigma}^2$ is not very interesting. The two random terms, however, create "errors in variables" problems (see Judge et al., 1980) biasing estimated coefficients towards zero and insignificance. The difficulty which we and other researchers experienced in trying to find a significant effect of exchange rate uncertainty may in part be attributable to our inability to observe directly risk as perceived by economic agents.

B. One may also ask, what the appropriate statistic is to measure risk. Previous studies have used the variance or standard deviation, the mean absolute deviation, the Gini index and, in the case of Coes (1979), an ingenious combination of several moments. In fact, as Coes and Justice (1983) show, these different statistics produce very similar rankings across currencies and over time (see below), so one might favour a measure like variance for its intuitive appeal at little cost. If a distribution is symmetric then the variance will be a good measure of its spread. More importantly, there is evidence that floating rates and effective rates follow an approximately log-normal distribution (see Domowitz and Hakkio, 1985, and Diebold and Nerlove, 1985) with autoregressive conditional heteroskedasticity (Engle, 1982). Now, it is well known that any distribution in the normal family is fully characterized by the mean and variance alone. Hence an agent facing a normally or log-normally distributed risk will undertake some form of mean-variance optimization. Therefore variance is the appropriate risk measure

and all other measures, such as those used by Justice (1983), Bailey, Tavlas and Ulan (1986) or de Grauwe und Bellefroid (1986) have no theoretic backing.

Furthermore, if exchange rates are log-normally distributed, then the variance of the log of the exchange rate or of its first difference should be used. Akhtar and Hilton (1984), Gotur (1985) and in many cases Justice (1983) use a measure based upon the level of the exchange rate, but this approach seems to lead to gross collinearity: suppose that the exchange rate E is log-normally distributed

$$E \sim \Lambda (\mu, \sigma^2)$$

Then the expected value of E is

$$\exp (\mu + \sigma^2/2)$$

and its variance is

$$\left[\exp(\sigma^2) - 1\right] \exp. (2\mu + \sigma^2).$$

Therefore when both the variance of E and its level or its log is included in an equation explaining trade flows, multicollinearity must result.

In addition, if one does not take logs or differences of logs one must deal with an asymmetry between importers and exporters arising from Jensen's inequality (see Hooper and Kohlhagen, 1978) and one should then take the third moment into account.

Having selected variance as the appropriate statistic, one must then choose the relevant exchange rate.

First, it is the real, deflated exchange rate rather than the nominal which should be relevant to exporters and importers. Insofar as exchange rates react to offset relative price movements they constitute an automatic "hedge" (see Justice, for example). However, all studies and our own calculations (see below) indicate that real and nominal exchange rate variance are very close due to the large deviations from PPP (see Levich, 1985). One should not, then, dismiss for example risk measures based on daily observations just because price data is not available at that frequency.

A second, fairly minor point is that in estimating the variance of the effective exchange rate one should use an index based on as many bilateral rates as possible. Here the effective rate is calculated from twenty bilateral rates, considerably more than the twelve used by Akhtar and Hilton (1984) or Gotur (1985).

Finally, one should consider to what extent a risk measure captures "long-term" risk, the spread of prediction errors for forecasts over, say, a year or more. It has already been argued that all the measures used capture long-term volatility to some degree, but those based on a longer series of observations will be more influenced by persistent phenomena. A measure which uses data from just one quarter, say, may be more heavily influenced by outliers and by transient shocks to variance in that quarter.

All proxies for exchange rate risk were calculated by quarter and the series begin in 1973 or 1974 depending upon how many lags were needed.

(i) Let us start with a very short-term measure, yet one which is well founded in statistical theory. The path followed by a floating nominal exchange rate, traded all but continuously in well-organized markets, can be well described by a Wiener process:

$$\frac{de}{e_t} = \mu(t)dt + \sigma(t)dz; \qquad dz \sim N(0,1)$$

where e_t is the log of the exchange rate at time t, $\mu(t)$ is its drift and $\sigma(t)^2$ its instantaneous variance. Then it can be shown that $\sigma(t)$ can be calculated arbitrarily well from any finite time interval as the number of observations increases (see Merton, 1980).

Since daily exchange rate data were available from the Bundesbank, a good estimate of σ^2 is obtained by calculating

$$NV_q = \frac{1}{T_q} \sum_{t=o}^{T_q-1} \left[(e_{t+1} - e_t) - \overline{\Delta e_q} \right]^2,$$

where T_q is the number of working days in quarter q (typically around 65), e_t is the log nominal exchange rate on day t in quarter q and $\overline{\Delta e_q}$ is the average daily proportional change in the exchange rate over q. Gosling (1986) employs a similar measure.

Although this estimate is of the instantaneous variance, variance over longer timespans is simply linear in time: knowing e_t and looking forward to time t+r,

$$\text{Var} \left[(e_{t+r} - e_t \mid e_t \right] = \sigma^2 r.$$

It follows that one could, say, multiply NV_q by 65 to obtain quarterly variance, but that would only serve to divide the coefficients on NV_q by 65 when it is used later in regressions. One should not be perturbed by the small size of the NV estimator.

The measure NV_q depends on the assumption that the exchange rate follows a Wiener process, which is acceptable for freely floating currencies (see above). However, this assumption is clearly violated for the DM/FF rate which has been controlled under the EMS of pegged rates with large discrete changes since 1979, and heavily manipulated even before then in the "snake". Hence we did not calculate NV_q for the DM/FF exchange rate.

Further, daily data on effective weighted exchange rates were not available and of course the real exchange rate is measurable at best monthly since only then are price indices available. The measure NV_q is thus only employable in regressions for bilateral trade between countries with floating rates.

(ii) It was mentioned above that the economist must be not better, and usually worse, informed than market participants. Yet economic agents may reveal their expectations to us, notably through the use of forward contracts. If uncovered interest parity holds, then the forward rate equals the market's expectation of the spot rate when the forward contract matures, and we assume this to be unbiased; it may even be efficient. If we can take it that

$$\varepsilon\left(E_{t+N} \mid \Omega_t\right) = {}_tF_{t+N}$$

(Ω_t is the market's information set at time t, ${}_tF_{t+N}$ is the forward rate at t for t+N, and upper case letters denote absolute values rather than logs), then the variance of the market's forecast can be estimated by

$$FV_q = \frac{1}{T_q} \sum_{t=o}^{T_q} \left(\frac{E_{t+N} - {}_tF_{t+N}}{E_{t+N}} \right)^2$$

The notation is as before. FV_q was calculated with daily data from the Bundesbank, again only bilaterally and of course in nominal terms, using N=90 day forward prices. A similar measure is used by Maskus (1986) and Cushman (1983).

The measure FV_q suffers some of the problems associated with NV_q but it does not depend on an assuption of normality. Therefore it was felt appropriate to calculate FV_q even for the DM/FF rate under the EMS; there is, of course, residual exchange rate risk under the EMS, not merely because of the bands of permissible fluctuations but also because the exact timing and magnitude of realignments are unknown in advance.

The usefulness of FV_q is, however, diminished by the considerable body of literature (see Domowitz and Hakkio, 1985, for a recent example) which suggests that the forward rate is not a very efficient forecaster and may well be biased, if not consistently biased one way.

(iii) Kenen and Rodrick in their papers (1984, 1986) favour a measure of exchange rate variance based on a rolling average of squared monthly percentage changes. Inspired by their relative success with this measure, we constructed something similar

$$MV_q = \frac{1}{23} \sum_{i=1}^{24} \left[(e_{q-i+1} - e_{q-i}) - \overline{\Delta e_q} \right]^2 ,$$

where subscripts index months and q = 24, 27, 3o, ... with O in 1972 (i.e. we need two years of lags and the average is always rolled forward by one quarter). The term $\overline{\Delta e_q}$ denotes the average percentage monthly change in the relevant two years, which Kenen and Rodrick argue is a suitable timespan. In order not simply to reproduce the results of Kenen and Rodrick, MV_q is calculated using nominal rates. MV_q can readily be calculated for effective rates rather than just for bilateral rates. It should be pointed out that although MV_q is estimated from two years of data, it is a measure of the spread of the one month forecasting error; it is in fact more short-term than FV_q, which can be calculated quarter by quarter due to the high frequency of observations but is derived from the three month forward rate. The only longer-term component in MV_q is the mean $\overline{\Delta e_q}$, calculated over 24 months, i.e. it is as if one's forecast were always the mean change during the last two years.

The monthly data on exchange rates and prices consist of period averages, which biases estimated variance downwards, or rather, the variance of the period average is itself smaller than that of its components. To see this, consider the mean of N i.i.d. random variables[1] each with a variance σ^2; it is elementary to show that the variance of the average is σ^2/N. However, since the number of days in the month is roughly constant this amounts to no more than a scaling.

[1] That is, independently and identically distributed.

(iv) Finally, a proxy for "long-term" real exchange rate uncertainty was constructed by taking a moving average of the squared residuals from a simple exchange rate regression. Again, the forecasting error is monthly, but the forecast is derived from an equation which covers the whole period 1972-1986. Where r_t is the log of the real exchange rate (log $(E_t p^*_t/P_t$, P_t and P^*_t are the home and foreign consumer price indices respectively), we estimated

$$r_t = \alpha + \beta_1 r_{t-1} + \beta_2 r_{1-2} + \beta_3 r_{t-3} + \gamma t + \varepsilon_t$$

This AR(3) process with trend was chosen to represent a simple atheoretic way to forecast the exchange rate, including a long-term component (the trend) and incorporating some recent information (the autoregressive part). Because the regression uses three lags and the period since 1974 was to be covered without using more than two years' data per observation, a moving average of twenty-one squared residuals was taken:

$$RV_q = \frac{1}{21} \sum_{i=o}^{20} \left(\varepsilon^2_{q-i} \right)$$

This measure was employed both for bilateral exchange rates and for various weighted rates (e.g. the effective rate against twenty industrial countries, against EMS currencies, against non-EMS currencies.

One may criticize the proxy RV_q for being excessively atheoretic and unrelated to formal concepts in statistics or economics. Further, its "long-term" aspect derives from the coefficient estimates in the regression being constant across the sample period, which is a little curious: it is as if agents always used a forecasting equation, even in the early years, based upon information from 1972 to 1986. Nevertheless, such an assumption must be made if we are to have an operational notion of distinctively "long-term" exchange rate uncertainty.

All four measures of exchange rate risk have some relevance and are worth trying. Nevertheless, a ranking is possible and a most appropriate measure can be selected. The measures NV and FV are both estimated using observations drawn only from the relevant quarter; this, it has been argued, is a drawback. Furthermore, the data available allowed the estimation of these two measures only for bilateral, nominal exchange rates. Therefore they could not be used when investigating total trade, price indices or trade shares, for which bilateral exchange rate variance relative to the variance of the effective rate is relevant. The measure NV, furthermore, is only appropriate when currencies follow a Wiener process. The measures MV and RV have none of these faults, and so should be preferred. It is difficult to choose between them because they turn out to be very close (see below). This similarity arises because MV is calculated from deviations of percentage changes from their mean while RV is the mean squared deviation of the logged exchange rate from an autoregression with time trend; the mean of percentage changes corresponds to a trend in logarithms. Still, RV is to be preferred somewhat because it is based upon the real exchange rate. For total trade and price indices the variance of the effective exchange rate is of course most appropriate, and for trade shares (and perhaps bilateral trade) relative variance is important.

C. The averages across the entire period of all the measures calculated are provided in Table 13a-d below. Some of the tables are not perfectly symmetric due to Jensen's inequality. Note that the rankings between currencies is almost always identical for all measures. The variance of the DM and FF against other EMS currencies is very much lower than against non-EMS currencies, especially after 1979. The U.S. dollar, in contrast, is more unstable against the EMS bloc than against third currencies, perhaps because, by export weighting, Canada figures largely here.

Table 13

Averages of Variance Measures

Means of each exchange rate risk proxy; all variables were calculated by quarter or explained in the text.

a) NV (multiplied by 10^5) 1973/I - 1985/IV

against	DM	£	FF	$
DM		3.021	-	4.860
£			3.146	4.142
FF				4.802
$				

b) FV (multiplied by 10^3) 1973/I - 1985/IV

against	DM	£	FF	$
DM	-	2.734	1.264	3.594
£	2.724	-	3.080	3.916
FF	0.965	2.902	-	3.404
$	3.787	4.025	3.858	-

c) MV (multiplied by 10^4) 1974/I - 1985/IV

against	DM	£	FF	$	20 industrial countries
DM	-	5.712	1.917	7.728	1.577
£	5.330	-	5.718	5.972	3.506
FF	2.193	5.747	-	6.957	1.745
$	7.728	5.972	7.190	-	3.200

d) RV (multiplied by 10^4) 1974/I - 1985/IV

against	DM	£	FF	$	20 industrial countries	EMS currencies	non-EMS currencies
DM	-	5.690	1.879	7.838	1.569	1.022	2.866
£	5.690	-	5.300	6.180	3.538	4.527	3.865
FF	1.879	5.300	-	7.308	1.600	1.240	2.867
$	7.838	6.180	7.308	-	3.268	6.372	2.739

Table 14

Correlations between Measures of Risk

a) Variance of the Pound Sterling against the U.S. Dollar

	FV	MV	RV
NV	0.557	0.582	0.681
FV	-	0.257	0.141
MV		-	0.720

b) Variance of the Deutschmark against the French Franc

	MV	RV
FV	0.209	0.109
MV	-	0.808

c) Variance of the U.S. Dollar against the Deutschmark

	FV	MV	RV
NV	0.461	0.255	0.057
FV	-	0.157	0.126
MV		-	0.909

d) Variance of the French Franc against the Pound Sterling

	FV	MV	RV
NV	0.269	-0.004	-0.039
FV	-	-0.129	0.192
MV		-	0.719

Table 15

Correlations between Currencies of Risk Measures

a) NV U.S. Dollar exchange rate against ...

	FF	£
DM	0.916	0.726
FF	-	0.684

b) FV Pound Sterling against ...

	DM	FF
$	0.207	0.067
DM	-	0.637

c) MV Deutschmark against ...

	FF	£
$	0.198	0.596
FF	-	0.161

d) RV French Franc against ...

	DM	£
$	0.038	0.637
DM	-	0.161

The strong simularity between MV and RV is brought out by comparing Tables 13c and 13d where the values are almost identical.

In Table 14 some correlations between different measures are presented. The association between MV and RV is always very high while the two "financial" measures NV and FV seem to go their own way. One reason for low correlations is the difference in timespans. MV and RV effectively measure average variance over eight and seven quarters respectively, whereas FV and NV each cover just one quarter. Suppose that the standard deviation of the exchange rate follows an AR(1) process

$$\sigma_t = a + b\sigma_{t-1} + \varepsilon_t$$

$$|b|<1, \quad E(\varepsilon_t) = 0 \quad E(\varepsilon_t\varepsilon_s) = \left.\begin{matrix} s^2 \\ 0 \end{matrix}\right\} \text{for} \begin{cases} t = s \\ \text{otherweise} \end{cases}$$

Then it can be shown that the correlation between σ_t and an average of σ_t to σ_{t+N}, given information at t-1, is

$$\frac{b^{N-1}}{N \sum_{1=o}^{N-1} b^{2i}},$$

which is clearly declining in N. The correlation between MV and RV on the one hand and FV and NV on the other is expected to be low. Indeed, if the correlations were always close to unity one would not need to use all the risk measures in the regressions. Sometimes this correlation is even negative - though small and insignificantly different from zero - which is rather more worrying (see below).

In Table 15 another selection of correlations is presented, this time between variance measures of different bilateral rates. Here a certain grouping becomes apparent which can also be seen in the time plots of the different measures: when variance against

the French Franc is great it is also great against the Deutschmark, as one might expect from their long history of controlling their bilateral exchange rates. If the Franc or the Mark is highly volatile against the Pound then it tends also to be highly volatile against the Dollar. If any currency is fluctuating much against the Dollar, they all do.

There is an interesting explanation for this phenomenon which rests on the rational expectations concept of "news" (see Frenkel, 1981, for an application in international finance) or "surprises". For simplicity, regard just three countries (1, 2 and 3) with bilateral exchange rates e_{12}, e_{13} and e_{23}, for convenience, with means naught. These rates react to "news" from country 1, 2 and 3 (ε_1, ε_2, ε_3 respectively) so that the realized rates are

$$e_{12} = \varepsilon_1 - \varepsilon_2$$

$$e_{13} = \varepsilon_1 - \varepsilon_3$$

$$e_{23} = \varepsilon_2 - \varepsilon_3$$

$$\text{Var } (\varepsilon_1) = \sigma_1^2, \quad \text{Var } (\varepsilon_2) = \sigma_2^2, \quad \text{Var } (\varepsilon_3) = \sigma_3^2$$

$$E(\varepsilon_i \varepsilon_j) = \rho_{ij} \qquad i \neq j$$

Hence

$$\text{Var } (e_{12}) = \sigma_1^2 + \sigma_2^2 - \rho_{12}$$

$$\text{Var } (e_{13}) = \sigma_1^2 + \sigma_3^2 - \rho_{13}$$

$$\text{Var } (e_{23}) = \sigma_2^2 + \sigma_3^2 - \rho_{23}$$

Regard country 1 as the U.S. and countries 2 and 3 as Germany and France respectively (Britain is something of an intermediary case). We have seen that Var (e_{12}) and Var (e_{13}) are highly correlated and that neither is well correlated with Var (e_{23}). Further, Var (e_{23}) is much smaller than Var (e_{12}) or Var (e_{13}). This suggests that most of the variance in the Dollar-DM and Dollar-Franc rates is due to U.S. "news" and that changes in variances are due to changes in the amount of U.S. "news". France and Germany produce relatively smaller "surprises" and/or their surprises are offsetting within the framework of the EMS.

A similar pattern can be observed in Figures 9-26 which illustrate the time paths of the various risk measures. Figure 9 shows NV for Sterling against the other three currencies; it will be noticed that the NV of the Sterling-DM is almost identical to that of the Sterling-FF rate. All three variances rose together in 1976, corresponding to the British "news" of IMF intervention, etc. in that year. In Figure 10 the correlation between NVs of the Dollar against other currencies is manifest, disturbed only by a couple of incidents (e.g. after Mitterrand's election in 1982). Further, Figure 10 suggests that NV tends to be greatest at "turning points": the adjustment to the new floating regime in 1973-74, the Dollar's low in 1978, its appreciation in 1981 and fall in 1985. This pattern confirms the argument presented above that even a very "short-term" measure captures uncertainty concerning forecasts of the exchange over the longer run.

In Figures 11 through 14 are shown the various estimates of FV, and the peculiarity of this measure becomes apparent, namely, the tendency to display "spikes". Some of these are explicable by special events (e.g. an EMS realignment of the FF in early 1983) or correspond to the pattern we see in other risk measures (everywhere high variance in 1973-4, for Sterling in 1976, for the Dollar in 1981 and 1985). Other "spikes", such as that for Sterling in late 1982, are more obscure; possibly a programming error was responsible but we were unable to track one down.

The measures MV and RV, being moving average processes, are much smoother. Nevertheless, there is a rough correspondence of peaks and troughs between all measures. Figures 15, 17, 20 and 22 make clear that the DM/FF rate was typically more stable than that of other bilateral rates throughout the period and that this divergence became greater after the founding of the EMS in 1979.

In part as a consequence ,the variance of the export weighted exchange rate was markedly lower for France and Germany than for the U.S. and Great Britain after 1979, as shown by Figures 19 and 26.

Figures 24 and 25 depict the RVs of our four currencies against (other) EMS and non-EMS currencies respectively. The variance of the Franc and the Mark against non-EMS currencies has in fact risen since 1979 compared to the 1976-1978 period, leading Rogoff (1985) to suggest that EMS internal stability has been purchased at the cost of greater external instability. However, a closer examination of the evidence casts doubt on this proposition. For the Dollar, variance against non-EMS currencies is dominated by variance against the Yen, Sterling and the Canadian Dollar. For the Mark and the Franc, variance against non-EMS currencies depends also on variance against the Dollar. We have already seen evidence that changes in the variance of the DM-Dollar and FF-Dollar rates can largely be attributed to changes in the amount of U.S. "news". Therefore any rise in the RV of the Mark and the Franc against non-EMS currencies after 1979 is not principally of European origin. A fairer comparison is provided in Table 16 which presents average MV for the Dollar, Sterling and the Mark against the Yen for two periods, 1974-1978 and 1979-1985.

Table 16

Average MV against the Yen ($\times 10^4$)

	1974-1978	1979-1985
$	4.21	9.50
£	4.37	8.71
DM	5.77	7.34

In all three cases average variance increased, and the DM-Yen rate went from being the most instable to being the most stable of the three. What this table suggests is that exchange rates have generally become more uncertain and that joining the EMS does not make a currency especially volatile in other markets.

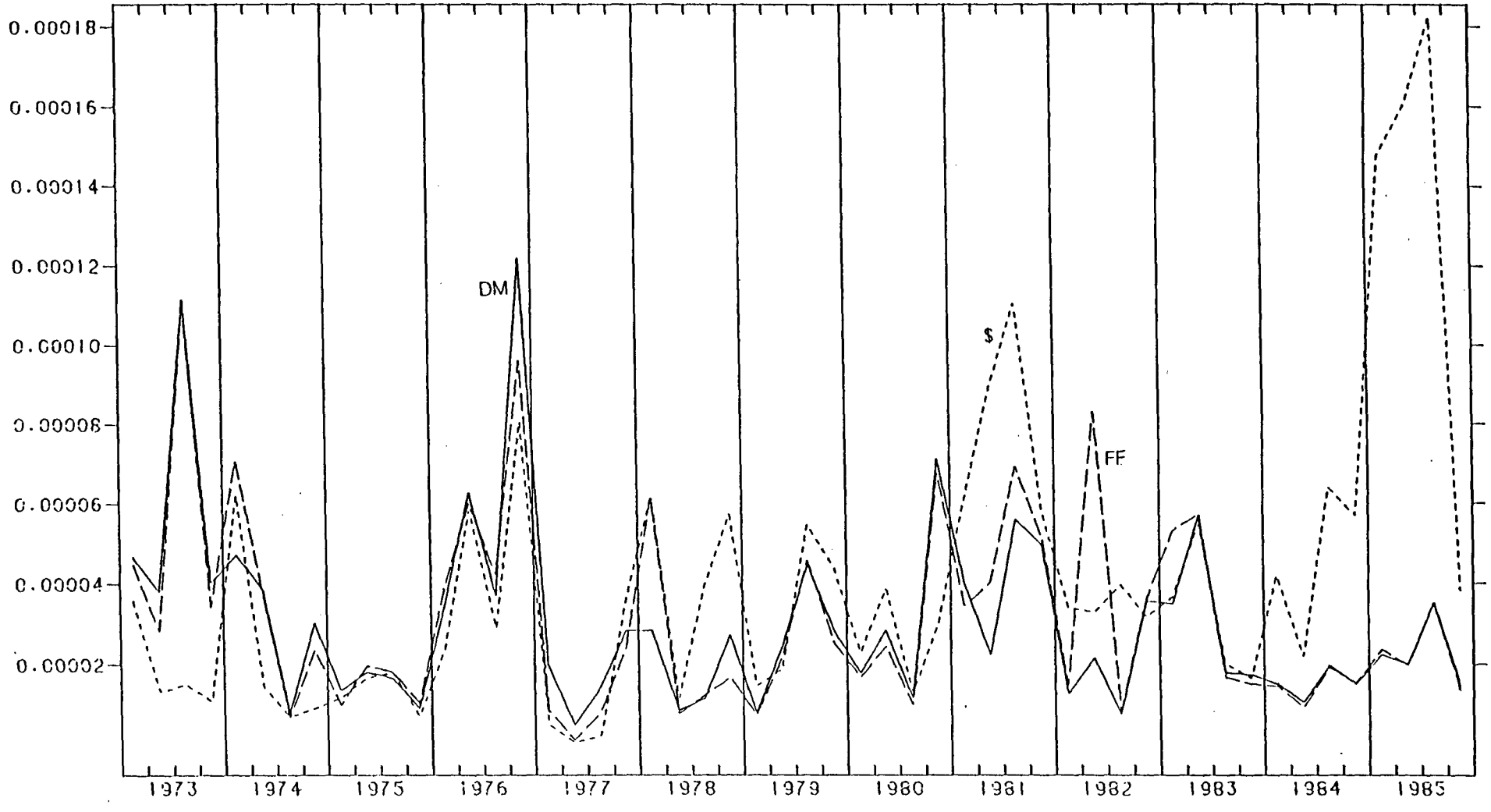


Figure 9
NV of pound Sterling against the U.S. dollar, deutschmark, French franc

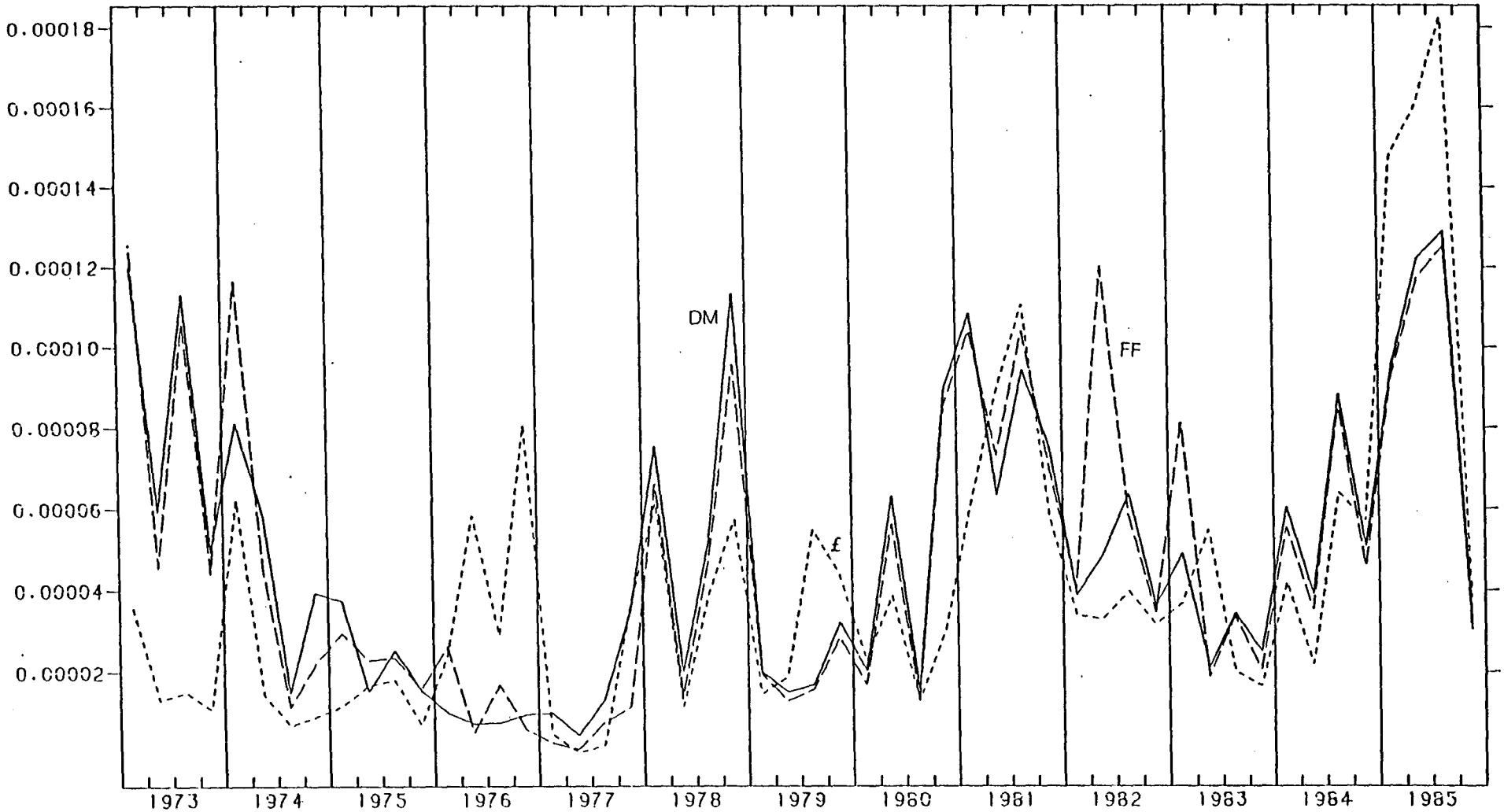


Figure 10

NV of U.S. dollar against the deutschmark, pound Sterling, French franc

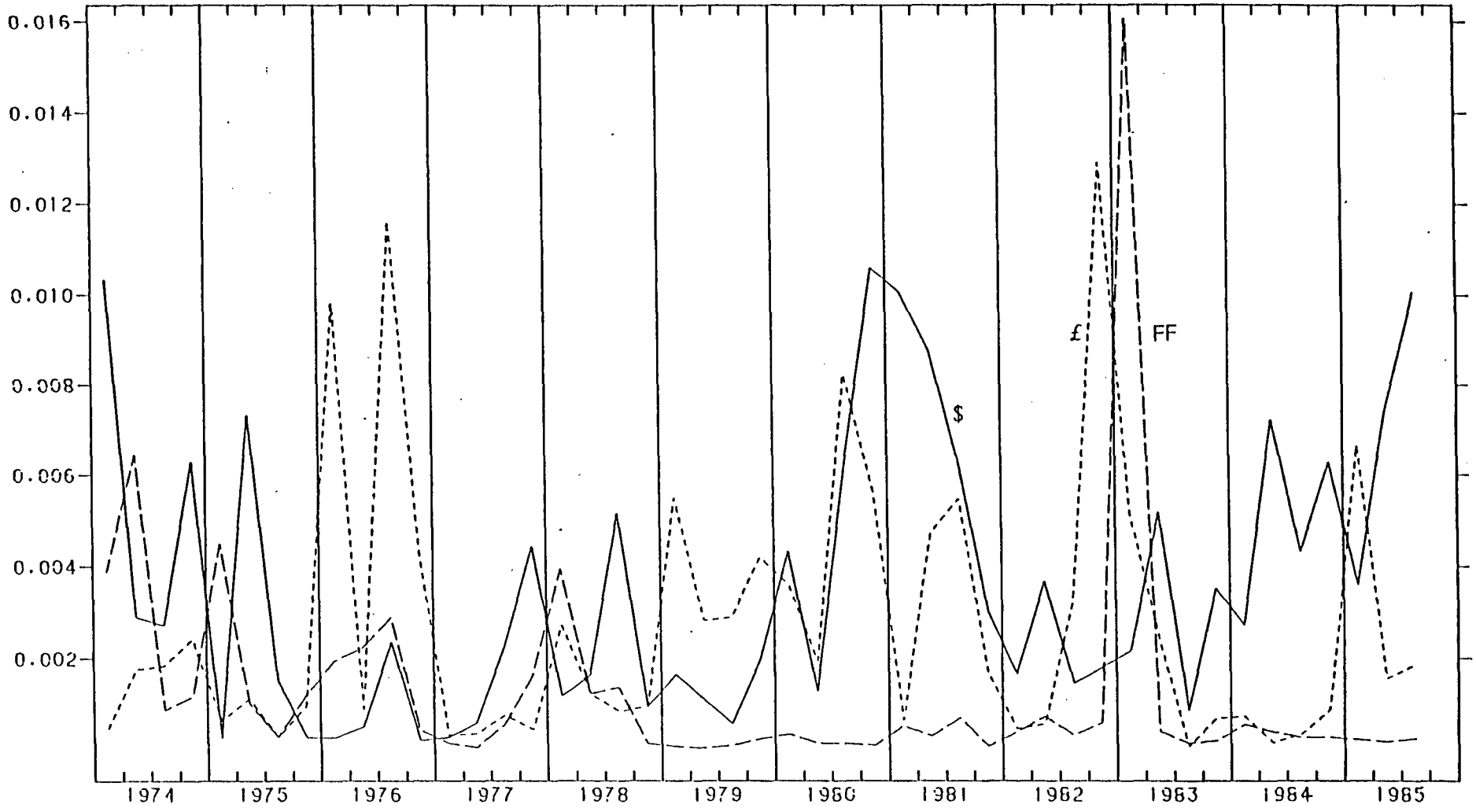


Figure 11

FV of deutschmark against the U.S. dollar, pound Sterling, French franc

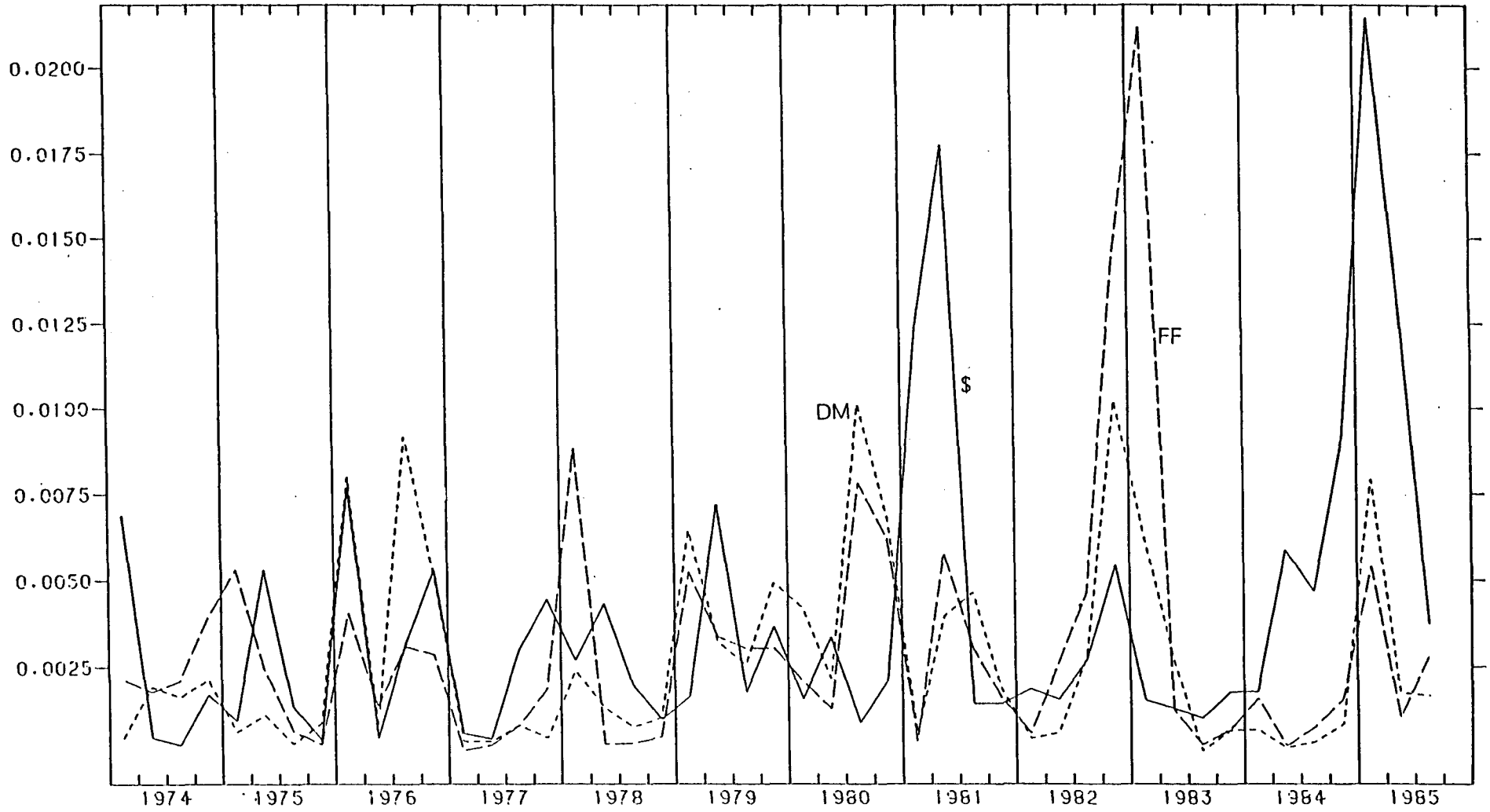


Figure 12
FV of the pound Sterling against the U.S. dollar, deutschmark, French franc

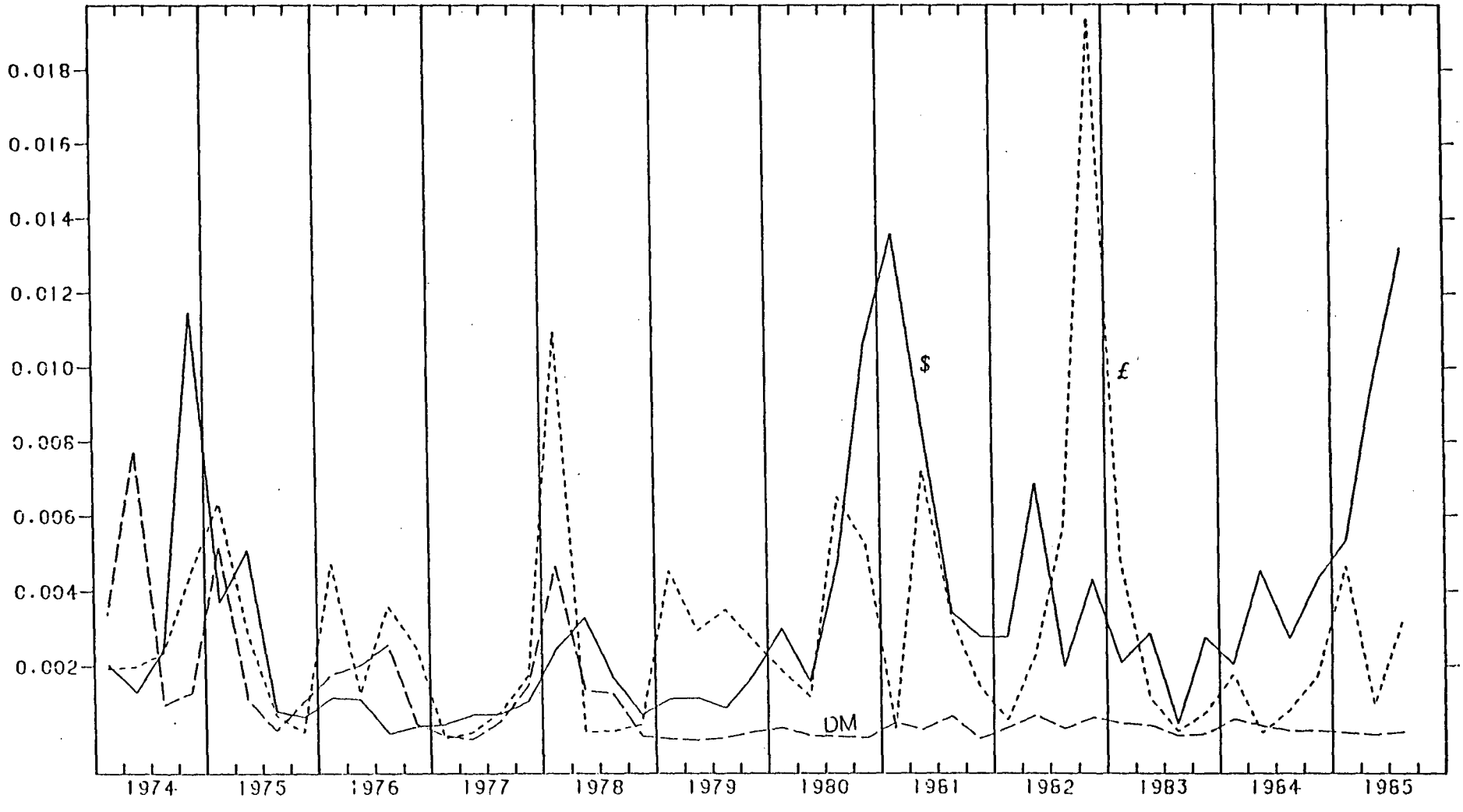


Figure 13
FV of the French franc against the U.S. dollar, pound Sterling, deutschmark

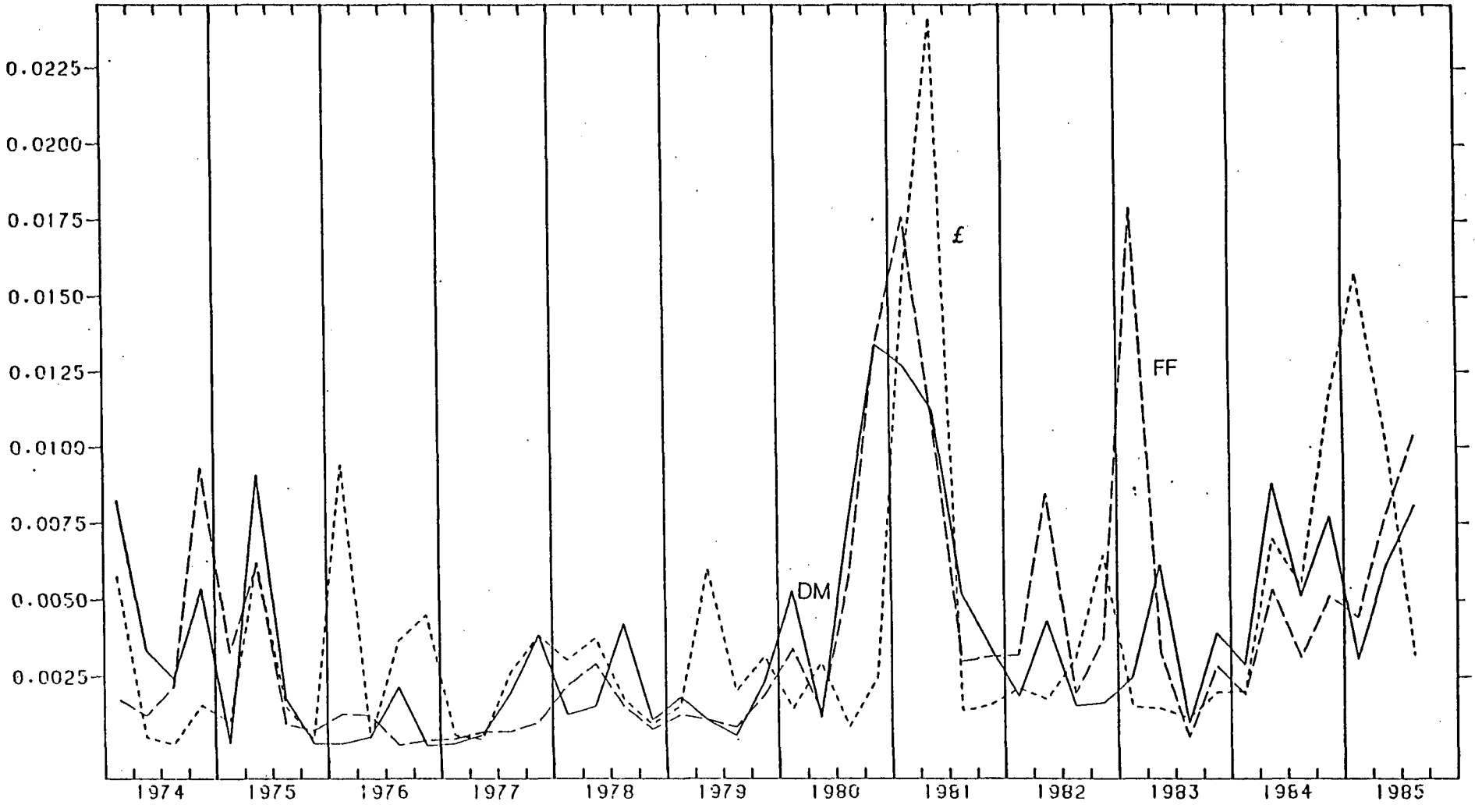


Figure 14
FV of the U.S. dollar against the deutschmark, pound Sterling, French franc

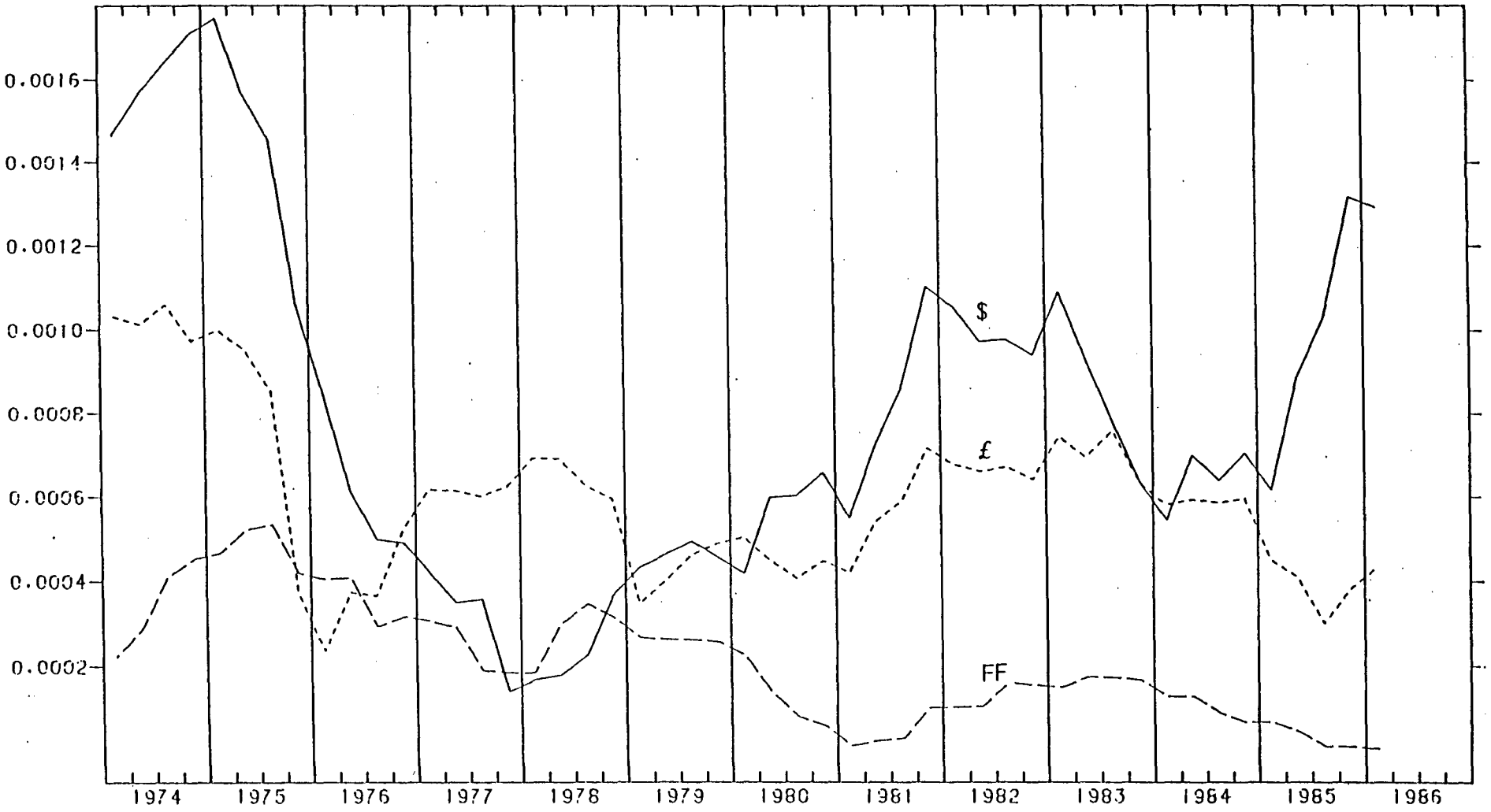


Figure 15

MV of the deutschmark against the U.S. dollar, pound Sterling and French franc

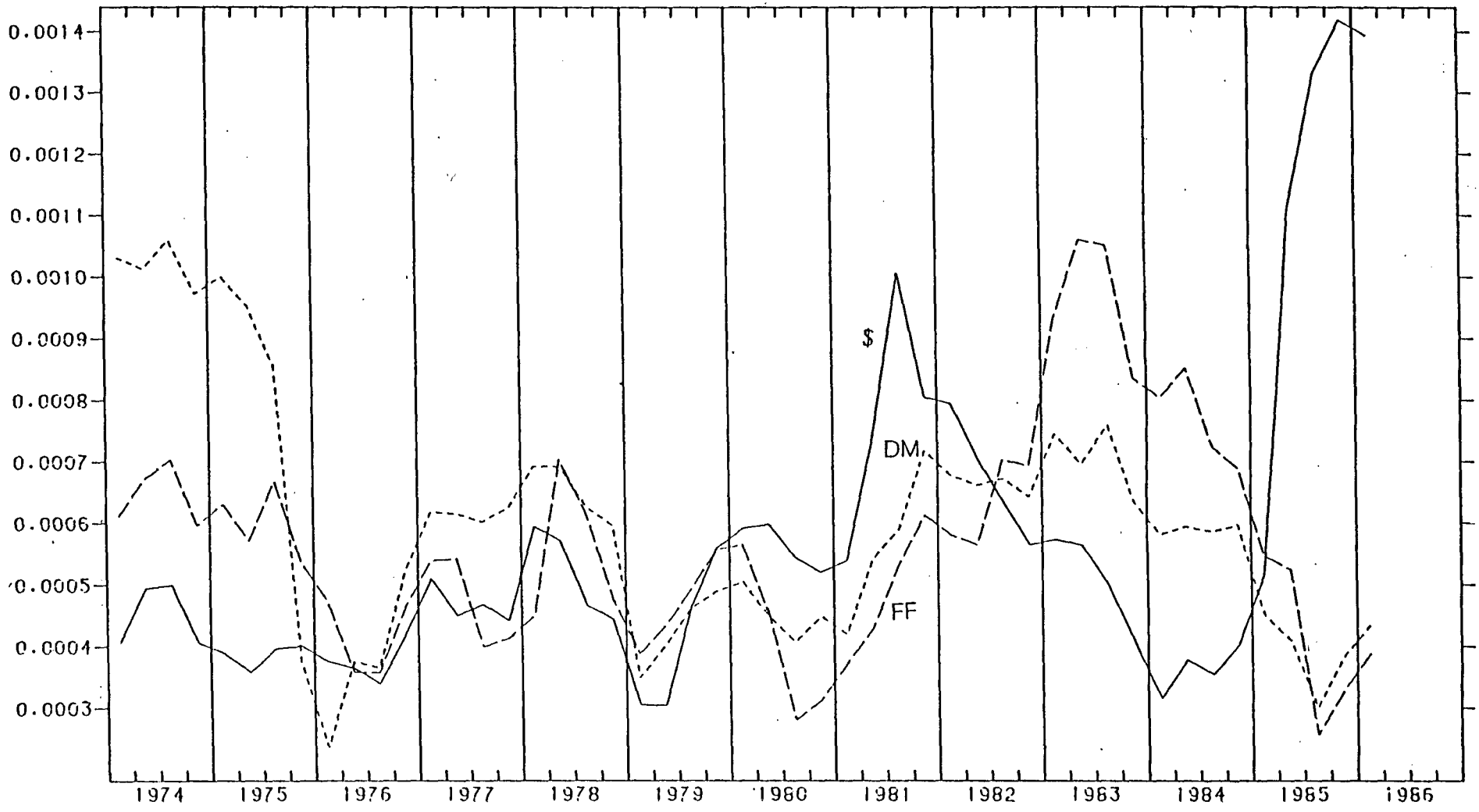


Figure 16

MV of the pound Sterling against the U.S. dollar, deutschmark and French franc

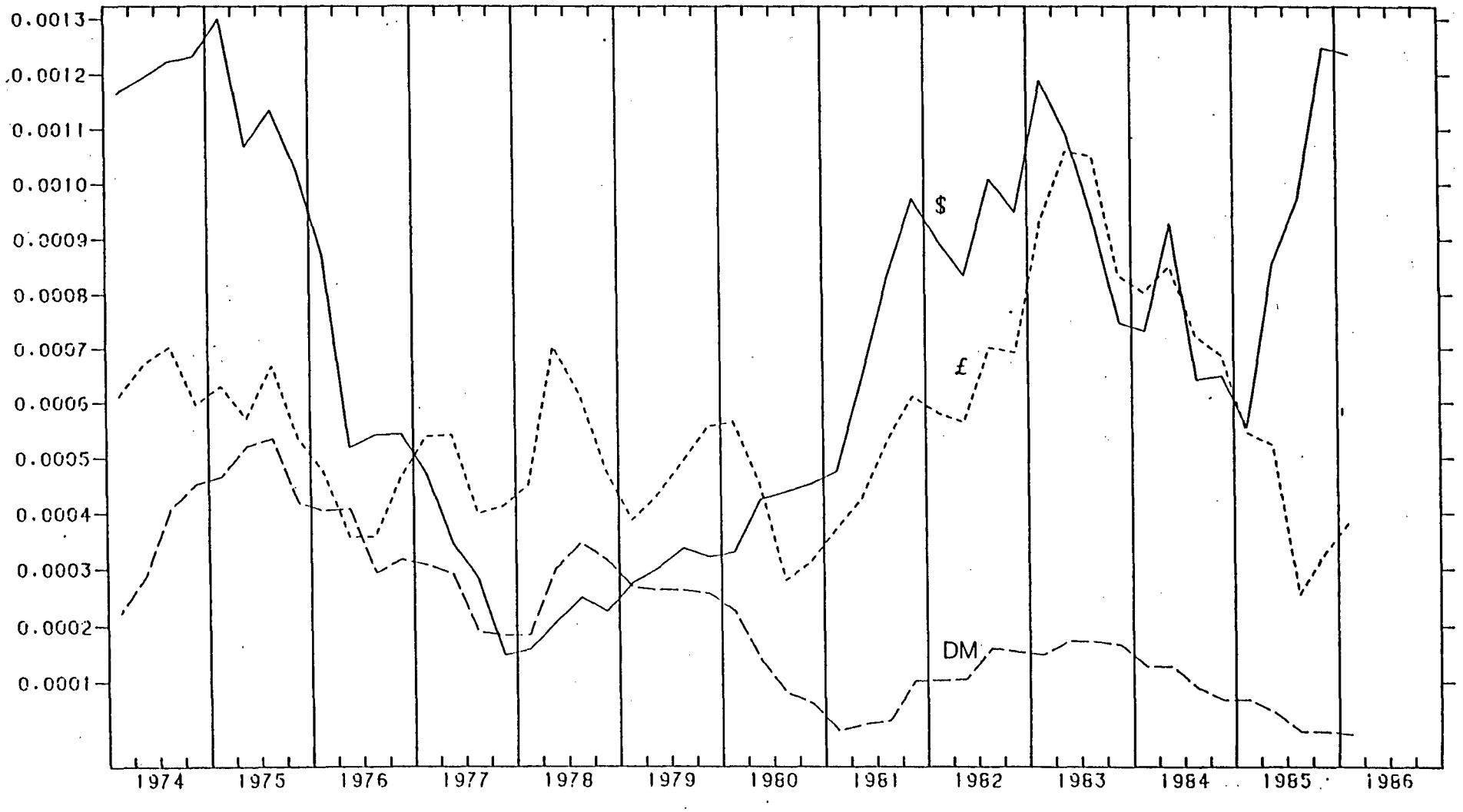


Figure 17

MV of the French franc against the U.S. dollar, pound Sterling and deutschmark

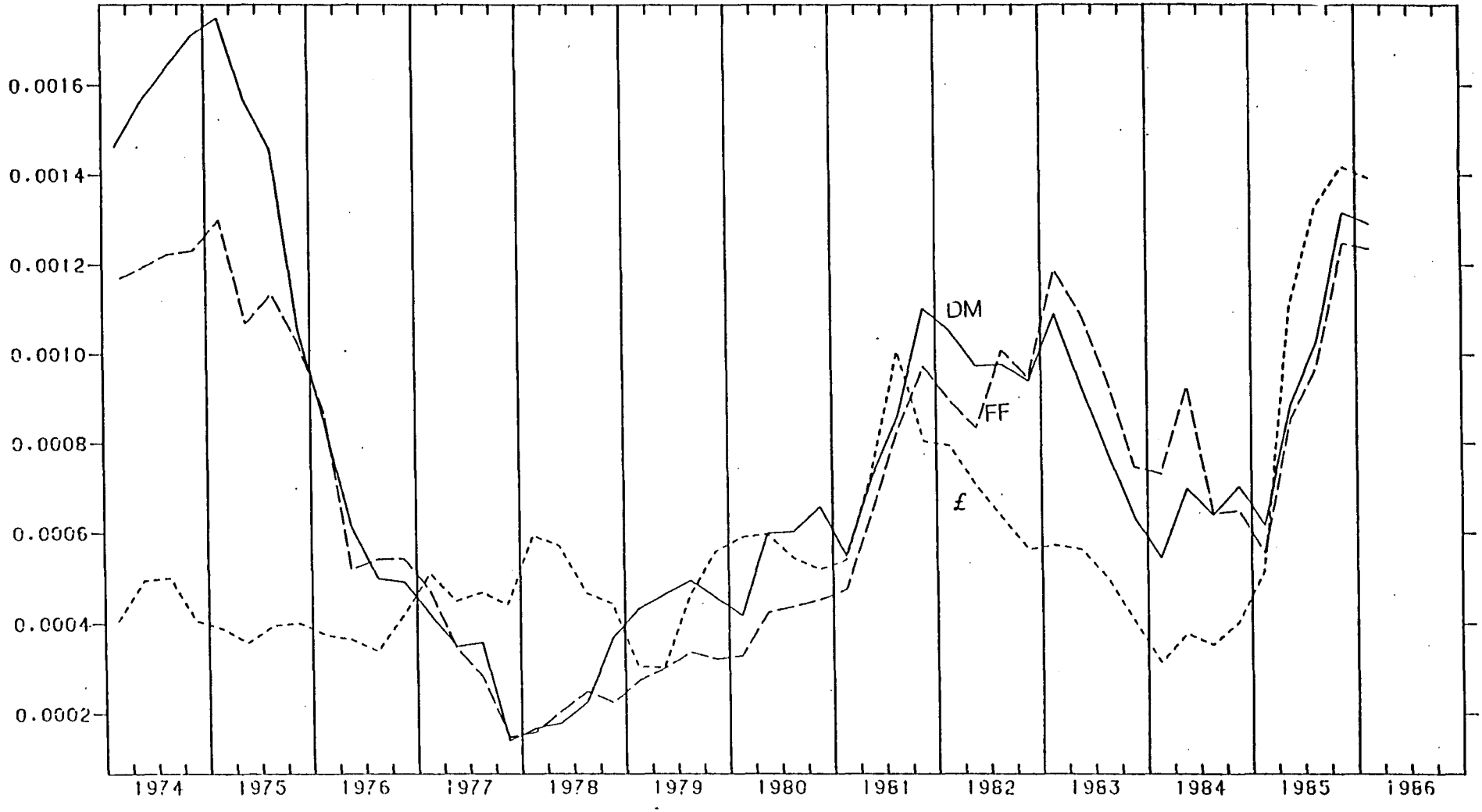


Figure 18
MV of the U.S. dollar against the deutschmark, pound Sterling and French franc

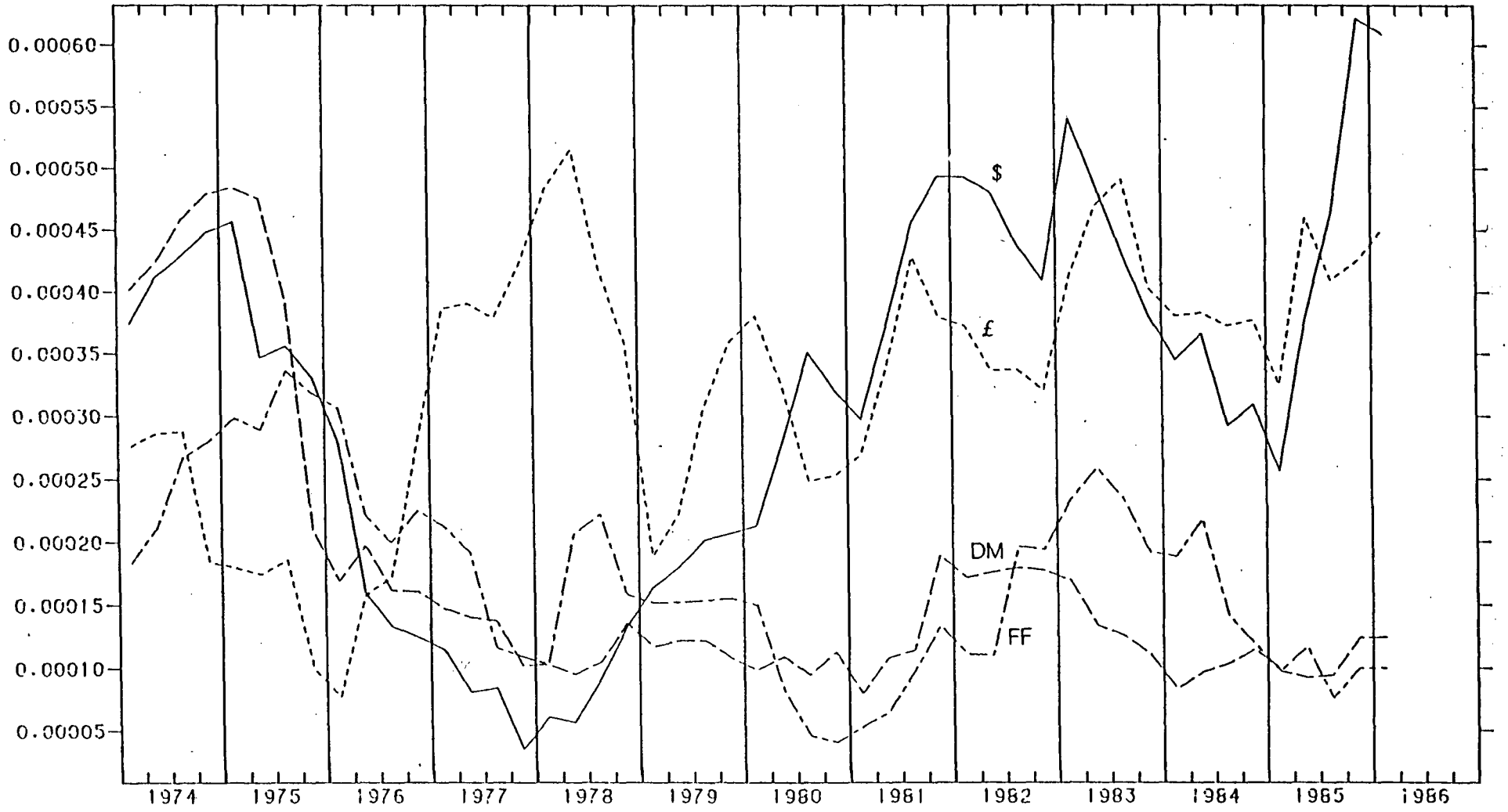


Figure 19

MV of the effective nominal exchange rates against 20 industrialized countries; U.S. dollar, pound Sterling, deutschmark, French franc

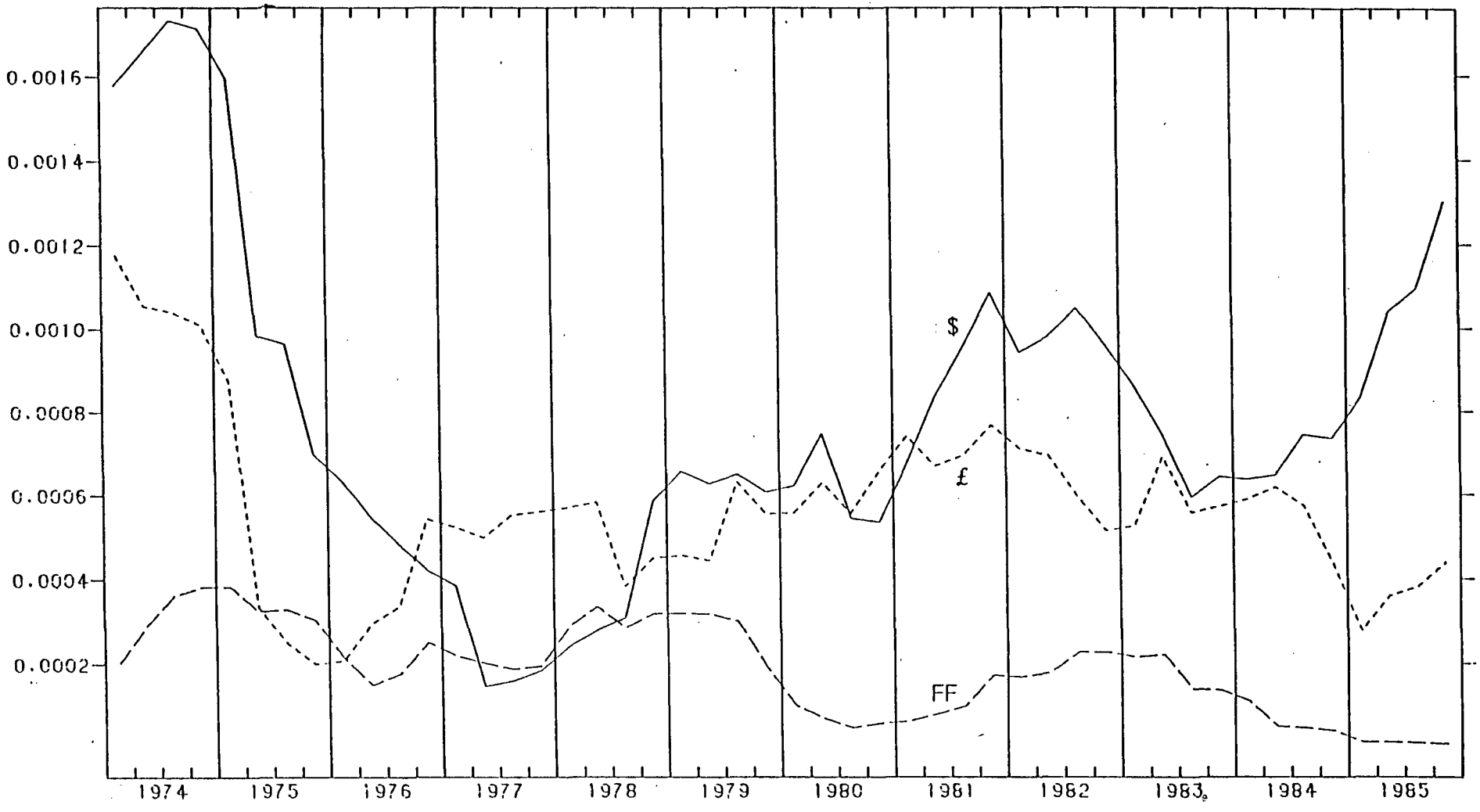


Figure 20

RV of the deutschmark against the U.S. dollar, pound Sterling and French franc

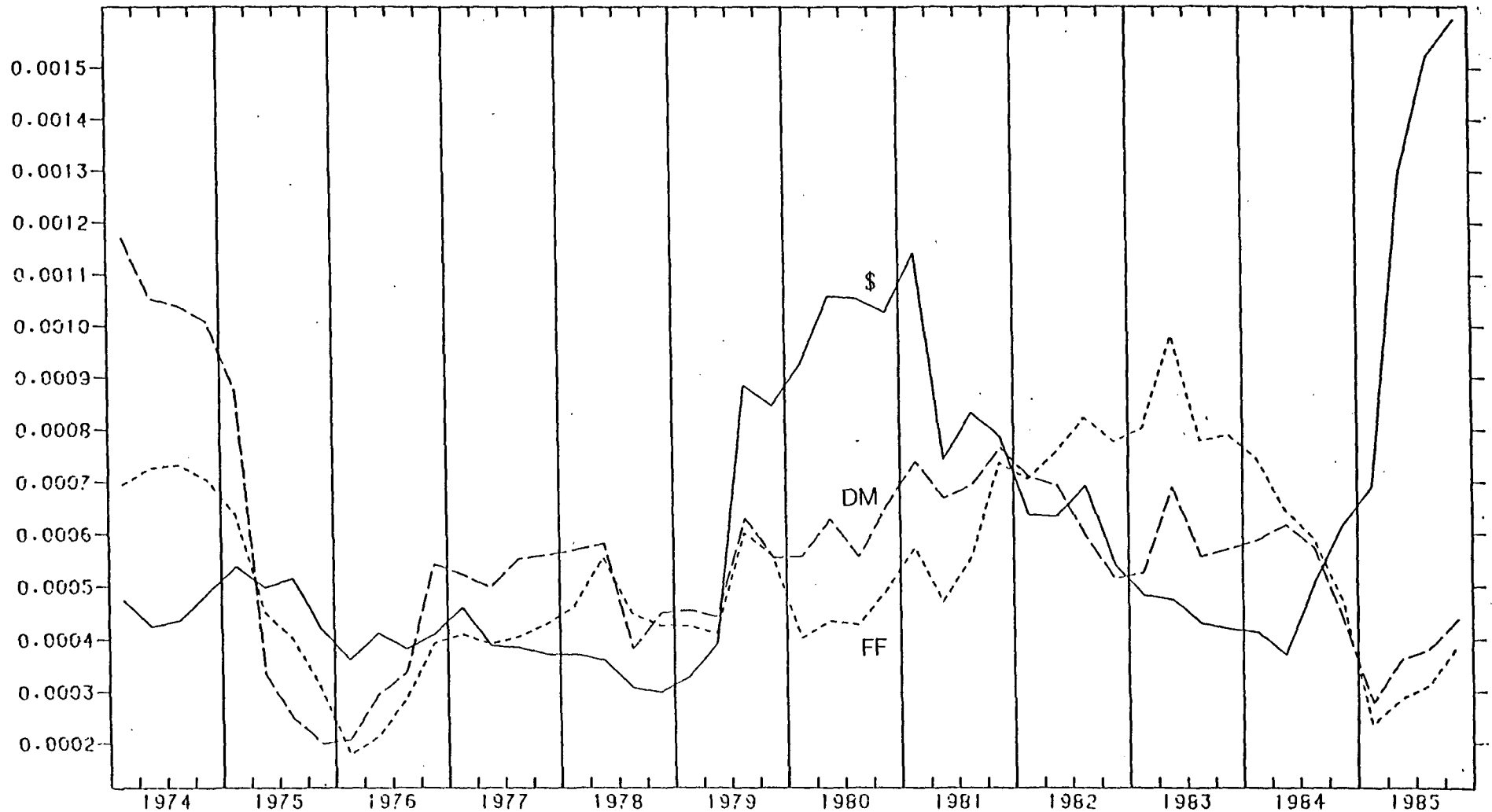


Figure 21

RV of the pound Sterling against the U.S. dollar, deutschmark and French franc

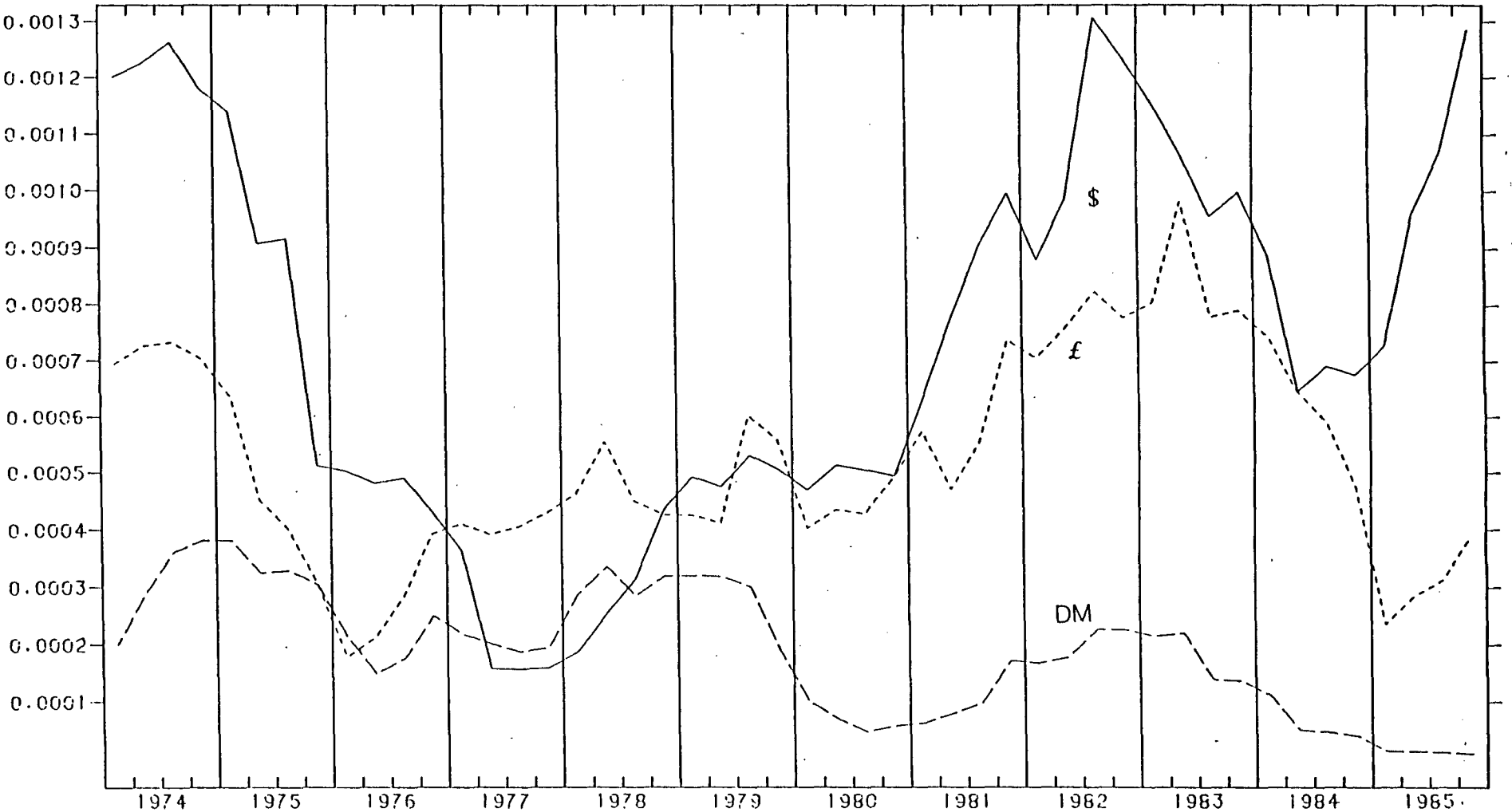


Figure 22
RV of the French franc against the U.S. dollar, pound Sterling, deutschmark

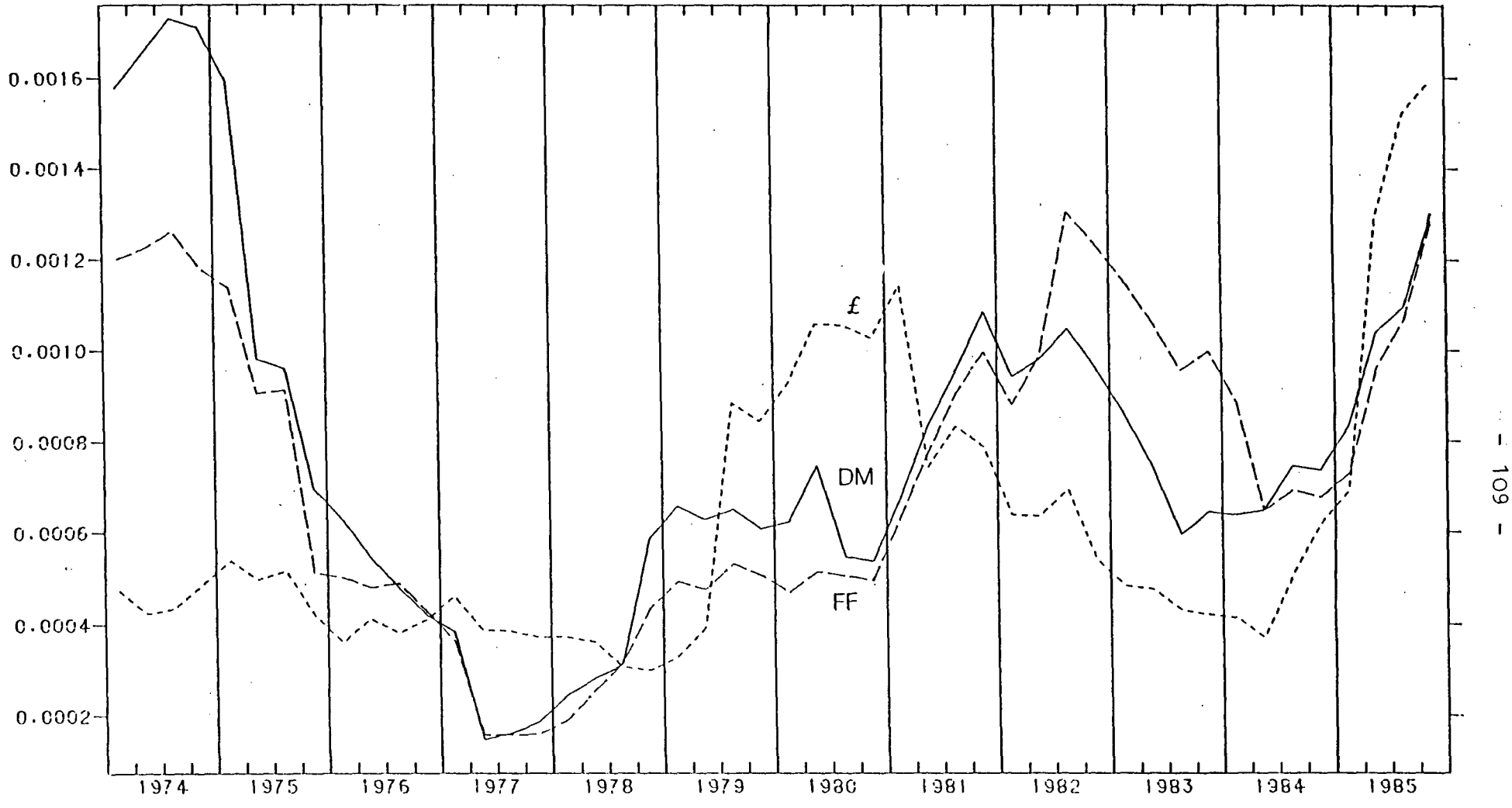


Figure 23
RV of the U.S. dollar against the deutschmark, pound Sterling and French franc

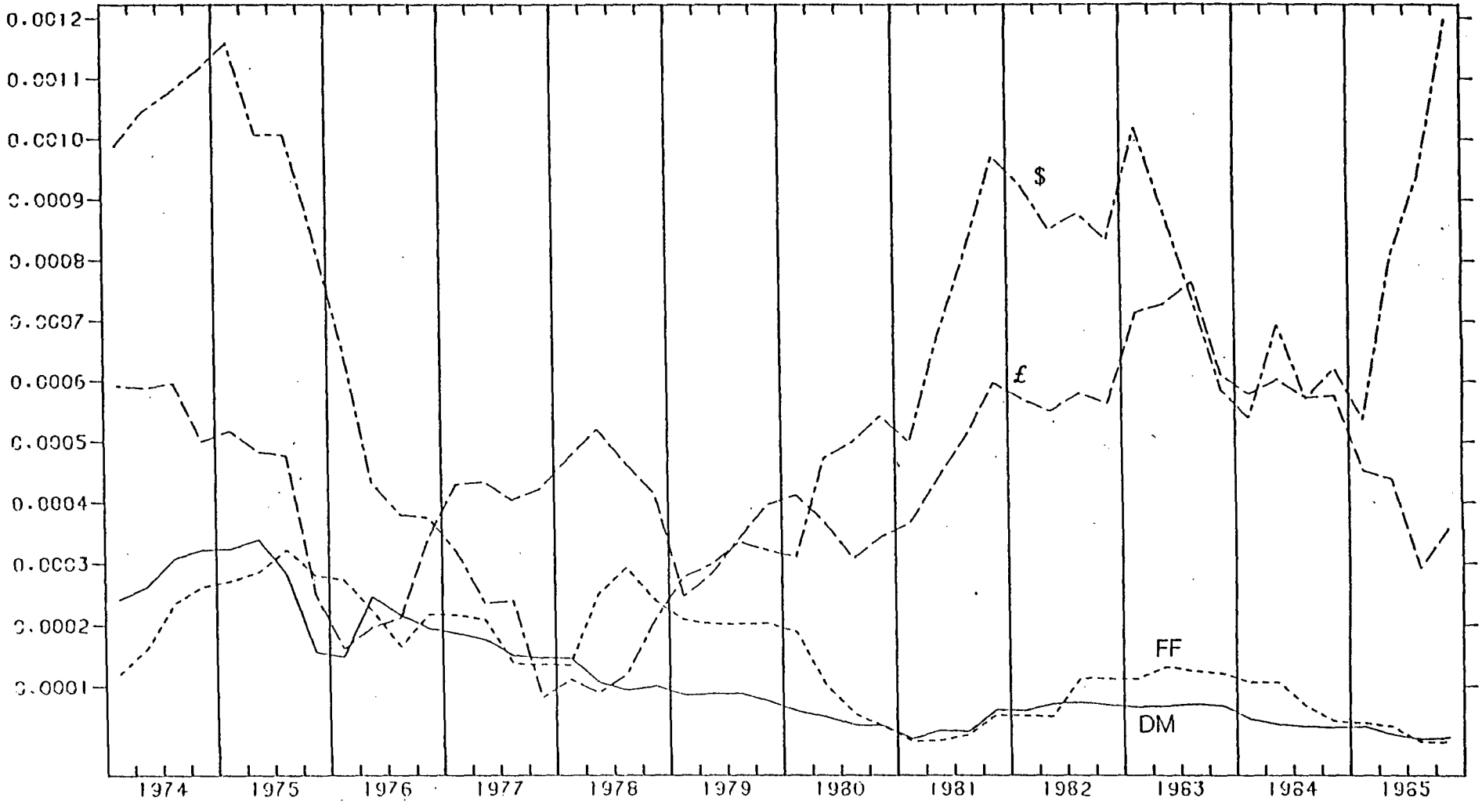


Figure 24

RV against (other) EMS currencies; deutschmark, French franc, pound Sterling, U.S. dollar

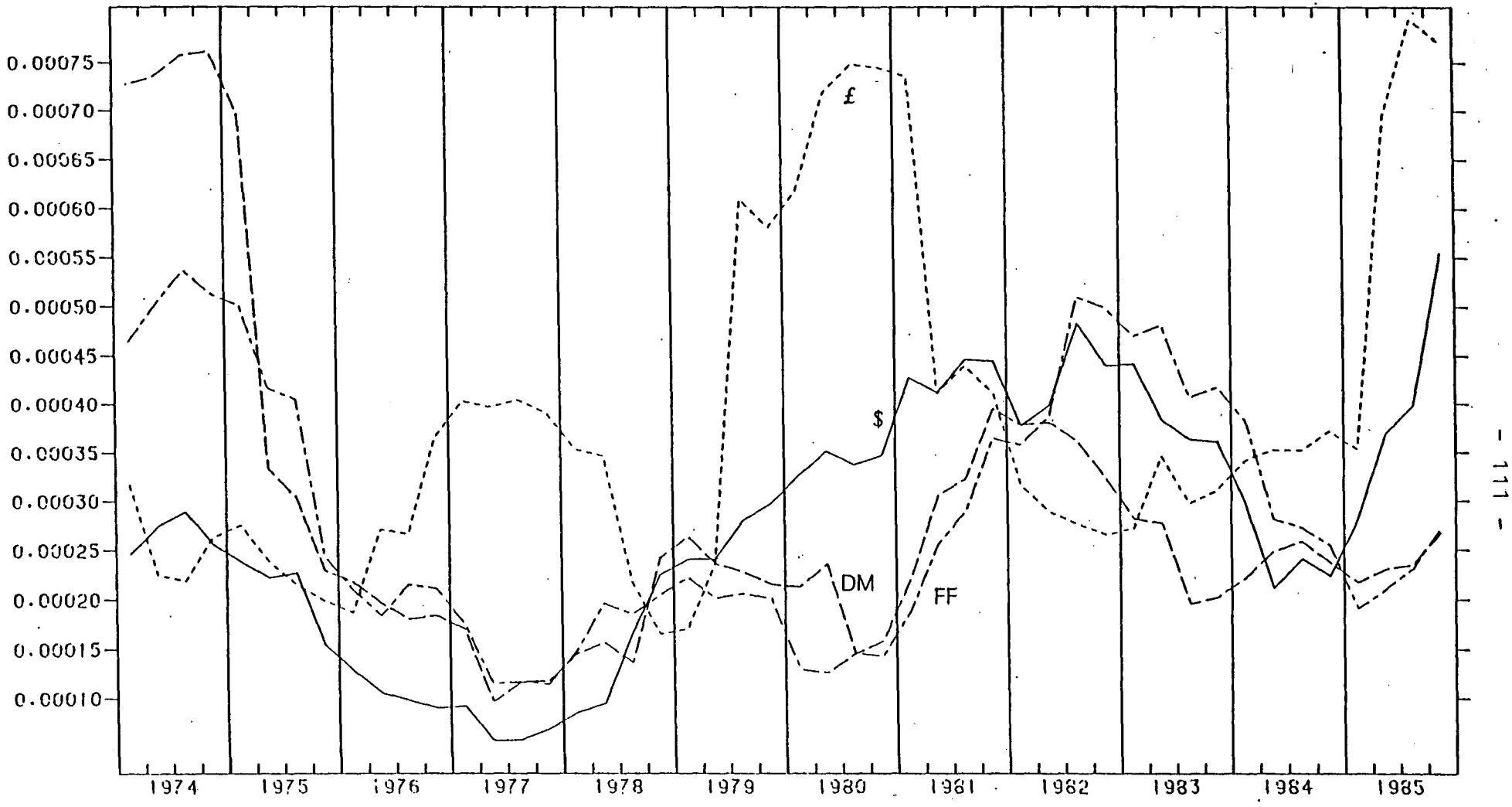


Figure 25
RV against (other) non-EMS currencies; U.S. dollar, deutschmark, pound Sterling, French franc

2. Econometric and Modelling Issues

The aim of this study is to investigate the effects of exchange rate risk on trade. One may then ask why regressions are not run which relate trade volumes or prices to variance terms alone? Indeed, such a strategy would, besides saving a great deal of efforts, provide many more degrees of freedom and thus more powerful tests; especially for the sectoral equations using only eleven observations that would constitute one significant gain. However, such a strategy may be vitiated by "omitted variable bias", that is, the bias created in the estimate of the parameter on one explanatory variable when another variable is excluded (see Judge et al., 1980).

To explain, let the true relationship be

$$y = ax + bz + \varepsilon; \quad E(\varepsilon) = 0 \quad E(\varepsilon^2) = s^2.$$

Consider the researcher who ignores z and attempts to estimate

$$y = ax$$

by OLS. Then her estimator $\tilde{a}$ is given by

$$\tilde{a} = (X'X)^{-1}(X'Y),$$

which by substituting out Y, is equivalent to

$$\tilde{a} = (X'X)^{-1}\left[X'(aX + bZ + e)\right]$$

$$= a + b(X'X)^{-1} X'Z + (X'X)^{-1} X'e.$$

Taking probability limits,

$$\text{plim } (\tilde{a}) = a + b \text{ plim } \left[(X'X)^{-1} X'Z\right] \qquad \neq a$$

i.e., the mean of the estimate $\tilde{a}$ ist not equal to a, in small or large samples. A fortiori estimates of standard errors are misleading. It would be desasterous to ignore other influences on trade besides the variance of the exchange rate. In a typical macro-economic setting the estimate $\tilde{a}$ tends to be greater in absolute magnitu than a and with an unwarranted level of significance; the estimate "picks up" some of the influence of z on y.

However, the problem of omitted variable bias need not be too daunting and perhaps one does not in the end have to account for every significant explanatory variable: from the last equation above it can be seen that $\tilde{a}$ is at least asymptotically unbiased if plim (X'Z) = 0, that is, if the two explanatory variables are orthogonal to one another. The degree of omitted variable bias depends on the covariance between the included and excluded variables, but this could be zero or extremely low. If one is only interested in some parameters (like 'a' above) rather than the best possible explanation of the behaviour of y, then one need not be concerned with any explanatory variables which are orthogonal to x.

To apply these principles to the problem at hand, consider first the sectoral trade equations. Here only eleven observations were available, making the conservation of degrees of freedom essential if any sort of test was to be performed. On the right hand side as an explanatory variable a variance term was, of course, included; that was the point of the exercise. One may also suspect that the real exchange rate, besides affecting trade flows directly, is also somehow correlated with exchange rate risk and thus should be included to prevent omitted variable bias. Further, perhaps "bad times" are also uncertain times, so a term capturing demand conditions is needed.

If the aim were to explain trade by sector as well as possible, then sector-specific variables - say, relative prices - would be very desirable, but this is not the aim here. Exchange rate variance is macro-economic identical for all sectors, and therefore

orthogonal to sector-specific shocks. Hence one can exclude variables peculiar to individual sectors without loss of unbiasedness and with a gain of power in our tests.

Likewise in the macro-economic equations it was not necessary to produce the world's best explanation of trade flows or the highest possible R^2, but only to include enough that omitted variable bias is not a problem for the estimates of the coefficients on exchange rate risk. Elaborate lag structures on real exchange rates and a meticulous examination of diverse proxis for demand are unnecessary and possibly counterproductive by using up degrees of freedom (inclusion of irrelevant variables does not create a bias but does cause a loss of efficiency).

Therefore that those econometric criticisms of the results presented below which spring to mind may be mostly irrelevant to the investigation of the effects of exchange rate risk on trade.

For example, there seems to be multicollinearity - resulting in loss of efficiency, not bias - between a number of explanatory variables. In particular real income or industrial production, a time trend and capacity utilization are included in the exporting country, and occasionally the coefficients on these terms and their lags are a bit peculiar when looked at individually. However, usually when this is the case the trend implicit in real income or production offsets the explicit time trend and/or the cyclical correlation between the former and capacity utilization results in low power and perverse and sensitive estimated coefficients. Be that as it may, all this may be immaterial to the question of the influence of exchange rate variance. Some checks for estimator sensitivity and diagnostic statistics confirmed this intuition.

Similarly price effects are not always well modelled, or rather, supply and demand effects are conflated (see Goldstein and Khan, 1985). Let the log of the real exchange rate be r (the log of the nominal rate E times the foreign price P^* level divided by the domestic price level P) exchange rate risk be σ^2 and the demand and supply of exports be X^d and X^s respectively. Let us take the simplest log-linear case

$$X^d = a + br - c\sigma^2$$

$$X^s = i - jr - k\sigma^2$$

$$r = e + p^* - p$$

where a, b, c, i, j and k are all positive parameters. We are interested in knowing $\partial X / \partial \sigma^2$ and $\partial p / \partial \sigma^2$. When supply and demand are equal

$$r = \frac{(a - i)}{(b + j)} + \frac{(c - k)}{(b + j)} \sigma^2$$

so that

$$p = e + p^* + \frac{(a - i)}{(b + j)} - \frac{(c - k)}{(b + j)} \sigma^2$$

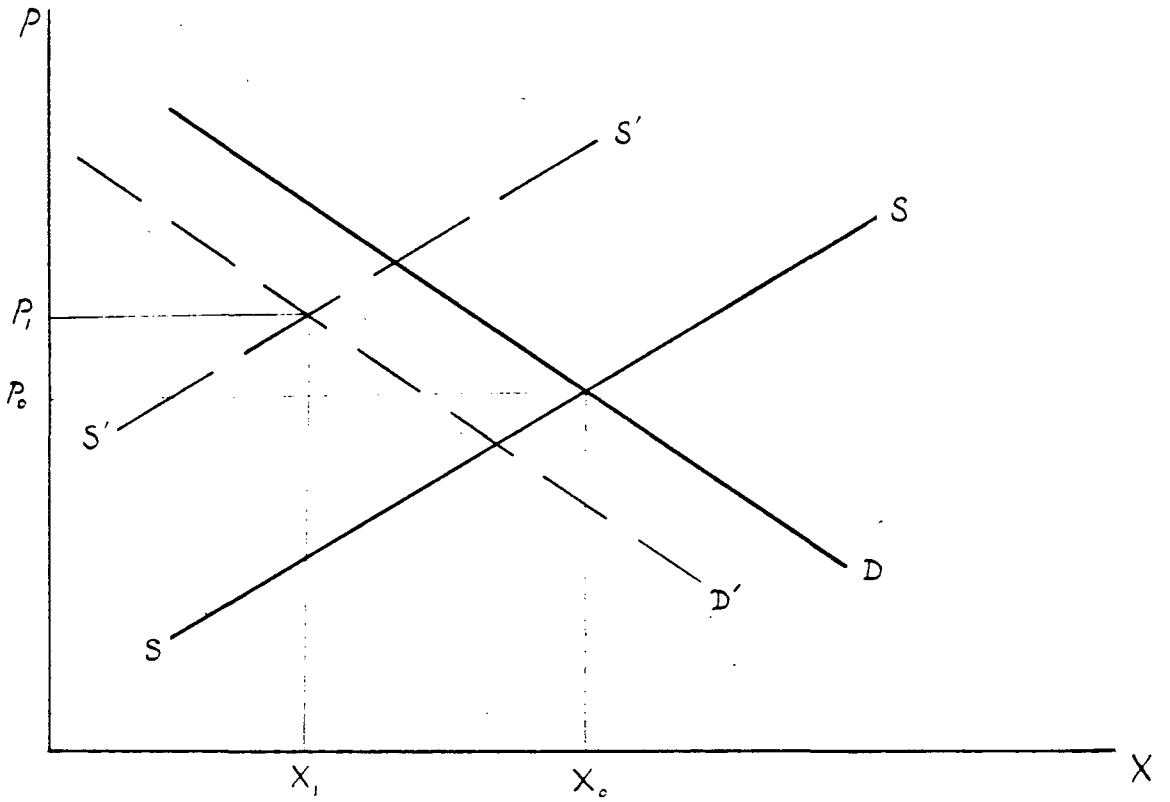
and

$$X = \frac{(bi + aj)}{(b + j)} - \frac{(bk + cj)}{(b + j)} \sigma^2 .$$

Trade always falls with increasing risk and prices rise if $k > c$, that is, if the effect of risk on supply is greater than that on demand. In Figure 27 below the shifts in the demand and supply schedules after an increase in σ^2 are shown and a new equilibrium illustrated.

Figure 27

Shift in Supply and Demand Curves after an Increase in Exchange Rate Risk



Were only exchange rate variance fluctuating over time the task would be very easy. Since though this is not the case it is extremely difficult to estimate either the export demand or the export supply curve alone; when they are summed together it is unclear whether the coefficient on the relative price term will be positive or negative (in the linear case it is zero). Yet we only want to know the total effect of exchange rate variance, which is independent of the price elasticity of the net export function. Therefore any "perverse" estimated coefficients on relative price terms were not regarded as extremely worrying.

Instead the main econometric concern was not to prejudge the results and not to engineer a positive or negative influence of exchange rate variance on trade. The following strategy was adopted towards model selection: first a very general regression was run using OLS, including all lags up to a maximum for all variables. Then highly insignificent terms were omitted and the highest adjusted R^2 was searched for. While doing this we tried to ignore the significance and sign on the variance term(s) in order not to bias the results towards preconceptions. Of course, at least one variance term was always included and among variance terms the choice was made according to significance levels. Further, it was recognized that the influence of real exchange rates on trade volumes involve long and complex lags, so we were especially hesitant about dopping any of these terms. Roughly the following procedure was used: let the real exchange rate at time t be r_t and suppose that our initial estimated equation includes

$$\ldots + \hat{a}_1 r_t + \hat{a}_2 r_{t-1} + \hat{a}_3 r_{t-2} + \ldots,$$

where all the estimates $\hat{a}_1$, $\hat{a}_2$ and $\hat{a}_3$ are insignificant but not greatly so (say, t-statistics around unity). If they are all of the same sign one or two could be dropped. If they are positive, negative and positive respectively (or vice versa) they are all kept. If $\hat{a}$ or $\hat{a}_3$ is of different sign to the other two parameters then dropping $\hat{a}_2$ was tried. No particular lag structure such as the Almon was imposed because effects of the real exchange rate level are not the concern and no a priori knowledge of lag structures is claimed.

When a reasonably explanatory and parsimoneous form had been achieved sometimes with other estimation techniques were experimented with. If the Durban-Watson statistic was worrying (recall that it is biased towards 2 in the presence of autoregressive terms) the Maximum Likelihood (ML) technique assuming AR (1) residuals was employed. The ML/AR (1) method has the advantage of using the "information" contained in the autocorrelation of residuals. Note that with very few degrees of freedom, as in

the sector equations, the D.W. statistic loses so much precision that it is almost meaningless. Where autocorrelated residuals were not a problem sometimes equations were grouped and the method of Seemingly Unrelated Regression (SUR) was used. In SUR estimation each equation is first estimated by OLS and then a variance-covarience matrix constructed. The system is reestimated by Generalized Least Squares using the calculated variance-covariance matrix as weighting. Thus the "information" contained in one equation which is relevant to another is employed, without having to impose crossequation restrictions (see Judge et al. for further details).

Typically ML and SUR yield estimates which do not differ much from what is obtained by OLS but the standard errors can be greatly affected. Under the right conditions both techniques provide more powerful tests; often coefficients significant at the 80 % level or better under OLS became even more significant and insignificant estimates became even less so. However, small sample problems can lead to misleading results and, especially for our sectoral equations, we have very small samples to deal with. The ML method in particular is questionable with so few degrees of freedom and the t-statistics generated are only suggestive. SUR is closer to OLS and more "trustworthy"; the main problem is that the variance-covariance matrix can only be estimated and therefore is known only with "noise". In using SUR on sectoral equations the problem cropped up that the estimated standard errors tended to zero and thus the t-statistics were absurdly large when many sectors were estimated together. Therefore the sectors were usually estimated in groups of eight or ten. All regressions were run using the SAS statistical package.

The most general methodological issue is whether or not it is justified to adopt a time-series approach, and then to concentrate on the period of floating exchange rates after 1973.

First, as has already been asserted, people should be more influenced by relative riskiness than by the absolute level of risk. Emphasis on the comparative volatility of currencies or their covariances with some equivalent to the "market portfolio" suggests that a cross-sectional study would be most relevant. We investigate the effects of bilateral exchange rate variance relative to the variance of the effective exchange rate index, and look at export and import shares.

Second, it would be very interesting to know whether or not a regime of pegged or closely targeted exchange rates would enhance trade relative to the present regime of floating. In other words, would a system of stable exchange rates, where this stability is anticipated and expected to persist, be an improvement? As things now stand periods of relative constancy in exchange markets (for example, after the Louvre Accord of April 1986, or the current (1987) British policy of following a DM target for Sterling) are regarded as "lulls in the storm" which generally end chaotically. Therefore temporary stabilization efforts may not be very encouraging to exporters or importers who fear a revival in exchange rate risk.

Yet what can be done econometrically (in the absence of knowledge about the "deep parameters" of tastes, technology, etc.)? We are interested in the effects of creating a structural break under the present circumstances. Econometrics must always assume that the observations upon which a regression is run can in fact be explained by one equation, that is, that no structural breaks occur in series covered by any one equation. One should not compare apples and oranges, and one cannot compare real apples with hypothetical apples.

Would it then be fair to test for the effects of exchange rate risk over a long period, say, 1960 to 1985? We think not, for not only is it plausible that parameters on risk terms have changed, not only has the shape of the probability distribution of the exchange rate changed, but most likely there have also been changes in the relationship between trade flows and all the other explanatory variables. One would not be comparing like with like. Of course, one cannot compare what did occur in the 1970s and 80s with what would have occured, had exchange rates been fixed. Similarly, a cross-sectional study - even if one had enough observations - would entail a comparison across regimes; it is not obvious that trade between France and Germany, conducted under the European "snake" and then the EMS, can be explained together with American or British trade by a single equation.

Hence effort was concentrated on trade by country, over the period 1973-1985, and it was hoped that there were no major structural changes over that timespan. The greatest cost is that results do not carry over immediately to a situation where all currencies are pegged; post experience is not, unfortunately, always a good guide to what could or should be done.

3. Summary

The most appropriate measure of exchange rate risk is that which best captures the risk relevant to economic agents. This is the variance of the log or the proportional changes in the real exchange rate over a fairly long period. The four measures employed are based on daily exchange rate movements (NV), the spot-forward spread (FV), monthly changes (MV) and residuals from a simple autoregressive equation with time trend (RV). All four capture long-term real exchange rate risk to some degree, but the preferred measure is RV. For several applications the variance of bilateral exchange rates relative to that of the effective rate is most appropriate.

The time paths of these measures show that there has been if anything an increase in the volatility of floating rates in the 1980s. The EMS has decreased the variance of member currencies amongst themselves very markedly, at no discernable cost in terms of increased variance against the currencies of third countries.

A sound methodology attempts to find a parsimoneous representation of the explanandum by going from a general to a particular specification. In practice particular care must be taken to conserve degrees of freedom by excluding superfluous variables, and not to rely on asymptotic procedures such as Maximum Likelihood or Seemingly Unrelated Regression except where dictated by the failings of OLS. Further, it should be born in mind that the approach is a partial equilibrium one and is based on induction from the history of a particular exchange rate regime.

V. Econometric Results

In the next section econometric results are presented. The volume of total trade, trade with member of the EMS and with other countries, and bilateral trade between the four countries studied (the Federal Republic of Germany, France, the United States and Great Britain) is the subject of the first three subsections. Then trade shares and trade by sector by country are covered. Finally the estimates for import and export price indices are set forth.

Definition of Variables

Data sources are explained in Appendix A.

Lower case denotes logarithms.

CU	Capacity utilization index for the exporting country
E	Nominal exchange rate
IP	Index of industrial production
M	Real imports
MC	Manufacturers' unit labour costs
MPI	Imports price index
MS	Import share
PIW	GDP deflator for 20 industrial countries constructed using export shares or weights (see below)
R	Real exchange rate; nominal exchange rate deflated by relative consumer price indices
T	Time; 1974 first quarter = 74.00
X	Real exports
XPI	Export price index
XS	Export share
YPI	Home GDP deflator

Variance measures

NV	Variance of daily nominal exchange rate movements
FV	Variance of the 3-month forward/spot differential
SFV	Sum of four consecutive FV terms
MV	Variance of monthly exchange rate movements
RMV	MV of the bilateral exchange rate minus MV of the effective rate
RRV	RV of the bilateral exchange rate minus RV of the effective rate
RV	Variance of the real exchange rate
RVE, RVT	RV against EMS and third country currencies, respectively
RVW	RV of the effective exchange rate

Prefixes and Suffixes

-E	Relative to other EMS members (export weighted)
C-	Change in; first difference
L-	Lag operator; Ln-, n = 2, 3, ... denotes the nth power of L
R-	Relative; bilateral variable minus global measure
S-	Sum; in particular SFV is the sum of four consecutive FV observations
-T	Relative to non-EMS countries (export weighted)
-W	World, global; bilateral variables combined using export weights
*	Significant at 5 % in a two-tailed test
**	Significant at 1 % in a two-tailed test
FR	France
DE	Federal Republic of Germany
UK	United Kingdom
US	United States

1. Total Trade

Most studies of the effects of exchange rate volatility concentrate on aggregate imports and exports. We also perform such an investigation and the results are summarized in Tables 17 and 18. The two available risk measures are RV and MV, in both cases calculated from the effective exchange rate against twenty industrial countries. It was decided to use a rather generous lag structure, in contrast to the specifications used in most of this study, to see what difference it made, and accepted the loss of observations entailed. The basic functional form (see the definition variables above) was

$$x = a + b(L)x + c(L)rw + d(L)ipw + f_1 T + \text{variance terms},$$

in the case of exports and analogues for imports with real domestic GNP (y) replacing foreign industrial production (ipw). The terms b(L), c(L) and d(L) are polynominals in the lag operator of order four, seven and four, respectively, and up to eight lags (i.e. more than two years) of the variance measures (MVW or RVW) were experimented with.

After paring down the estimated equations to leave only the more significant coefficients a very good fit was still achieved in all classes (R^2 and R^2 adjusted for the number of explanatory variables was almost always greater

than 98) and the Durbin-Watson statistics were mostly acceptable; when estimated by OLS the equation for US imports seemed to exhibit negative autocorrelation and so it was reestimated using a Maximum Likelihood method assuming AR(1) errors. The individual coefficients were usually of the right sign and highly significant despite multicollinearity between successive lag terms.

Multicollinearity is especially relevant when it comes to the variance terms which, by construction, follow a moving average process of order seven or eight. Nevertheless, in many cases highly significant coefficients were obtained, secured better even than at the 1 % level. The problem is that in most cases positive and negative coefficients occur together and no net effect can be detected; if anything there are slighty more positive than negative estimates which are significant. Thus it would be fair to say that for French imports, UK exports and French exports when the measure MVW was used, no appreciable influence of exchange rate variance on trade was found. The influence was noticably negative on UK imports and German exports. Higher exchange rate variance was on balance associated with greater US imports and exports, German imports and French exports (for the measure RVW).

These results can by no means be said to be encouraging. Effects of exchange rate risk are certainly not glaringly obvious when total trade flows are looked at, so a more disaggregate approach must be the way forward.

Table 17

Total Trade; RVW

Explanandum	Variance measure	Estimated coefficient	% Pr(Coef.=0) [1] (significance)	R^2 DW
DE total imports (ML/AR(3))	L2RVW	295.99	0.17 **	
	L4RVW	108.68	17.44	
	L5RVW	-180.57	2.05 *	99.4
	L7RVW	114.45	1.01 *	2.27
DE total exports	RVW	-322.87	0.75 **	98.6
				2.19
FR total imports	L5RVW	243.41	1.47 *	99.3
	L6RVW	-311.89	2.95 *	2.31
	L7RVW	76.08	39.0	
FR total exports	L2RVW	-110.19	15.16	99.4
	L3RVW	285.48	0.42 **	2.23
	L5RVW	-49.47	45.61	
UK total imports	RVW	164.64	9.27	94.4
	LRVW	-206.05	1.42 *	1.68
	L3RVW	-181.97	2.74 *	
	L5RVW	-122.59	11.94	
	L7RVW	153.39	8.14	
UK total exports	RVW	98.78	10.46	54.7
	L3RVW	-90.88	8.00	1.97
US total imports (ML/AR(1))	RVW	125.98	13.40	99.8
	LRVW	-92.19	44.25	2.45
	L2RVW	170.07	6.00	
	L6RVW	402.08	0.02 **	
	L7RVW	-224.14	2.73 *	
US total exports	RVW	212.61	1.42 *	98.8
	LRVW	-206.40	3.56 *	2.25
	L2RVW	183.57	3.47 *	
	L4RVW	129.94	5.40	
	L7RVW	138.56	4.82 *	

1) i.e., the probability that the relevant coefficient equals zero; results of t-tests.

Table 18

Total Trade; MVW

Explanandum	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE total imports	LMVW	187.17	0.31 **	98.7
	L4MVW	-245.21	0.34 **	1.99
	L5MVW	384.60	0.11 **	
	L6MVW	-133.14	6.51	
DE total exports	MVW	-272.23	4.81 *	98.9
				2.09
FR total imports	LMVW	-118.57	10.94	99.4
	L2MVW	194.86	0.39 **	2.31
	L6MVW	-82.88	22.77	
	L7MVW	29.55	67.05	
FR total exports	MVW	-49.19	52.78	99.2
	L3MVW	114.55	17.15	1.83
	L7MVW	-93.92	10.68	
UK total imports	MVW	-128.41	17.91	95.0
	LMVW	146.98	27.06	1.96
	L2MVW	-349.76	0.15 **	
	L6MVW	-139.69	9.71	
	L7MVW	227.85	0.87 **	
UK total exports	MVW	182.56	0.75 **	95.7
	LMVW	-203.96	3.57 *	1.99
	L2MVW	162.89	10.57	
	L3MVW	-142.01	4.72 *	
US total imports (ML/AR(1))	L2MVW	147.77	0.66 **	99.8
	L4MVW	298.84	0.01 **	2.60
	L7MVW	-66.88	21.25	
US total exports	MVW	63.15	29.61	98.5
	L3MVW	95.86	18.33	2.43
	L6MVW	157.67	3.64 *	

2. Intra- and Extra-EMS Trade

Informal discussion with businesses and reports in the press suggest that the stability of exchange rates achieved by the EMS is much appreciated by those engaged in international trade. Therefore we looked at French and German trade with other EMS member countries and with third countries.

It is not obvious that the coefficients on risk terms should differ. A given marginal increase in risk may well, ceteris paribus, have the same detrimental impact whether one is trading with the United States or with the Netherlands; the total reduction in trade caused by exchange rate variance will be smaller between Germany and the Netherlands than between Germany and the US because the level of uncertainty is that much lower.

There is at least one argument why coefficients on risk terms should differ between EMS trade and non-EMS trade equations. Currencies within the EMS all have very stable exchange rates relative to one another, and this stability is quasi-permanent. Suppose that firms have to commit themselves to export markets, import supplies, etc. Then a German firm, say, is discouraged from trading with Americans even in a period of low DM/$ exchange rate turbulence by the realization that volatility could very well rise again.

In trading with the Netherlands, changes in the variance of the DM/Guilder exchange rate are expected to be fairly persistant, but the changes are rarer. In the language of financial economics, firms may have to hedge less against changes in the investment opportunity set when they deal with EMS currencies (see below).

The estimated equations are of a simple format which will be used again for bilateral trade; for exports

$$x = a_1 + b_1 Lx + b_2 L^2 x + c_1 rk + c_2 Lrk + c_3 L^2 rk$$
$$+ d_1\ ipk + d_2 Lipk + d_3 L^2 ipk + f_1 cu + f_2 Lcu + g_1 T$$
$$+ h_1\ RVk + h_2\ LRVk$$

where k = E or T depending upon whether the dependent variable is real exports to EMS partners or real exports to third countries (see definition of variables above). Also estimated was the same equation in first differences (i.e. proportional changes). The import equation is almost identical with the importer's capacity utilization included and its real GNP serving to capture domestic demand conditions.

The explanatory power of the equations in log-linear form was high (see Table 19) except for that fitted to German imports from other EMS countries, and that was also the case in which most wrong-signed and insignifi-

cant estimates occured. The equations estimated in rates of change are of more variable quality (see Table 20) and inevitably contain much more "noise"; a R^2 of less than 35 was associated with few if any significant parameters.

The estimates of the coefficients on terms measuring exchange rate variance are again rather inconclusive. Only one is significantly different from zero, and then positive (for the proportional change in French exports to the EMS), and also French imports from the EMS show a positive effect at close to 10 % significance. It is interesting to note that negative coefficients on risk are found in all the equations which seek to explain the rates of growth of trade with non-EMS member countries; this result is consistent with the intuitive notion that a given rise in risk is more important in such cases because firms are sensitized to such changes. But we do not want to place too much emphasis on this point, especially as in our bilateral equations it was found that risk effects were more concentrated within Europe.

If there is a link between exchange rate uncertainty and trade flows, it is too weak and too subtle to be manifest on this level of aggregation.

Table 19

Intra- and Extra-EMS Trade; log-linear form

Explanandum logs	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE imports from EMS	LRVE	-186.24	59.9	79.8 1.8
DE exports to EMS	RVE	428.06	35.3	85.7
	LRVE	-696.11	14.8	2.2
DE imports from non-EMS	LRVT	-21.43	51.2	96.3 2.4
DE exports to non-EMS	RVT	77.38	24.0	97.9
	LRVT	-146.04	2.0 *	2.3
FR imports from EMS	RVE	405.52	11.5	86.0 2.2
FR exports to EMS	RVE	41.06	85.2	92.0 1.7
FR imports from non-EMS	RVT	86.61	21.3	95.5 2.2
FR exports to non-EMS	RVT	-61.18	26.5	95.0 2.2

Table 20

Intra- and Extra-EMS Trade; growth rates

Explanandum % change	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE imports from EMS	CRVE	147.65	78.9	12.3
	LCRVE	-144.43	76.8	2.0
DE exports to EMS	LRVE	172.522	65.2	20.6
				1.9
DE imports from non-EMS	CRVT	-138.572	18.4	36.4
				1.7
DE exports to non-EMS	CRVT	-168.475	9.1	34.1
				2.0
FR imports from EMS	LCRVE	533.627	11.8	33.6
				2.0
FR exports to EMS	LCRVE	684.139	3.2 *	48.5
				1.8
FR imports from non-EMS	CRVT	-53.578	72.8	32.3
				2.1
FR exports to non-EMS	LCRVT	-154.838	22.4	47.9
				2.0

3. Bilateral Trade

The next step in disaggregating trade flows was to look at trade by partner countries, that is, at bilateral trade. The basic equation which was estimated is

$$x = a_1 + b_1Lx + b_2L^2x + c_1r + c_2Lr + c_3L^2r$$
$$+ d_1y + d_2Ly + f_1cu + f_2Lcu + g_1T$$
$$+ \text{variance terms},$$

where x is the logarithm of the real exports from one country to another, L as usual the log operator and the variance terms, to be explained shortly, are derived from the various measures of bilateral risk; for other notation see above. This equation was first estimated including all terms and then we experimented with subsets of the more significant terms until a good, parsimonious fit was obtained. The observations were quarterly and covered the period 1974-1985 inclusive, the longest span for which complete series on all variables were available.

In generally the results are rather satisfying. Just using OLS and a few logs of the endogenous and explanatory variagles yielded R^2 in the 90s, often the very high 90s, and a Durbin-Watson statistic very close to two. The only problematic case was American exports to Germany which, judging by the plot of residuals, suffer from slight heteroskedasticity.

Quite often the real exchange rate terms were individually insignificant and/or their net effect was close to zero, but this is not really worrying as was explained in section IV.2. Multicollinearity also affected the estimated coefficient on capacity utilization, real income and the time trend, but when one looks at these coefficients together somewhere there will be a strong cyclical component and somewhere there will be a net positive secular trend.

The coefficients on the different variance terms in the bilateral trade relations are given in Tables 21-25, column 3, and their significance level in percent is given in column 4; a number smaller than 5 in the fourth column indicates that the estimate passes the two-tailed test for equality to zero at the 5 % level.

Table 21 contains the results using NV (variance calculated from daily exchange rate investments). Because this series is very erratic and we hypothesise that agents may be more concerned by an extended period of risk than by a temporary peak we included up to three lags of this term. As explained above NV was not calculated for the DM/FF rate.

In Table 22 results using variance from the forward-realized spot rate spread are reported; the peculiar peaks to which this measure is prone suggested that the series should be evened out, which was done by taking the sum

of four consecutive observations (hence the abbreviation SFV). Since summation introduces much serial correlation it was thought that only contemporaneous SFV and one lag would suffice.

The series MV ("moving-average" variance) also of course has much autocorrelation and so again only one lag was employed, as shown in Table 23.

In Table 24 are shown different results using the MV measure, now relativized by subtracting from the bilateral MV the MV of the effective, export-weighted exchange rate of the exporting country's currency against those of twenty industrial nations. For example, when estimating German exports to France we calculated

RMV (DE to FR) = MV (DM/FF) - MV (effective DM exchange rate)

The notion here is that economic agents may be committed to trade and cannot escape exchange rate variance but they may attempt to substitute between markets depending upon relative risk. In this case up to two lags were tried out.

Finally, Table 25 shows results using RV, the measure calculated from the residuals of an equation for the real bilateral exchange rate, and its first lag.

Just glancing across the tables the two most striking features are the paucity of significant results and the disparities between different bilateral results. The rareness

of clear-cut exchange rate variance effects corresponds to the results in most of the previous literature in this field. If there is any link from exchange rate risk to the volume of bilateral trade, it is not strong enough to show up often in these aggregate estimates: of the 114 reported coefficients only 14 are significantly different from zero at the 5 % level. Furthermore, of these 14 eight are negative and six positive, so also the negative impact of exchange rate risk does not come out clearly here.

Comparing results across tables the picture is not quite so bland. The significant results are concentrated in a number of bilateral relations, namely, German exports to Britain and France, and all British exports. Further, the signs on the estimates tend to be the same for different risk measures - which is not so surprising considering that they are almost always positively correlated, the similarity nevertheless provides at least some corroberation. For example, the net effect of risk on German exports to France is twice estimated to be significantly negative, once weakly negative and once as good as zero. German exports to Britain yield peculiar estimates, negative (and at least at 15 % significance) for NV and SFV, and positive, even very significantly so, in the other three cases. No net effect could be found on German exports to the US and French exports to Britain, while French exports to the US show a pervasive but never significant negative influence. In regressing French exports to Germany mainly negative coeffi-

cients were obtained on risk, once significant, and likewise for British exports to France. British exports to the US seem to have been encouraged by exchange rate variance, yet the coefficients on the NV, RMV and RV terms in the equation explaining British exports to Germany are all significantly negative (while the coefficient on SFV is insignificantly positive and those on NV and LNV, while significant, almost exactly cancel out). Our results for the US show least pattern, being either grossly insignificant or cancelling out; perhaps there is a slight tendency for the coefficients to be positive, especial in US-German trade.

In sum, in five cases there is a pervasive negative impact, and in four of them there is at least one estimate significantly different from zero. In one case an important positive influence is found and another of weaker positive influence. In the remaining five cases we were unable to uncover any pattern or meaningful results.

Table 21

Bilateral Trade; NV

Explanandum logs	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE to UK	NV	-896.21	14.87	96.5
	NV	328.73	52.96	1.7
	L^2NV	-358.04	50.04	
DE to US	NV	-132.46	80.83	93.2
	LNV	704.09	16.02	2.1
	L^2NV	-165.00	75.78	
FR to UK	NV	223.52	58.28	95.1
	LNV	-80.87	83.96	1.8
	L^3NV	230.43	53.75	
FR to US	L^2NV	-411.17	17.04	97.3
				1.8
UK to US	NV	699.81	28.11	91.9
	LNV	-314.79	66.88	2.2
	L^2NV	526.10	44.52	
UK to DE	NV	1095.88	3.13 *	96.3
	LNV	-956.83	2.52 *	2.1
UK to FR	NV	430.85	28.23	96.8
	LNV	-520.06	14.31	2.1
US to DE	NV	214.36	67.37	72.7
	LNV	-69.50	90.00	2.1
US to UK	LNV	183.50	71.12	93.4
	L^3NV	258.75	60.63	2.3
US to FR	L^3NV	397.39	25.01	89.0
				2.0

Table 22

Bilateral Trade; SFV

Explanandum logs	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE to FR	SFV	1.72	52.0	94.2
	LSFV	-1.64	51.7	2.2
DE to UK	SFV	-2.51	12.1	97.1
				1.8
DE to US	SFV	-3.41	42.2	93.8
	LSFV	2.90	44.5	2.1
FR to UK	SFV	-1.11	48.0	93.8
				1.9
FR to US	SFV	1.61	55.8	97.2
	LSFV	-2.31	37.7	1.9
FR to DE	SFV	-6.87	1.79 *	90.1
				1.6
UK to US	SFV	3.36	18.0	93.2
				1.9
UK to DE	SFV	2.61	15.25	95.5
				2.2
UK to FR	SFV	1.27	49.4	95.6
	LSFV	-1.45	42.7	2.1
US to DE	SFV	-2.92	42.8	76.4
	LSFV	4.49	17.8	2.1
US to UK	SFV	-0.43	88.6	93.3
	LSFV	0.63	79.1	2.3
US to FR	SFV	-0.25	91.6	89.0
	LSFV	0.12	95.4	2.0

Table 23

Bilateral Trade; MV

Explanandum logs	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE to FR	MV	258.5	19.4	94.6
	LMV	-390.7	4.32 *	2.1
DE to UK	MV	276.0	0.01 **	95.7
				2.0
DE to US	MV	111.2	38.6	93.1
	LMV	-99.8	49.4	2.0
FR to UK	MV	-18.8	73.5	95.3
				1.9
FR to US	MV	55.5	46.9	97.5
	LMV	-133.7	11.6	2.0
FR to DE	MV	-144.3	42.7	90.2
	LMV	82.9	59.0	1.9
UK to US	MV	227.0	15.4	92.2
				2.0
UK to DE (ML/AR(1))	LMV	-260.9	0.01 **	98.6
				2.4
UK to FR	MV	-94.3	15.6	96.5
				2.1
US to DE	MV	63.4	18.3	74.0
				2.1
US to UK	MV	-1.2	99.0	93.4
				2.3
US to FR	LMV	25.9	58.7	88.7
				2.0

Table 24

Bilateral Trade; RMV

Explanandum logs	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE to FR	LRMV	-498.0	3.1 *	95.0
	L^2RMV	156.6	44.0	2.2
DE to UK	RMV	247.8	8.6	97.2
	LRMV	-90.3	64.8	2.2
	L^2RMV	174.7	21.5	
DE to US	RMV	173.4	26.5	94.0
	LRMV	-357.2	11.8	2.3
	L^2RMV	272.9	11.2	
FR to UK	LRMV	-60.5	64.1	95.1
	L^2RMV	58.2	64.2	1.9
FR to US	RMV	17.6	86.1	97.4
	LRMV	-104.7	33.4	2.0
FR to DE	RMV	210.1	34.0	90.0
	LRMV	-113.9	66.2	1.9
	L^2RMV	160.8	40.9	
UK to US	LRMV	365.4	4.2 *	93.0
				2.3
UK to DE	RMV	-220.1	12.9	97.0
	LRMV	119.3	56.1	2.3
	L^2RMV	-373.7	3.6 *	
UK to FR	LRMV	-183.2	16.8	96.4
	L^2RMV	102.8	47.4	2.2
US to DE	RMV	75.6	27.2	73.5
				2.3
US to UK	LRMV	147.60	28.8	93.6
	L^2RMV	-181.32	20.9	2.2
US to FR	RMV	-41.2	76.2	89.0
	LRMV	159.3	33.5	1.9
	L^2RMV	-133.1	35.2	

Table 25

Bilateral Trade; RV

Explanandum logs	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE to FR	RV	-239.5	11.7	94.6 2.3
DE to UK	RV	286.0	0.01 **	97.5 2.1
DE to US	RV	13.6	90	93.4
	LRV	39.0	78	2.1
FR to UK	RV	-137.0	21	95.1
	LRV	100.0	35	1.8
FR to US	LRV	-68.5	11.5	97.9 2.2
FR to DE	RV	-90.7	13.2	91.5
	LRV	40.6	51	1.9
UK to US	RV	-109.5	44	93.5
	LRV	392.2	2.0	2.1
UK to DE (ML/AR(1))	RV	-171.2	0.02 **	96.1 2.4
UK to FR (ML/AR(2))	LRV	-147.6	3.0 *	98.2 2.3
US to DE	LRV	64.9	14.0	73.2 2.0
US to UK	RV	389.5	0.1 **	93.1
	LRV	-277.1	4.0 *	2.3
US to FR	RV	68.9	15.3	89.1 1.9

Table 26 is provided to report on an experiment with a different functional form, namely, an equation linear in proportional changes (that is, in log differences). Here risk is proxied by the change in RV from one quarter to the next (designated by CRV). The functional form is basically the same as in the log-linear model above once differences are taken except that only one lag of the changes in the trade volume and the real bilateral exchange rate were used. As usual, working in growth rates increased the ratio of "noise" to "signal" and the R^2 statistics are sometimes very low. The estimated coefficients on CRV correspond roughly to the results given in Tables 21 to 25: a slightly higher proportion is negative, but the one significant negative result is matched by a positive coefficient on CRV in the equation for US exports to the UK. All coefficients for both France and Britain are negative, American results are positive and German mixed (with the significant negative term for her exports to France).

Table 26

Growth Rates of Bilateral Trade; CRV

Explanandum % change	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE to FR	CRV	-601	1.2 *	34 2.0
DE to UK	CRV	159	13	37 2.2
DE to US	CRV	65.5	57	47 2.3
FR to UK	CRV	-206.1	6.7	29 2.1
FR to US	CRV	-19	84	56 2.2
FR to DE	CRV	-117.6	11.4	30 2.2
UK to US	CRV	-98.5	54	37 2.0
UK to DE	CRV	-100.7	38.6	19 2.2
UK to FR	CRV	-121.9	36.5	35 2.1
US to DE	CRV	60.3	57	11 2.1
US to UK	CRV	362.7	0.4 **	37 1.9
US to FR	CRV	62.0	59	13 2.0

It is interesting to note that there is some indication of harm from exchange rate risk on Franco-German trade in both directions, that is, trade between precisely those countries which were willing to enter a formal arrangement of pegging. Negative effects are also pervasive in British trade with its European partners, which may help to account for that country's interest in the EMS or at least tacit exchange rate targeting relative to the Deutschmark.

One can suggest several reasons why negative effects are concentrated within Europe. First, intra-European trade may involve disproportionately many smaller firms which lack the knowledge and means to undertake a full range of financial and strategic insurance measures. Second, the very integration of firms and markets across European borders may make them especially vulnerable; firms may not have so well-established mechanisms to insure against exchange rate fluctuations within Europe when they do occur. Third, economic agents may be as concerned about the potential for volatility as its realization; the dollar may have a quiet quarter or year, but everyone is aware that it may start gyrating at any moment. When the Franc and the Deutschmark joined the EMS (and more recently Sterling has been targeted) people grew to expect exchange rate stability, and thus it was of more value to them. The persistence of low risk, the stability of stability so to speak, may be an important achievement of the EMS. The reaction to changes in exchange rate variance is greater within Europe because the changes are seen to be longer lasting.

4. Export and Import Shares

Firms in the tradeables sector may not be able easily to switch into sectors which are insulated from exchange rate risk, but they may be able to change trading partners quite readily. The possibility that exchange rate risk affects the pattern of trade rather than its total volume is investigated in the following section where export and import shares are looked at. Indeed, Coes (1979) shows under very general conditions that when a firm operates in a more than one market and the price risk in one of these markets rises, then the share of output going to that market must fall. In investigating shares one implicitly makes a comparison between bilateral trade and total trade, so this approach can be thought of as a rough substitute for a cross-sectional study.

An export or import share, of course, is determined both by factors affecting bilateral trade and by influences on total trade. Therefore we chose the following prototype functional forms: for export shares (XS)

$$\begin{aligned} XS = {} & a_1 + b_1 LXS + c_1 r + c_2 Lr + c_3 L^2 r + d_1 rw \\ & + d_2 Lrw + d_3 L^2 rw + f_1 ip + f_2 Lip \\ & + g_1 ipw + g_2 Lipw + h_1 T + h_2 t + j_1 RRV \\ & + j_2 LRRV + j_3 L^2 RRV \end{aligned}$$

Levels are in upper case letters, logarithms in lower case. Time - which was often wholely insignificant - enters both in levels and in logs because one wants to allow both for a uniform trend and for a special impetus to British integration in Europe after its entry into the EEC in 1973, which then wears off. The variable "r" is the logarithm of the relevant bilateral real rate (deflated as usual by the consumer price index) and "rw" is the effective real rate of the exporter against 20 industrial nations ("w" stands for "world"). Likewise "ip" is the log of the index of industrial production in the importing nation, "ipw" the log of an index of production in 20 developed nations, constructed using the exporter's export shares. One expects the c_i and the d_i coefficients, the f_i and the g_i coefficients to be of opposite signs, and they almost always were. RRV is analogous to RMV used before in bilateral equations, namely, the bilateral RV measure minus the RV of the exporters effective real exchange rate.

Note that both production in the importing country (helping determining bilateral trade) and world industrial production (determining total exports) are included. No such comparison is appropriate when dealing with import shares; each share varies pro- or anti-cyclically depending upon whether imports from that country have above or below average income elasticity. Therefore the import share (MS) equations looked like

$$MS = a_1 + b_1LMS + b_2L^2MS + c_1r + c_2Lr + c_3L^2r$$
$$+ d_1rw + d_2Lrw + d_3L^2rw + f_1y + f_2Ly$$
$$+ g_1T + g_2t + h_1RRV + h_2LRRV + h_3L^2RRV$$

In Tables 27 and 28 results are presented. Without a strong secular trend or cyclical component trade shares are often hard to explain, especially import shares for which fewer explanatory variables are appropriate. Hence some, but by no means all the R^2 statistics are rather low. The autocorrelograms of the residuals were plotted and they were found to look very much like white noise (except in two cases when Maximum Likelihood was used), an impression backed up by the very acceptable Durbin-Watson statistics. Even when the R^2 was low there were many significant coefficients of the right sign.

Turning first to export shares one finds pervasive evidence of export market switching in response to relative exchange rate variance. The proportion of German exports going to France is significantly reduced when the RV of the real DM/FF rate rises relative to the RV of the DM effective exchange rate. Export shares of Britain and the US are not really affected; the coefficients are insignificant and offsetting. The shares of French exports to Britain and the US, however, are significantly negatively affected by relative exchange rate risk, while no net effect could be found on the share of exports to Germany. All

British trade shares show net negative coefficients on the relative variance terms, twice certainly significantly different from zero and once nearly so. America is, once more, the odd man out, with two significant "perverse" results, even though lagged variance terms counteract much of this influence and the share of American exports going to France is significantly reduced when relative risk increases.

The import share equations are, as mentioned already, usually less successful in explaining the observations, but not worrisomely so. The sum of coefficients on variance terms is often very small and the individual coefficients are often insignificant, a result which corroborates with our other findings that exchange rate variance tends to operate primarily on the export side. Thus, for Germany there is one positive result (which is insignificant), one small but significant and negative result and one result which is as good as zero. In the case of France both significant effects are positive, though the role of exchange rate variance in determining the share of imports coming from Germany may be peculiar because RRV is extremely small and often negative. British import shares are rather like the French: in one case the sum of coefficients is almost exactly zero, once small, positive and insignificant and once small, negative and significant. For once the "best" results are for America, where the share of imports coming from the UK is strongly restrained by the relative exchange rate risk; the coeffi-

cients associated with the German import share are also individually significant although they sum to a small negative number; also the French import share is, if weakly, negatively affected by relative exchange rate risk.

It seems, then, that the relative riskiness of a currency can affect firms' willingness to export to a particular market, even if the volumes of trade are not appreciably affected. Somewhat weaker evidence suggests that in the sourcing of imports agents often seek to avoid suppliers with volatile currencies. We find the results presented here especially weighty because they were obtained by investigating trade shares in relation to relative exchange rate volatility, a procedure which combines some of the benefits of both time-series and cross-sectional analysis.

One may argue that implicit is a loss of allocative efficiency: if I shift my export effort from one country to another when the former currency becomes more unstable, I am diverging from the pattern of trade which would prevail were all currencies equally risky. Yet the pattern of trade under equal risk should reflect the "fundamentals" of comparative advantage and thus be efficient, so that a departure from this pattern is at most second best.

Table 27

Export Shares

Explanandum	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
Share of DE exports going to				
FR	RRV	-38.40	6.90	77.1 2.2
UK	RRV	9.22	20.38	93.5
	LRRV	-8.34	31.21	2.3
US	LRRV	10.30	15.38	86.2
	L2RRV	-11.28	16.13	2.2
Share of FR exports going to				
UK	RRV	-13.77	1.15 *	79.6 2.1
US (ML/AR(2))	LRRV	-9.83	0.01 **	99.2 2.2
DE	RRV	-13.30	59.95	93.5
	LRRV	42.60	15.33	2.1
	L2RRV	-29.37	24.94	
Share of UK exports going to				
US	RRV	-25.19	6.52	92.2
	LRRV	17.20	34.66	1.8
	L2RRV	-25.67	11.71	
DE	LRRV	-19.16	3.29 *	93.8
	L2RRV	11.51	21.15	2.2
FR	LRRV	-16.08	2.26	95.4
	L2RRV	11.83	9.66	2.0
Share of US exports going to				
DE	LRRV	8.10	1.22 *	78.3
	L2RRV	-6.19	5.66	1.7
UK	RRV	7.02	2.16 *	81.5
	LRRV	-4.17	21.06	2.1
FR	LRRV	3.46	17.02	72.9
	L2RRV	-5.91	4.92 *	2.3

Table 28

Import Shares

Explanandum	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
Share of DE imports coming from				
FR	LRRV	-11.68	28.10	89.3
	L2RRV	19.94	9.73	2.2
UK	LRRV	7.51	14.41	94.5
	L2RRV	-9.20	5.55	1.6
US	RRV	-4.86	34.03	57.1
(ML/AR(2))	LRRV	13.27	5.56	1.8
	L2RRV	-8.72	0.41 **	
Share of FR imports coming from				
UK	L2RRV	-1.44	83.31	92.1
				1.9
US	RRV	11.44	0.13 **	63.6
	LRRV	-7.87	3.39 *	2.0
DE	LRRV	69.24	3.76 *	54.4
				1.8
Share of UK imports coming from				
US	RRV	19.07	14.68	80.6
	LRRV	-19.71	23.43	2.2
DE	RRV	18.12	27.21	85.8
	LRRV	-16.26	28.27	2.1
FR	LRRV	13.81	7.92	73.0
	L2RRV	-15.51	4.43 *	2.1
Share of US imports coming from				
DE	LRRV	18.45	16.10	71.1
	L2RRV	-18.69	13.62	2.4
UK	RRV	-16.72	2.97 *	79.7
				1.6
FR	RRV	-9.09	0.53 **	81.4
				1.8

We applied the same approach to the shares of French and German trade conducted with fellow EMS countries and with third countries. Again the equations are "sucessful" in terms of having high R^2 statistics and many significant coefficients of the correct sign. In one case (share of German imports from third countries) the equation estimated by OLS manifested serial correlation in the residuals, so the Maximum Likelihood method assuming AR(1) residuals was employed. French import shares were relatively poorly explained but an inspection of the residuals revealed no special problems.

The estimated coefficients on relative risk terms are presented in Table 29. Note that the dependent variables sum pairwise to unity (e.g. share of German imports from the EMS region plus share from outside the EMS equals one) so pairs of results are not really independent. Since, however, the explanatory variables differ all results are reported.

The same pattern as for bilateral trade shares is manifest: variance terms in the import equations tend to cancel each other out, so that the net effect is small, positive and insignificant; the negative terms, though, tend to be somewhat better secured. In contrast, the negative impact of relative exchange rate risk on export shares is very marked. Firms in one country are able and willing to divert exports towards markets with compara-

tively stable real exchange rates against the home currency. In the case of France and Germany, this means the "snake" and then more effectively the EMS furthered the integration of the continental European economies.

To make this result more plastic, suppose that the EMS had not existed and that the mark and the French franc had returned to their pre-1979 level of volatility against other EMS currencies with RVE around 2×10^{-4}. The RV of the effective rates against all 20 industrial countries could also therefore have been somewhat higher, say 2.3×10^{-4}. Then belonging to the EMS may have reduced the RRVE (RV against other EMS currencies relative to that of the effective rate) of the German mark by about 1.5×10^{-5} and reduced the RRVE of the Franc by 1×10^{-5}. Using the estimated coefficients it appears that EMS membership may have increased the share of German and French exports going to their fellow members by 6.3 and 1.7 percentage points respectively. These very rough estimates seem a little high but do drive home the importance of currency stability for European integration.

Table 29

Intra- and Extra EMS Trade Shares

Explanandum	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
Share of DE imports coming from EMS member country	LRRVE	-152.93	4.24 *	92.5
	L2RRVE	178.12	7.75	1.96
	L3RRVE	242.53	0.98 **	
	L4RRVE	-201.55	0.91 **	
Share of DE imports coming from non-EMS member countries (ML/AR(1))	RRVT	-131.28	0.10 **	98.0
	L2RRVT	169.57	0.84 **	2.30
	L3RRVT	15.40	83.97	
	L4RRVT	-54.34	19.90	
Share of DE exports going to EMS member countries	RRVE	-414.80	4.42 *	86.5
	L4RRVE	211.46	21.32	1.76
	L5RRVE	-210.95	15.38	
Share of DE exports going to non-EMS member countries	RRVT	-302.92	0.45 **	87.3
	L4RRVT	204.98	7.77	1.74
	L5RRVT	-174.52	8.33	
Share of FR imports coming from EMS member countries (ML/AR(1))	RRVE	165.01	6.01	85.6
	L3RRVE	-105.10	28.71	2.27
Share of FR imports coming from non-EMS member countries	RRVT	36.33	25.64	68.4
				2.25
Share of FR exports going to EMS member countries (ML/AR(3))	RRVE	-172.92	0.07	99.1
				1.86
Share of FR exports going to non-EMS member countries (ML/AR(2))	RRVT	-69.16	30.73	91.4
	L2RRVT	81.43	38.42	2.10
	L3RRVT	-95.64	16.52	

5. Sectoral Trade

The EEC's VOLIMEX data tape allowed us to investigate imports and exports by sector for each subject countries. What was received was the nominal value of trade and a price index for exchanges, by sector, by trading partner; a trading partner is either a single large country or a geo-economic group. The raw trade values were deflated and summed by year. Unfortunately not all series for all partner countries were complete - the price index was usually what was missing - which introduces "noise" into the series. However, this problem should not be exaggerated: first, when the series for one sector was very bad it was simply excluded. Particularly American data was often missing. Second, data was inadequate mainly when bilateral trade was very small (US coal exports to Sub-Saharan Africa say). Third, the sector-specific intercept and trend terms in the regression equations should pick up most of the more pervasive gaps in the data.

The data was annual and estimates are based on the period 1974-1984 inclusive, so we were faced with an acute shortage of degrees of freedom. Considerable effort was made to cut down the number of exploratory variables and the SUR estimation method was often employed (see above). Nevertheless, the sectoral results should be treated as no more than suggestive.

For imports in sector i into some country (M_i) the baseline equation took the form

$$m_i = a_1 + b_1 Lm_i + c_1 rw + c_2 Lrw + d_1 y + f_1 T + g_1 RVW.$$

The variable "rw" is the log of the real effective exchange rate against 20 industrial nations and RVW is the RV measure calculated for this rate; since RVW was calculated quarterly the four RVW observations in each year were added together (in effect taking the average).

The export equations are almost identical except that an index of industrial production in 20 industrial countries, export weighted (ipw), is substituted for real GNP (y). Therefore the import equations tend to have slightly more explanatory power. With careful "pruning" it was usually possible to retain at least five degrees of freedom.

Table 32 summarizes sectoral results by displaying the number of sectors, in each country, for which the estimated coefficient has a t-statistic smaller than -2, between -2 and -1, etc. A t-statistic smaller than -2 corresponds roughly to the coefficient being significally negative at the 5 % level in an one-tailed test. A t-statistic

between -2 and -1 indicates that the estimated coefficient was negative but poorly defined. When the t-statistic is between -1 and 1 we felt that the estimated coefficient was as good as zero. The same principles apply, mutatis mutandis, to positive t-statistics. Tables 33 through 40 give more details on each equation, the value of the estimated coefficient on RVW and its t-statistic. The sectors are defined in Appendix B; roughly speaking, sector 1 to 8 are raw materials, 9 to 12 are intermediary and investment goods, 16, 17, 18 are traditional consumption goods and the rest are mixtures of investment goods, durables, and so on. Sector 24 is total imports or exports, provided for comparison. The sectors vary greatly in size, coherence and market structure: agriculture is especially heavily regulated, as presumably are radioactive materials, although there are also organized exchanges in the former products. "Products of coking" and "non-metallic minerals" are small sectors with homogeneous products, machinery is a huge sector with diverse and differentiated products.

This diversity was recognized and therefore no restrictions across equations were imposed. Yet sector-specific explanatory variables were not included because it was felt that these should all be orthogonal to exchange rate risk and so their inclusion would only lower the efficiency of estimators, as has been explained in section IV.2.

Table 32 provides an overview by country for both imports and exports; the results correspond to those in the rows marked "24" (total trade) in Tables 33 to 40. On the import side, only for France is there a marked tendency to have negative coefficients on the risk term, but then they are usually significantly so. The other three nations tend to show positive coefficients. As regards exports, France is again exceptional, with no strong leaning, while the other three all show a definite negative effect of exchange rate variance. The distribution of positive and negative coefficients is more even for imports than for exports, and overall the results are skewed towards the negative side with a large number of sectors with no discernable effect.

It is worth comparing the distribution of results in Table 32 with the results for total trade using RV as the risk measure, which are given in Table 17. At least for Germany and France there is a strong correspondence. Furthermore the sectoral results are well reflected in row 24 of Tables 33 through 40, where estimates are given for the effect of exchange rate variance in total trade using annual data.

From Tables 33 to 40 one sees that most equations were very successful in terms of R^2 statistics; where the R^2 is noticeably lower we suspect data problems and the results should be treated with caution. The Durbin-Watson statistic is also reported although with so few degrees of freedom it is almost meaningless. Results using OLS and either SUR or

Maximum Likelihood with AR(1) errors (ML/AR(1)) are reported. In the full equations coefficients on other explanatory variables are usually significant and of the right sign; difficulties are concentrated in the raw materials sector presumably because the relative price term, the nominal exchange rate deflated by consumer prices, is only weakly correlated with the relevant relative price given the fluctuations in raw material and energy costs during the '70s and '80s.

Are exchange rate risk effects concentrated in certain sectors independent of country? Sector 1 (agriculture, forestry, fisheries) shows no strong pattern except perhaps a slight negative tendency on the export side. In sectors 2 (coal, etc.) and 3 (coking) we find positive coefficients for imports and negative for exports, but only one is significant. Sector 4 (oil and gas) displays more definite effects, again mostly on exports, although also one large and significant positive coefficient; we suspect that currencies may be relatively volatile during oil crises when also net oil imports fall. For sector 6 (radioactive materials) only French and German data was available, but then all four estimated coefficients on risk terms were negative and sizeable. Sector 7 (metal ores) produces many significant results but of mixed sign, while for sector 8 (non-metallic minerals) in three cases imports noticeably increased with exchange rate variance. A positive effect on imports and negative on exports is to be found in sectors 9 (chemicals),

13 (electricals) and perhaps 21 (rubber, plastic). No decisive impact of exchange rate uncertainty on imports but a general reduction of exports appears in sectors 10 (sundry metal goods), 11 (machinery), 16 (food, etc.) and 22 (other manufacturers). No particular tendency is evident in sectors 14 and 15 (motor and other transport equipment, respectively) or sector 18 (leather and footwear). For sector 19 (wood, furniture) no less than five significantly negative coefficients (and one positive significant) were obtained while sector 20 (paper) showed four positive and significant coefficients along with a number of weakly negative terms.

It is interesting to compare these results with those of Gosling (1986), one of the few studies which deals thouroughly with the effects of exchange rate risk on trade by sector for a developed country. Gosling looked at British exports - the sectoral definitions differ somewhat from ours - using a measure for risk similar to our NV. She found no significant effect for manufacturing generally but obtained well secured negative coefficients on risk for chemicals (our sector 9), textiles (our sector 17) but not clothing, and scientific instruments (which would be covered primarily by sector 12) as we did. Both Gosling and ourselves uncovered a negative but insignificant effect in the motor vehicles sector (14). Only in the case of machinery (11) did Gosling find a significant negative coefficient when we did not. Thus there is some corroberation for our results at least as far as U.K. exports are concerned.

To make these results more immediate, the following exercise was undertaken: after the founding of the EMS in 1979, the variance of the real effective exchange rates (RVW) of the Franc and Deutschmark declined, whereas that of Sterling rose, as shown in table 30 below:

Table 30

$x10^4$	DM	FF	£
Average RVW 1974 I - 1979 I	2,07	1,81	2,81
Average RVW 1979 II - 1985 IV	1,18	1,43	3,63

Source: Own calculations

The reduction in RVW for the Franc and the Deutschmark can be attributed almost wholly to the EMS, as argued in section IV.1. If Britain had joined, it is reasonable to suppose that the RVW of Sterling would also have been lower; to be conservative, suppose that the RVW could have been reduced by about a third, say, by 1×10^{-4}. The estimated effects of such a stabilization of the exchange rate are shown below in Table 31. For comparison, the effects on German sectoral exports have been selected for which reasonably well secured and negative estimates were obtained. Sectors of a similar decline in the RVW of the Deutschmark are also presented.

The results of the OLS regressions were used and due allowance was made for lagged endogenous terms and annualization.

Table 31

Estimated percentage change in exports of selected British and German sectors after a reduction of RVW by 1×10^{-4}

	Sector	British exports % change	German exports % change
9	chemicals	3.8	3.4
10	metal products	3.1	7.1
12	office equipment, optics, etc.	4.3	1.2
13	electrical goods	3.2	7.6
14	motor vehicles	4.0	7.6
16	food, beverages	3.7	2.0
17	textiles, clothing	5.0	5.5
18	leather and footwear	5.2	4.0
19	wood and furniture	5.5	7.1
24	Total exports	2.8	5.4

These projections should, of course, be treated with much caution, as the coefficients upon which they are based are usually not significant and sectors were chosen only if negative effects of exchange rate variance were found.

Sectoral investigations were more handicapped by problems over data quality and availability than was the examination of aggregate exports and imports. Yet the equations were often more "successful" in finding some effect of exchange rate risk, or at least in making clear when there was none. Further, the diversity of results, not only between countries but also between sectors within each country reinforced the suspicion that reactions to exchange rate uncertainty are too industry- and even firm-specific to be well captured in total trade statistics.

Table 32

Summary of Sectoral Results

Explanandum	No. of t-statistics on estimated coefficients on RVW which are				
	<-2.0	$-2.0< <-1.0$	$-1.0< <1.0$	$1.0< <2.0$	$2.0<$
German imports	1	1	8	2	9
French imports	8	3	10	0	0
U. K. imports	1	1	5	4	8
U. S. imports	2	1	2	1	7
German exports	13	4	2	1	1
French exports	0	3	11	5	2
U. K. exports	5	7	5	2	0
U. S. exports	6	4	4	0	0
all imports	12	6	25	7	24
all exports	24	13	22	8	3
total	36	24	43	15	27

Table 33

German Imports by Sector

Sector	Estimation Method	Estimated coefficient on RVW (t-statistic)	R^2 DW
1	OLS	- 23.2	93.8
		(- 0.41)	1.5
1	SUR	- 20.9	
		(- 0.37)	
2	OLS	142.5	80.1
		(1.31)	2.6
2	SUR	136.6	
		(1.26)	
3	OLS	448.8 *	92.3
		(3.08)	2.7
3	SUR	446.6	
		(3.10)	
4	OLS	- 37.0	67.1
		(- 0.18)	2.8
4	ML/AR (1)	- 98.1	
		(- 0.55)	
6	OLS	- 700.0	68.4
		(- 1.25)	2.4
6	SUR	- 719.9	
		(- 1.29)	
7	OLS	267.1 *	98.6
		(11.89)	3.8
7	ML/AR (1)	267.9	
		(22.41)	
8	OLS	37.9 *	98.1
		(2.35)	2.5
8	SUR	35.7	
		(2.27)	
9	OLS	133.3 *	95.0
		(2.31)	1.4
9	SUR	138.4	
		(2.58)	
10	OLS	75.3 *	99.0
		(3.68)	3.5

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
10	ML/AR (1)	86.2 (10.63)	
11	OLS	13.1 (0.56)	69.5 2.9
11	ML/AR (1)	5.8 (0.46)	
12	OLS	135.9 * (2.66)	93.9 2.1
12	SUR	137.0 (2.69)	
13	OLS	24.0 (1.67)	98.3 2.5
13	SUR	24.8 (1.12)	
14	OLS	41.4 * (2.12)	99.0 1.6
14	SUR	41.28 (2.11)	
15	OLS	80.2 (0.94)	75.5 1.7
15	SUR	79.7 (0.93)	
16	OLS	15.8 (0.37)	99.1 2.9
16	ML/AR (1)	19.56 (0.44)	
17	OLS	- 6.0 (- 0.27)	98.9 2.2
17	SUR	- 5.6 (- 0.25)	
18	OLS	- 32.8 (- 0.62)	94.2 1.6
18	SUR	- 34.3 (- 0.78)	
19	OLS	- 79.3 (- 1.98)	95.1 1.6
19	SUR	- 79.3 (- 2.00)	

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
20	OLS	188.3 *	98.6
		(4.07)	2.2
20	SUR	182.6	
		(4.44)	
21	OLS	85.4 *	99.1
		(3.14)	2.4
21	SUR	92.2	
		(3.43)	
22	OLS	- 5.21	98.6
		(- 0.20)	2.1
22	SUR	- 5.58	
		(- 0.22)	
24	OLS	59.4 *	98.5
		(3.29)	3.0
24	ML/AR (1)	57.0	
		(3.45)	

Table 34

French Imports by Sector

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
1	OLS	39.7 (0.20)	87 2.6
1	SUR	101.9 (0.54)	
2	OLS	- 44.6 (- 0.20)	72 2.3
2	SUR	- 127.9 (- 0.63)	
3	OLS	106.3 (0.33)	34 2.8
3	SUR	219.4 (0.74)	
4	OLS	- 147.5 (- 1.74)	94 3.3
4	ML/AR (1)	- 170.8 (- 3.19)	
6	OLS	- 2346.9 * (- 2,48)	87.2 2.4
6	SUR	- 2617.9 (- 2.92)	
7	OLS	- 209.7 * (- 2.19)	86.3 1.6
7	SUR	- 202.3 (- 2.25)	
8	OLS	- 34.9 (- 0.65)	97.7 2.4
8	SUR	- 30.9 (- 0.58)	
9	OLS	- 60.5 (- 1.09)	97.5 1.6
9	SUR	- 50.5 (- 0.93)	
10	OLS	- 5.1 (- 0.07)	92.1 2.7

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
10	ML/AR (1)	22.6 (0.41)	
11	OLS	- 4.2 (- 0.25)	97.7 2.9
11	SUR	- 6.9 (- 0.46)	
12	OLS	- 193.3 * (- 2.84)	96.1 1.3
12	ML/AR (1)	- 183.2 (- 2.92)	
13	OLS	- 10.9 (- 0.42)	99.7 3.1
13	ML/AR (1)	- 12.7 (- 0.55)	
14	OLS	- 67.3 (- 0.91)	89.7 2.2
14	SUR	- 47.7 (- 0.66)	
15	OLS	108.4 (0.46)	74.9 2.3
15	SUR	139.9 (0.72)	
16	OLS	- 86.2 (- 1.88)	98.6 1.3
16	ML/AR (1)	- 90.4 (- 2.09)	
17	OLS	- 110.63 * (- 2.88)	93.1 2.2
17	SUR	- 113.72 (- 3.23)	
18	OLS	- 38.37 (- 0.45)	64.8 2.4
18	SUR	- 37.90 (- 0.50)	
19	OLS	- 42.36 (- 0.62)	96.2 2.8

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
19	ML/AR (1)	- 73.25 (- 1.11)	
20	OLS	- 193.7 (- 1.49)	94.5 1.7
20	ML/AR (1)	- 193.6 (- 1.36)	
21	OLS	- 128.3 * (- 2.17)	95.0 2.1
21	SUR	- 135.6 (- 2.69)	
22	OLS	- 259.7 * (- 2.23)	96.5 1.8
22	SUR	- 287.6 (- 2.62)	
24	OLS	- 65.7 (- 1.68)	97.3 1.7
24	ML/AR (1)	- 65.6 (- 1.56)	

Table 35

U. K. Imports by Sector

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
1	OLS	- 367.2 *	99.5
		(- 7.07)	2.8
1	SUR	- 376.6	
		(- 8.53)	
2	OLS	- 25.4	88.9
		(- 0.07)	2.2
2	SUR	68.1	
		(0.22)	
4	OLS	100.48	98.5
		(0.84)	2.1
4	SUR	109.7	
		(0.97)	
7	OLS	56.8	90.9
		(1.76)	1.4
7	SUR	69.5	
		(2.45)	
8	OLS	144.0 *	93.5
		(3.23)	1.7
8	SUR	135.0	
		(3.73)	
9	OLS	129.7 *	95.5
		(2.45)	2.7
9	SUR	119.5	
		(2.47)	
10	OLS	33.0	66.8
		(0.54)	2.7
10	ML/AR (1)	48.7	
		(1.32)	
11	OLS	16.7	93.7
		(0.28)	2.8
11	ML/AR (1)	52.2	
		(1.63)	

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
12	OLS	98.6 (0.66)	78.4 1.6
12	SUR	31.1 (0.23)	
13	OLS	93.3 (1.67)	88.0 3.2
13	ML/AR (1)	77.5 (2.59)	
14	OLS	12.43 (0.27)	97.5 2.4
14	ML/AR (1)	16.3 (0.34)	
15	OLS	- 200.8 (- 0.87)	84.7 3.3
15	ML/AR (1)	- 300.0 (- 1.74)	
16	OLS	38.1 (0.81)	91.3 1.9
16	SUR	34.4 (0.92)	
17	OLS	111.8 * (2.05)	68.8 2.1
17	SUR	109.5 (2.01)	
18	OLS	70.5 * (2.21)	83.1 1.8
18	SUR	70.5 (2.33)	
19	OLS	225.7 * (2.20)	92.4 2.6
19	SUR	193.2 (2.11)	
20	OLS	166.0 * (2.86)	89.8 2.8
20	ML/AR (1)	165.5 (5.58)	
21	OLS	81.5 (1.86)	92.8 2.2

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
21	SUR	58.87 (1.54)	
22	OLS	236.8 (1.14)	95.7 2.7
22	SUR	217.1 (1.13)	
24	OLS	66.8 * (2.10)	95.7 3.1
24	ML/AR (1)	79.3 (2.77)	

Table 36

U. S. Imports by Sector

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
1	OLS	45.5	96.8
		(1.51)	3.4
1	ML/AR (1)	45.5	
		(3.37)	
2	OLS	108.8	93.1
		(1.23)	2.7
2	SUR	67.6	
		(1.28)	
4	OLS	496.4 *	92.2
		(3.02)	2.6
4	SUR	428.8	
		(4.48)	
7	OLS	273.3	65.1
		(1.80)	1.8
7	SUR	236.2	
		(2.68)	
8	OLS	116.3 *	89.7
		(2.94)	2.5
8	SUR	105.9	
		(3.16)	
9	OLS	- 16.2	89.8
		(- 0.39)	2.3
9	SUR	- 17.73	
		(- 0.43)	
10	OLS	- 65.9	91.3
		(- 1.89)	2.5
10	SUR	- 71.3	
		(- 2.10)	
15	OLS	156.8	92.2
		(1.53)	
15	SUR	157.7	
		(3.80)	
16	OLS	19.7	89.8
		(0.46)	2.2

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
16	SUR	15.0 (0.38)	
17	OLS	- 103.8 (- 1.80)	90.9 2.6
17	SUR	- 108.0 (- 2.60)	
19	OLS	- 88.6 (- 1.44)	86.4 3.0
19	ML/AR (1)	- 96.0 (- 1.99)	
20	OLS	118.1 * (2.31)	90.2 2.8
20	ML/AR (1)	105.9 (2.39)	
21	OLS	406.5 * (6.12)	99.0 3.4
21	ML/AR (1)	396.3 (9.45)	
24	OLS	10.4 (0.45)	94.6 3.4
24	ML/AR (1)	16.6 (1.47)	

Table 37

German Exports by Sector

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
1	OLS	- 83.3 *	79.8
		(- 2.07)	2.3
1	SUR	- 78.1	
		(- 2.28)	
2	OLS	- 163.0	75.5
		(- 1.28)	2.6
2	SUR	- 153.9	
		(- 1.36)	
3	OLS	133.7	58.7
		(1.16)	2.7
3	SUR	153.2	
		(1.30)	
4	OLS	- 84.3	95.1
		(- 1.90)	2.1
4	SUR	- 95.6	
		(- 2.58)	
6	OLS	- 196.1	82.1
		(- 0.78)	2.7
6	SUR	- 141.3	
		(- 1.28)	
7	OLS	- 175.5 *	94.7
		(- 3.63)	2.9
7	ML/AR (1)	- 182.4	
		(- 4.08)	
8	OLS	- 83.7 *	88.4
		(- 2.54)	2.5
8	SUR	- 85.7	
		(- 3.80)	
9	OLS	- 84.5 *	99.6
		(- 2.93)	3.0
9	ML/AR (1)	- 97.0	
		(- 5.48)	
10	OLS	- 174.8 *	96.5
		(- 2.74)	2.4

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
10	SUR	- 159.5 (- 6.63)	
11	OLS	- 92.1 * (- 2.78)	98.1 2.2
11	SUR	- 91.6 (- 11.21)	
12	OLS	- 29.8 (- 0.90)	99.7 3.0
12	ML/AR (1)	- 32.9 (- 1.56)	
13	OLS	- 190.6 * (- 4.12)	98.5 2.9
13	ML/AR (1)	- 202.7 (- 5.57)	
14	OLS	- 190.1 * (- 2.04)	97.3 2.7
14	SUR	- 116.1 (- 3.11)	
15	OLS	- 414.5 (- 1.78)	83.9 1.4
15	SUR	- 203.0 (- 1.70)	
16	OLS	- 50.6 (- 1.65)	97.7 2.7
16	ML/AR (1)	- 61.7 (- 2.78)	
17	OLS	- 138.6 * (- 2.90)	95.2 2.8
17	SUR	- 142.6 (- 10.81)	
18	OLS	- 101.2 * (- 3.52)	96.2 2.3
18	SUR	- 96.7 (- 9.35)	
19	OLS	- 177.0 * (- 3.04)	98.4 2.4
19	ML/AR (1)	- 199.9 (- 4.52)	

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
20	OLS	84.3 *	99.7
		(4.06)	2.0
20	SUR	88.2	
		(23.51)	
21	OLS	- 89.4 *	99.4
		(- 2.49)	2.6
21	SUR	- 38.85	
		(- 5.16)	
22	OLS	- 327.1 *	89.8
		(- 4.51)	3.2
22	ML/AR (1)	- 325.7	
		(- 6.39)	
24	OLS	- 135.8 *	95.3
		(- 3.68)	2.7
24	SUR	- 151.6	
		(- 17.55)	

Table 38

French Exports by Sector

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
1	OLS	31.3 (0.44)	87.2 2.1
1	SUR	39.4 n.a.	
2	OLS	- 96.5 (- 0.88)	93.9 1.1
2	SUR	- 54.1 n.a.	
3	OLS	- 362.2 (- 0.94)	76.1 1.4
3	SUR	- 329.8 (- 1.85)	
4	OLS	7.52 (0.11)	95.4 2.0
4	SUR	49.7 n.a.	
6	OLS	- 1257.7 (- 0.73)	80.5 1.6
6	SUR	- 1038.7 (- 1.69)	
7	OLS	- 24.8 (- 0.95)	98.4 2.9
7	SUR	- 17.3 n.a.	
8	OLS	83.5 * (2.13)	98.6 3.0
8	ML/AR (1)	71.9 (2.00)	
9	OLS	69.0 * (2.42)	99.7 3.00
9	ML/AR (1)	64.3 (2.50)	
10	OLS	19.7 (0.31)	96.4 2.1

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
10	ML/AR (1)	24.0 (0.36)	
11	OLS	37.37 (0.43)	73.7 1.7
11	SUR	45.5 (1.12)	
12	OLS	52.4 (1.25)	99.9 3.1
12	ML/AR (1)	52.0 (1.24)	
13	OLS	61.6 (0.72)	96.5 2.0
13	SUR	69.6 (1.58)	
14	OLS	54.4 (0.40)	95.2 1.7
14	ML/AR (1)	69.4 (0.48)	
15	OLS	218.2 (1.07)	42.8 2.4
15	SUR	197.0 (1.37)	
16	OLS	- 49.0 (- 0.83)	98.0 2.4
16	ML/AR (1)	- 47.2 (- 0.76)	
17	OLS	- 51.5 (- 0.40)	90.6 2.5
17	SUR	- 11.1 (- 0.23)	
18	OLS	- 1.6 (- 0.01)	93.8 1.8
18	ML/AR (1)	3.8 (0.02)	
19	OLS	65.5 (0.42)	91.5 2.2

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
19	ML/AR (1)	- 50.4 (- 0.37)	
20	OLS	115.4 (1.53)	98.5 2.2
20	SUR	69.4 n.a.	
21	OLS	- 11.2 (- 0.10)	94.6 1.4
21	SUR	- 8.1 (- 0.38)	
22	OLS	48.2 (0.26)	93.0 1.7
22	SUR	69.8 (0.99)	
24	OLS	17.6 (0.33)	96.6 1.9
24	SUR	- 14.8 n.a.	

Table 39

U. K. Exports by Sector

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
1	OLS	- 26.5	59.3
		(- 0.35)	1.4
1	SUR	- 21.4	
		(- 0.41)	
2	OLS	- 355.3	43.3
		(- 0.53)	1.4
2	ML/AR (1)	- 309.2	
		(- 0.59)	
4	OLS	- 238.1 *	96.5
		(- 2.04)	2.6
4	SUR	- 207.8	
		(- 18.48)	
7	OLS	115.7	43.0
		(0.81)	1.7
7	SUR	198.1	
		(1.77)	
8	OLS	- 122.4	80.8
		(- 0.76)	2.0
8	SUR	- 79.1	
		(- 1.24)	
9	OLS	- 95.7	95.9
		(- 1.09)	2.7
9	ML/AR (1)	- 178.8	
		(- 2.66)	
10	OLS	- 77.3	96.1
		(- 0.70)	1.7
10	ML/AR (1)	- 72.2	
		(- 0.60)	
11	OLS	37.9	96.6
		(0.45)	2.2
11	ML/AR (1)	22.4	
		(0.23)	
12	OLS	- 41.8	98.4
		(- 0.38)	2.2

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
12	SUR	- 66.8 (- 2.41)	
13	OLS	- 64.1 (- 0.45)	98.0 2.4
13	SUR	- 95.0 (- 1.26)	
14	OLS	- 101.1 (- 0.48)	93.6 2.0
14	SUR	- 186.6 (- 1.13)	
15	OLS	- 377.7 (- 0.44)	44.8 2.5
15	ML/AR (1)	- 668.2 (- 0.94)	84.0 2.2
16	OLS	- 91.4 (- 1.83)	71.6 1.4
16	ML/AR (1)	- 83.3 (- 1.77)	
17	OLS	- 126.2 (- 1.29)	96.2 3.0
17	ML/AR (1)	- 149.5 (- 2.80)	
18	OLS	- 130.6 (- 1.02)	91.7 2.4
18	ML/AR (1)	- 120.2 (- 1.04)	
19	OLS	- 138.5 (- 0.75)	69.3 2.3
19	SUR	- 107.4 (- 11.52)	
20	OLS	- 63.8 (- 0.79)	95.5 2.4
20	SUR	- 37.9 (- 1.44)	
21	OLS	- 53.6 (- 0.40)	96.7 2.3
21	SUR	- 82.2 (- 1.18)	

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
22	OLS	464.3 (1.02)	71.2 1.60
22	SUR	441.4 (1.32)	
24	OLS	- 71.5 (- 1.07)	85.5 2.2
24	SUR	- 71.6 (- 3.24)	

Table 40

U. S. Exports by Sector

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
1	OLS	- 24.2	68.8
		(- 0.64)	2.8
1	ML/AR (1)	- 28.5	84.2
		(- 1.03)	2.6
2	OLS	5.9	95.8
		(0.03)	3.0
2	ML/AR (1)	61.5	
		(0.40)	
4	OLS	- 233.6 *	93.8
		(- 5.07)	2.9
4	ML/AR (1)	- 237.0	
		(- 7.15)	
7	OLS	- 86.7	60.0
		(- 1.02)	2.7
7	ML/AR (1)	- 80.9	78.5
		(- 1.21)	
8	OLS	- 120.1	79.8
		(- 1.41)	3.1
8	ML/AR (1)	- 108.2	93.6
		(- 1.86)	
9	OLS	- 52.0	95.3
		(- 0.62)	3.4
9	ML/AR (1)	- 33.6	
		(- 0.63)	
10	OLS	- 121.2 *	92.0
		(- 2.09)	3.1
10	ML/AR (1)	- 120.6	
		(- 2.89)	
11	OLS	- 176.5 *	95.5
		(- 2.45)	2.8
11	SUR	- 180.0	
		(- 2.50)	
13	OLS	- 278.8 *	97.8
		(- 4.40)	2.7

Sector	Estimation Method	Estimated Coefficient on RVW (t-statistic)	R^2 DW
13	SUR	- 268.8 (- 3.46)	
16	OLS	- 33.7 (- 0.89)	91.0 2.8
16	ML/AR (1)	- 23.9 (- 0.57)	
17	OLS	- 245.8 * (- 2.85)	93.2 3.6
17	ML/AR (1)	- 240.3 (- 6.33)	
18	OLS	- 85.1 (- 0.86)	86.9 2.9
18	ML/AR (1)	- 45.0 (- 0.54)	95.3
19	OLS	- 181.1 (- 1.36)	86.0 2.5
19	ML/AR (1)	- 228.3 (- 2.02)	94.2
20	OLS	- 62.1 (- 1.15)	90.6 3.3
20	ML/AR (1)	- 57.3 (- 1.69)	97.7
24	OLS	- 170.7 * (- 5.31)	88.7 3.0
24	ML/AR (1)	- 186.2 (- 8.78)	95.5 2.4

6. Trade Price Indices

Some of the most striking results came from an investigation of import and export price indices. The basic export price index (XPI) equation took the form

$$\begin{aligned} xpi = {} & a_1 + b_1 Lxpi + b_2 L^2 xpi + b_3 L^3 xpi + b_4 L^4 xpi \\ & + c_1 ew + c_2 Lew + c_3 L^2 ew + d_1 mc + d_2 Lmc \\ & + f_1 cu + f_2 Lcu + g_1 ypi + g_2 Lypi \\ & + h_1 piw + h_2 Lpiw + j_1 T + k_1 RVW + k_2 LRVW \end{aligned}$$

As usual, lower case denotes logarithms and notation has been summarized above; notice that the effective nominal exchange rate against 20 industrial countries (EW) is used. The observations ran from 1974 I to 1985 IV and, once insignificant terms were chopped, typically about 30 degrees of freedom remained. The idea behind this specification was that export prices are affected by cost pressures (manufacturers' unit labour costs MC, capacity utilization CU), foreign competitiveness (GDP deflator abroad PIW and the nominal exchange rate) besides overall domestic inflation (YPI), autoregressive components, the time trend and exchange rate risk.

Many of these influences will be offsetting so that we do not presume much about the signs of coefficients. The import price index (MPI) equations are similar except that the export price index is included as an explanatory variable

$$\begin{aligned} mpi = {} & a_1 + b_1 Lmpi + b_2 L^2 mpi + b_3 L^3 mpi + b_4 L^4 mpi \\ & + c_1 ew + c_2 Lew + c_3 L^2 ew + d_1 mc + d_2 Lmc \\ & + f_1 cu + f_2 Lcu + g_1 ypi + g_2 Lypi \\ & + h_1 piw + h_2 Lpiw + j_1 xpi + j_2 Lxpi \\ & + k_1 T + l_1 RVW + l_2 LRVW \end{aligned}$$

Again many terms could be dropped and we always had at least 29 degrees of freedom.

The R^2 statistics achieved (presented in Table 1) are excellent. In two cases serial correlation in the residuals was found when the equation was estimated by OLS and so a Maximum Likelyhood estimator was employed. Not only was the overall fit very good but also many individual coefficients were significant at the 1 % or 5 % levels.

In every case the variance of a country's real effective exchange rate was positively related to its import and export price indices, and in all but two cases this relationship was manifest in coefficients very significantly greater than zero. Even when, as is twice the case, RVW and LRVW differ in sign, the positive one predominates.

An increase in RVW of 0.0001 - a reasonable order of magnitude judging from Figure 26 - would increase German import and export prices on impact by almost 0.5 %, French import prices by as much as 2.5 %, and so on.

These results have important implications for this study and for the way in which exchange rate variance affects trade. It was explained above that an increase in risk could shift both the supply and demand curves leftward in price-quantity space, and that the price could rise or fall depending upon which shift was greater. Here is evidence that the price rises, indicating that increased risk acts mainly to restrain supply. The consumers of tradeables are unwilling or unable to change their demand schedules much, while the providers will require a higher price for every given quantity when uncertainty mounts.

If follows that if demand is not only "risk inelastic" but also relatively price inelastic then the quantity traded will not be very sensitive to exchange rate volatility. The strong positive results for price indices help explain the absence of many significant results in equations seeking to explain quantities (although they cannot excuse significantly positive estimated coefficients).

It is interesting to note in this context that the coefficient on RVW or LRVW is typically largest in those cases where we had greatest difficulty finding volume effects (non-British imports) and usually smallest and least well secured where quantities responded most to exchange rate risk (such as British trade, French exports).

Even if prices rather than quantities of goods traded respond to exchange rate risk there is still an indirect welfare loss. Goods yield utility, and the direct utility from tradeables may be little affected, but resources have to come from somewhere - presumably non-tradeables - to purchase them. Thus total consumption will fall, compounding the loss of expected utility from uncertainty over total consumption and its composition.

Table 41

Import and Export Prices Indices

Explanandum	Variance measure	Estimated coefficient	% Pr(Coef.=0) (significance)	R^2 DW
DE import price index	RVW	48.86	15.38	99.8 2.0
DE export price index (ML/AR(1))	LRVW	46.41	0.01 **	99.9 2,4
FR import price index (ML/AR(1))	LRVW	249.43	0.01 **	99.9 2.4
FR export price index	RVW LRVW	-140.17 208.09	0.40 ** 0.04 **	99.9 2.1
UK import price index	RVW	44.01	1.11 *	99.9 2.0
UK export price index	RVW	16.11	37.97	99.9 2.1
US import price index	RVW	136.91	4.92 *	99.6 2.3
US export price index	RVW LRVW	-51.27 64.93	8.12 2.34 *	99.9 2.2

7. Summary

The effects of exchange rate uncertainty on the trade of Britain, France, the Federal Republic of Germany and the United States since the start of floating in 1973 were estimated by time series techniques using a variety of risk measures. On the highest levels of aggregation - total imports and exports or real trade flows categorized as intra- or extra-EMS trade - no pervasive negative impact could be found. As the degree of differentiation increased the results become somewhat clearer: On the bilateral level there is some evidence of harm caused by exchange rate variance on German and British exports to France, French exports to the U.S. and on German imports from France and Britain. When trade is disaggregated by sector one finds quite a strong negative effect on exports, insofar as a paucity of data does not proclude firm statements.

More striking is the effect of relative exchange rate variance on trade patterns, specifically on bilateral export shares and on the share of German and French trade conducted with their EMS partners or with others; the EMS, by stabilizing member countries' exchange rates against one another, has furthered the integration of the European market in goods.

It was also found that import and export prices increase significantly with higher exchange rate risk; risk may, thus, be harmful indirectly by raising prices rather than affecting quantities directly.

VI. Summary and Conclusion

The wandering paths followed by exchange rates since the introduction of floating in 1973 can be explained only partially, even with hindsight, and often seem to bear little relation to economic "fundamentals". Real exchange rate variance is barely less than that of nominal exchange rates, as the great real appreciations of Sterling and then the U.S. dollar during the 1980s demonstrate. The spread of *ex ante* forecasting errors is even larger, and thus a risk is created for exporters and importers which is not wholely insurable or diversifiable. Firms and indeed consumers may react by concentrating on markets or sectors with relatively low price uncertainty; implicit is an allocative loss compared to a world with less exchange rate volatility, in addition to the reduction in expected welfare caused directly by risk.

Concern about exchange rate volatility as popularly expressed and more formal economic considerations have inspired a number of studies into the effects of risk on trade. Typically, total or bilateral trade and export and import price indices are investigated, and a considerable number of proxies for exchange variance have been tried. On the whole the results have been mixed, with some authors uncovering pervasive negative effects, others finding negative effects only in some cases, and still others unable to obtain coefficients on the risk term which were significant or of the anticipated sign.

This study is more comprehensive than any other individual work in this field. Over the period 1973 to 1985 four countries are dealt with, of which two (the United States and Great Britain) had almost entirely unmanaged exchange rates and two (France and the Federal Republic of Germany) participated first in the "Snake" and then in the European Monetary System. Estimates were made for total imports and exports of each country, intra- and extra-EMS trade, bilateral trade between the four subject countries and sectoral trade, that is, going from the

highest to the lowest available level of aggregation. Furthermore trade shares and the prices of tradeables goods were investigated. Basically four measures of exchange rate risk were employed corresponding to different interpretations of this concept.

In the highest level of aggregation no systematic effect of exchange rate risk could be found; coefficients were often insignificant and of the wrong sign. But as the differentiation between destination and sector became finer a greater influence became apparent. Volatility seemed to have the greatest detrimental effect on exports of European countries in certain sectors such as oil, chemicals, electrical goods, textiles and clothing, and wood and furniture. One estimate suggests that joining the EMS might plausibly raise British exports in certain sectors by two to five per cent.

Some of the most impressive results were obtained when the variance of the bilateral exchange rate relative to that of the effective rate was used as an explanatory variable, and when import and export shares were examined. As is suggested by theory, relative exchange rate risk is an important determinant of trade patterns. The closest substitute for trading with a country with a very volatile exchange rate may be trade with a more stable currency area, rather than concentrating on the domestic market for tradeables or on non-tradeables. The importance of this distributional phenomenon, which has so far been neglected in the literature, helps to explain the difficulty in finding risk effects on aggregate trade, and for the somewhat better disaggregated results. The impact of risk on trade patterns also suggests that the EMS has made a significant contribution to the integration of the Continental European economies by making exchange rates between member countries much more predictable than all other rates.

Equally important is the effect of exchange rate risk on the prices of imports and exports. The traded goods price indices of all four countries were found to react positively to increased risk, the estimates being usually significant and often quite large. That prices are affected helps explain why it was difficult to find an impact on quantities when that was tested

for directly, and indicates that exchange rate risk is a phenomenon of macroeconomic relevance. The welfare costs of currency volatility may be transmitted through lower real income and distorted relative prices for tradeable goods.

These results are of course subject to the usual qualifications attached to econometrics, an art which does not so much confirm or falsify propositions as give grounds for preferring one hypothesis over another. Further, exchange rates and their variance, trade flows and income, are all endogeneous and intimately interrelated. Therefore a partial equilibrium approach must be open to some criticism. In particular one cannot jump to conclusions about the consequences of radically changing the exchange rate regime. It is our belief, though, that risk aversion has been shown to be so important and so widespread that more fixed exchange rates leading eventually even to monetary union within Europe would provide a great stimulus to integration and growth, and reduce the total variance in the economic system.

The effects of such regime changes would be one interesting area for future research, perhaps in relation to the literature on optimal currency areas and the political economy of monetary policy. More immediately feasible would be a study of the effects of exchange rate variance on investment, employment and on sectoral trade patterns. Initial tests suggest that it would be profitable to investigate whether exchange rate risk is more indirectly harmful by raising the relative prices of tradeable goods.

Appendix A

Data Sources

Daily spot and forward exchange rates were obtained from the Bundesbank. There rates are the mean of noon bid and ask quotes. Real and nominal exchange rates by month, quarter or year, come from the E.E.C. and we thank Mr. Schönborn for his cooperation. The QUEST and CRONOS data base, provided by Bucher and Mors, provided us with most of our data on bilateral trade, GNP, deflators, industrial production, etc.

For our sectoral analysis, we used data from VOLIMEX.

Appendix B

VOLIMEX. Sectoral Codes

	NACE-CLIO(R44)
1. Agricultural, forestry and fishery products	01
2. Coal, lignite,(brown coal) and briquettes	03
3. Products of coking	05
4. Crude petroleum, natural gas and petroleum products	07
5. Electric power, gas, steam and water	09
6. Production and processing of radioactive materials and ores	11
7. Ferrous and non-ferrous ores and metals, other than radioactive	13
8. Non-metallic mineral products	15
9. Chemical products	17
10. Metal products except machinery and transport equipment	19
11. Agricultural and industrial machinery	21
12. Office and data processing machines; precision and optical instruments	23
13. Electrical goods	25
14. Motor vehicles	27
15. Other transport equipment	29
16. Food, beverages, tobacco products	31+33+35+37+39
17. Textiles and clothing	41
18. Leathers, leather and skin goods, footwear	43
19. Timber, wooden products and furniture	45
20. Paper and printing products	47
21. Rubber and plastic products	49
22. Other manufacturing products	51
23. Products N.E.S.	-
24. Total trade	

Appendix C

Definition of Variables

Data sources are explained in Appendix A.

Lower case denotes logarithms.

CU	Capacity utilization index for the exporting country
E	Nominal exchange rate
IP	Index of industrial production
M	Real imports
MC	Manufacturers' unit labour costs
MPI	Imports price index
MS	Import share
PIW	GDP deflator for 20 industrial countries constructed using export shares or weights (see below)
R	Real exchange rate; nominal exchange rate deflated by relative consumer price indices
T	Time; 1974 first quarter = 74.00
X	Real exports
XPI	Export price index
XS	Export share
YPI	Home GDP deflator

Variance measures

NV	Variance of daily nominal exchange rate movements
FV	Variance of the 3-month forward/spot differential
SFV	Sum of four consecutive FV terms
MV	Variance of monthly exchange rate movements
RMV	MV of the bilateral exchange rate minus MV of the effective rate
RRV	RV of the bilateral exchange rate minus RV of the effective rate
RV	Variance of the real exchange rate
RVE, RVT	RV against EMS and third country currencies, respectively
RVW	RV of the effective exchange rate

Prefixes and Suffixes

-E	Relative to other EMS members (export weighted)
C-	Change in; first difference
L-	Lag operator; Ln-, n = 2, 3, ... denotes the nth power of L
R-	Relative; bilateral variable minus global measure
S-	Sum; in particular SFV is the sum of four consecutive FV observations
-T	Relative to non-EMS countries (export weighted)
-W	World, global; bilateral variables combined using export weights
*	Significant at 5 % in a two-tailed test
**	Significant at 1 % in a two-tailed test
FR	France
DE	Federal Republic of Germany
UK	United Kingdom
US	United States

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