THE EXCHANGE RATE MECHANISM OF THE EUROPEAN MONETARY SYSTEM: VOLATILITY, TARGET ZONES AND PROSPECTS

By

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ABSTRACT

This thesis presents six essays relating to various aspects of the workings of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS), an adjustable-peg exchange rate regime that has been in operation in Europe since 1979. The essays follow its development, from its inception in 1979, to its near collapse in 1992, and its current prospects in the context of economic and monetary union. The essays focus on several aspects of the EMS, notably volatility of exchange rates, offshore interest rates and forward exchange rates, the target zone model, time-series analysis of exchange rate changes, and how the EMS fits in with current plans for economic and monetary union in Europe.

ABSTRAIT

Cette thèse présente six essais relatifs aux différents aspects du fonctionnement de Mécanisme de Taux de Change (MTC) du Système Monétaire Européen (SME), un systeme de «taux de change à valeur determiné flexible» effectif en Europe depuis 1979. Ces essais retracent son évolution de sa conception en 1979 jusqu'au "quasi-effondrement" de 1992 et aux présentes perspectives dans le contexte de l'union monétaire européenne. Ces essais se concentrent sur plusieurs aspects du SME, notamment sur les aspects suivants: la fluctuation du taux de change, du taux d'intérêt *offshore*, du taux de change à terme, le modèle de forchette cible, une analyse économetrie de taux de change et comment le SME s'intègre dans les présentes perspectives économiques et monétaires de l'union européenne.

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What you collect at the grindstone
Becomes a millstone in time.
This is my thesis:
Why go to pieces?
Step out while you're in your prime
You may say I'm an escapist
But I would rather by far
Be that than be a red tapist.

Extract from the song "One Life to Live" from the musical "Lady in the Dark".
Lyrics by Ira Gershwin, Music by Kurt Weill.

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[Annexes and Graphs are contained in a separate volume]

PREFACE

Candidates have the option of including, as part of the thesis, the text of a paper(s) submitted or to be submitted for publication, or the clearly-duplicated text of a published paper(s). These texts must be bound as an integral part of the thesis.

If this option is chosen, connecting texts that provide logical bridges between the different papers are mandatory. The thesis must be written in such a way that it is more than a mere collection of manuscripts; in other words, results of a series of papers must be integrated.

The thesis must still conform to all other requirements of the "Guidelines for Thesis Preparation". The thesis must include: A Table of Contents, an abstract in English and French, an introduction which clearly states the rationale and objectives of the study, a comprehensive review of the literature, a final conclusion and summary, and a thorough bibliography or reference list.

Additional material must be provided where appropriate (e.g. in appendices) and in sufficient detail to allow a clear and precise judgement to be made of the importance and originality of the research reported in the thesis.

In the case of manuscripts co-authored by the candidate and others, the candidate is required to make an explicit statement in the thesis as to who contributed to such work and to what extent. Supervisors must attest to the accuracy of such statements at the doctoral oral defense. Since the task of the examiners is made more difficult in these cases, it is in the candidate's interest to make perfectly clear the responsibilities of all the authors of the co-authored papers. **Under no circumstances can a co-author of any component of such a thesis serve as an examiner for that thesis.**

INTRODUCTION

This thesis comprises six essays on the subject of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS). The essays form six stand-alone chapters, which each address various issues and aspects arising from the operation of the ERM of the EMS from 1979 onwards. The chapters form an integrated whole, as each chapter has as a common thread the behaviour of exchange rates and exchange rate policy in the European context. The ERM is an adjustable-peg exchange rate regime that has been in operation, with membership limited to European Union member states, since March of 1979.

The thesis addresses the issues of volatility of exchange rates, offshore interest rates and forward exchange rates, the applicability of the target zone model in the context of the ERM, and the prospects for the EMS in the light of the evolution of economic and monetary union in Europe. The methodology used is atypical of most of the economic studies on Europe to date, in that it focuses on the distributional aspects of financial and economic variables. An important aspect of this thesis is the interpretation of the results of this econometric investigation in the context of the institutional structure and monetary policy differences in different countries. This approach could significantly add to our understanding of how exchange rates, institutional characteristics and monetary policy interact in volatile financial markets.

The ERM of the EMS was born out of the ashes of the discredited European 'snake' which was operational for most of the 1970s. The establishment of the ERM was originally envisaged as a convenient replacement for the 'snake', due to institutional necessity to limit the fluctuation of exchange rates between member states. Its framework, though, was much more complex than that of the 'snake'. The background to the EMS and a detailed description of the workings of the EMS and the ERM, along with an assessment of the economic performance of the member states of the European Union, both members and non-members of the ERM, can be found in chapter one. In addition, an overview of the vast literature on the ERM of the EMS can be found in chapter one, although each chapter contains a more detailed literature review covering the literature pertinent to the specific issues addressed in each chapter.

Of the supposed benefits of membership of the ERM of the EMS, reduced volatility of exchange rates was advanced as a valuable enhancement. Given the mechanism's characteristic as an adjustable target zone for the exchange rate, this outcome is by no means certain, as member states can decide to appeal at any time to the other member states for realignments of the system. Chapter two addresses the issue of exchange rate volatility, with the collapse of the Bretton Woods exchange rate agreements (1971) as the starting point, and extending up to the beginning of 1992. The analysis uses non-parametric techniques not usually employed in econometrics. These techniques abstract from the time-series nature of the data and focus on the distributional aspects of the data.

One of the specific objections raised against membership of the ERM of the EMS relates to the phenomena of volatility transfer. The assertion here is that by restraining exchange rates, as perhaps the ERM does, interest rates may become more volatile. This issue is explored in depth in chapter three, where changes in the volatility of interest rates and forward exchange rates up to and after 1979 are explored using similar techniques to those employed in chapter two.

Until recently, economists were unable to construct an econometric model that out-performed a random walk in the context of a flexible exchange rate regime. Unable to overcome this apparent obstacle, in the late 1980s, as the EMS began to enjoy a certain degree of unfettered longevity, economists began to work on models that would mirror the economic underpinnings of the ERM: these models were labelled 'target zone' models. To test the appropriateness of these theoretical models though, the implications of these models needs to be compared with the actual behaviour of exchange rates. Chapter four attempts to assess the applicability of the target zone model to the empirically observed behaviour of exchange rates in the ERM, and also presents a simple econometric model which takes into account that exchange rates are restricted in their movements.

Explaining volatility in a time series context has largely eluded economists. One attempt to model volatility focused on how volatility appears to occur in sporadic bursts. This modelling approach is known as the Autoregressive Conditional Heteroskedastic (or ARCH) family of models. Chapter five uses several versions of this family of models and develops a hybrid model to attempt to capture the volatility process in the exchange rate data for the ERM currencies.

Since the massive speculative attacks mounted in the foreign exchange markets on ERM currencies in September 1992, the ERM has been operating under different arrangements to those prior to 1992. Part of the reason for these speculative attacks centred around the additional role that the ERM shouldered as one of several specified criteria for Economic and monetary union (EMU) agreed upon in the Maastricht Treaty of 1991. Chapter six reviews the process of EMU and evaluates the prospects for the ERM in the light of recent events in the European Union.

The ERM of the EMS has been an extremely controversial subject and policy tool, both in terms of economic and political debate, and in terms of its near collapse in September of 1992. The subject of the ERM continues, to this day, to divide economists: not only in assessing its track record in the 1980s but also as to its worth for the future (in the context of possible EMU). It is of crucial importance to continue to extend and improve research in this area, in order to shed more light on the nature of exchange rate behaviour in specific exchange rate regimes. Only then will some of the present day policy conflicts faced by policy-makers be satisfactorily resolved.

Chapter One: BACKGROUND, THE WORKINGS OF THE EUROPEAN MONETARY SYSTEM, EUROPE'S ECONOMIC PERFORMANCE AND REVIEW OF THE ACADEMIC LITERATURE.

I. Background

The success of the Exchange Rate Mechanism (ERM) of the European Monetary system (EMS) during the 1980s owes much to the sense of pragmatism adopted by the original founding members of the system when their Finance ministers met in Bremen in 1978. Conventional wisdom at that time was that a floating exchange rate regime was the only option for a sustainable long-term exchange rate policy. This skepticism towards any form of exchange rate targeting originated from experience with the Bretton Woods system and the European 'snake'. The former sought exchange rate stability by using the U.S. dollar as the de facto numeraire of the post-war exchange rate system, and the latter limited movements of European currencies against each other. (The two exchange rate systems were not instituted sequentially, as there was an overlap when both were simultaneously operational between 1971-3). Indeed, at its inception, most academic economists and foreign exchange analysts did not possess high expectations for the EMS, and many predicted its imminent collapse during its initial years of operation. The original blueprint for the system, agreed among a core of member states of the then European Economic Community (EEC) in 1979, established the system as an adjustable-peg system, with no single currency acting as numeraire (an adjustable-peg system limits exchange rate fluctuations around a specified central parity, but the central parity is adjustable under prescribed circumstances). The arrangements for the system differentiate it from previous exchange rate systems, and probably account for its apparent ability to weather a certain degree of instability, emanating within and without the system, and in particular, the speculation that accompanied the initial scepticism surrounding the longer-term sustainability of the system.

The Bretton Woods system of fixed exchange rates (which was originally established in 1945, first collapsed in 1971 and was resurrected in modified form only to be finally abandoned in 1973), was based on the convertibility of U.S. dollars into gold at US$35 per ounce. Exchange rates for other participating currencies were set against the U.S. dollar, and central bank intervention was used to maintain parities against the reserve currency. Exchange rates were only allowed to change when participating countries experienced a 'fundamental disequilibrium' i.e. a large and persistent current account deficit inconsistent with the exchange rate parity. To maintain exchange rates, the International Monetary Fund (IMF) made loans to deficit countries to assist them when experiencing difficulties, which in practice gave the IMF the ability to influence deficit countries to pursue more restrictive domestic policies. Only in the final resort were countries supposed to devalue their currencies within the system.

The most notable weakness with the Bretton Woods system was the asymmetry between deficit and surplus countries, in relation to the IMF's influence to persuade countries to adjust their parities. Surplus countries were reluctant to pursue more expansionary domestic policies or to revalue their currencies within the system. Further, the domestic policies of the U.S. were also taken as the benchmark for determining the leeway that other countries had to pursue expansionary fiscal policies. Mundell (1969) stated this in a different way, by noting that the U.S., by fixing the price of gold, effectively set the price level for the entire world - countries could either accept their fix against the U.S. dollar or realign. Although the Bretton Woods system was fairly stable in the 1950s, various crises occurred in the 1960s as the U.S. administration decided to pursue an expansionary monetary policy to counter rising U.S. unemployment and to finance the war in Vietnam. The British devaluation of 1967 was quickly followed by the French crisis of 1968, a devaluation of the French franc in August 1969 and the West German float and revaluation of September-October 1969.

Capital flows were, in the latter years of the Bretton Woods system, the biggest source of concern for European countries. The original blueprint for the system had been designed for the world as it was in the 1940s, that is, one with low capital mobility. IMF financing could not be used to meet reserve needs associated with capital flows. Article VI of the IMF Articles of Agreement stated that "a member country may not make use of the

Fund's resources to meet a large or sustained outflow of capital, and the Fund may request a member to exercise controls to prevent such use of the resources of the Fund." Exchange controls were the only method available to reduce the risk of a speculative attack, and even the "gold tranche" (part of the 'quota' deposit made by each member of the system of which 25 per cent had to be in gold - the rest was made in the country's own currency) was only available to a country on three days notice. 'Standby arrangements' were available, but only after being carefully considered by the IMF "in relation to the objectives and purposes of the fund."

The first efforts to patch up the Bretton Woods system were made in 1968, when, after much pressure from the French, the U.S. agreed that an international reserve currency should be established to supplement existing reserve assets, and the Special Drawing Right (SDR) was created and administered by the IMF. By 1971, however, the U.S. balance of payments deficit was growing rapidly, with the matching consequence that the West German surplus was also swelling. The Bundesbank (the West German central bank), being committed in its constitution to pursuing domestic price stability, undertook massive intervention to maintain the Deutschemark's parity, but to little avail, as intervention failed to dampen speculation of an imminent appreciation. On May 4, 1971, the Bundesbank announced that it was allowing the Deutschemark to float, and later that year the convertibility of the U.S. dollar was suspended, effectively terminating the Bretton Woods system. Viewed in hindsight, this might seem a rash move on the part of the Bundesbank, but within Germany from the early 1960s, the consensus had shifted away from maintaining fixed exchange rates at any costs. Kloten (1978) describes the German dilemma as a choice between floating the Deutschemark, which would enhance the perceived likelihood that dorestic price stability would be maintained, and maintaining exchange rate stability against its EEC partners to preserve the EEC customs union and common agricultural market.

The Smithsonian agreement of 1971 attempted to create a modified version of the Bretton Woods system that allowed for some movements in exchange rates, but it was not successful, as once again speculative pressures caused the system to collapse, and all currencies then floated.

Proponents of floating exchange rates, at the time, argued that there were inherent benefits to allowing such a regime to operate. More specifically, as MacDonald (1988) notes:-

i) Friedman (1953) argued that prices are sticky downwards, so that any inadvertent inflationary pressure would be best compensated for by a depreciation of a currency;

ii) Speculation regarding realignments of currencies would be eliminated;

iii) The domestic economy would be shielded against internationally generated shocks;

iv) Pursuance of an independent monetary policy would be feasible;

v) The need for protectionist trade barriers would be eliminated; and

vi) In principle, central banks need not intervene.

In practice, experience of floating rates has not yielded as many tangible benefits as the original proponents claimed would be the case. Firstly, exchange rate movements have not followed movements in relative inflation rates between countries (which should be the case if PPP holds) as is implied by i) above. Secondly, and most importantly here, exchange rates have exhibited extreme volatility since floating in 1973. Of the remaining claims for floating exchange rates, only v) has been partially fulfilled in practice, as the success in terminating the Uruguay Round of the General Agreement on Trade and Tariffs (GATT) demonstrates. The international business cycle was still a dominant influence throughout the 1970s and 1980s, so pursuance of independent monetary policies was hampered by external factors and the effects on the currency. Central bank intervention increased over the period as monetary authorities attempted to smooth excessive volatility in exchange rates.

The 'Snake'

During the latter years of the Bretton Woods system, many European countries were frustrated with the U.S. position, and decided to form a system to promote exchange rate stability independently of the U.S. As Tsoukalis (1977) notes, in April 1972, on recommendations emanating from the Werner committee report (a committee established in December 1969 to give some substance to the much vaunted concept of European Monetary Union (EMU)), the 'snake' was created. The 'snake' linked EEC currencies more closely than if they were left to move independently within the 'tunnel' (4.5% fluctuation from central parities) agreed as part of the Smithsonian agreement. Margins of fluctuation on all bilateral rates were fixed at 2.25%, with an obligation to intervene if these limits were reached. The original 'snake' members were the six EEC members plus the U.K., Ireland, Denmark and Norway.

After the collapse of the Smithsonian agreement in March 1973, the 'snake' continued to operate (Giavazzi and Giovannini (1989) call this the 'floating snake'), but was fraught with problems. Sterling left after 8 weeks, the Italian lira left the 'snake' in February 1973, the Deutschemark was revalued by 3% in March and then again in June of the same year, the Dutch guilder revalued in September and the Norwegian krona devalued in November 1973, and the final blow came in January 1974 when the French franc left the system. At the time of the departure of the French franc, Giscard d'Estaing declared that the 'snake' was "un animal de la préhistoire monétaire européenne"! In reality the 'snake' was a Deutschemark bloc, with Germany, Netherlands, Belgium, Denmark, Norway and Sweden the only consistent members during its life.

As a vehicle for reducing intra-European exchange rate variability, the problems surrounding the 'snake' ensured that in general, it was a failure. Thygesen (1979) claims that the snake was unable to operate effectively because of two basic flaws: i) the asymmetry of the exchange rate mechanism and ii) failure of the intervention rules to provide credibility to the margins of fluctuation set by the system. These two factors are linked as the inception of the 'snake' also saw the establishment of a new facility, called the Very Short Term Financing facility (VSTF), which was administered by a new institution, the European Monetary Cooperation Fund. This facility allowed central banks to borrow unlimited amounts from each other to intervene so as to maintain currencies within their prescribed margins. Borrowings, however, were to be repaid within a month, which for the weaker currencies in the system was too short a time to effectively counter a foreign exchange crisis. This meant that when weak currencies reached their bilateral limits, usually against the Deutschemark, attempts were made by the weaker country's monetary authority to support the currency, but due to the inadequate funding arrangements, this was not maintained for long, and with renewed speculative attacks in the knowledge that this was the case, the currency either devalued or left the system. The asymmetry within the system was caused by the onus put squarely and solely upon the weaker currency countries to act when bilateral limits were reached, without aid from the stronger currency countries. Table 1.1 gives the history of the snake.

TABLE 1.1

History of the Snake

Year	Date	Event
1972	April 24	Basle Agreement establishes snake.
		Participants: Bfr, Ffr, DM, Il , Lfr, Hfl
	May 1	UK£, Dkr join snake
	May 23	Nkr joins
	June 23	UK£ leaves snake
	June 27	Dkr withdraws
	October 10	Dkr rejoins
1973	February 13	Il withdraws
	March 19	Intervention to maintain margins vs US$ ends
		Skr joins and DM is revalued by 3%
	April 3	European Monetary Cooperation Fund established
	June 29	DM revalued by 5.5%
	September 17	Hfl revalued by 5.0%
	November 16	Nkr revalued by 5.0%
1974	January 19	Ffr withdraws
1975	July 10	Ffr returns
1976	March 15	Ffr withdraws again
	October 17	Frankfurt realignment: Dkr devalues 6%,
		Hfl, Bfr devalue by 2% and Nkr, Skr devalue by
1977	April 1	Skr devalues 6%, Nkr and Dkr devalue by 3%
	August 28	Sweden withdraws, Nkr and Dkr devalue by 5%
1978	February 13	Nkr devalued by 8%
	October 17	DM revalued by 4%, Hfl, Bfr revalued by 2%

Source: Triffin R (1979)

Notes: The following currency abbreviations are used:-
Bfr = Belgian franc, Dkr = Danish krona,
DM = Deutschemark, Ffr = French franc,
I£ = Irish punt, Il = Italian lira,
Hfl = Dutch guilder, Nkr = Norwegian krona,
Skr = Swedish krona

II. The Workings of the European Monetary System

After the experience of the Bretton Woods system and the 'snake', European policy-makers were mindful of creating a new system that avoided the pitfalls of the previous systems. Williamson (1977) noted that, to operate successfully, an adjustable peg requires:-

a) rules for monetary policy and exchange rate intervention;

b) sufficient facilities to weather speculative attacks and to effectively defend bilateral parities; and

c) an established process for changing parities.

The rules for exchange rate interventions are particularly important as they determine the extent of symmetry or asymmetry of the system. From the experience of the Bretton Woods system, the numeraire of the system is clearly of import. But on this matter the EEC had already created (in 1960) a composite currency for use in the common agricultural market, known as the European Unit of Account (EUA). So this was now superceded by the European Currency Unit (ECU), as established in the EMS agreements of 5 December, 1978. The ECU is a basket of fixed amounts of each currency in the EMS. All members of the European Union or EU (previously the EEC) are automatically members of the EMS, but membership of the ERM is not obligatory. As the number of units of each currency is fixed, the value of the ECU changes over time as bilateral rates change. Following Giavazzi and Giovannini (1989), ECU weights are computed as follows: let x_i be the units of currency i in one ECU - then the weight of currency i in the ECU basket is given by $w_i = x_i e_i$, where e_i is the price of one ECU in terms of currency i. The weights that compose the ECU are reviewed every 5 years, or on request, whenever the weight of any individual currency has changed by more than 25%. Table 1.2 shows the composition of the ECU since 1979 to the last reweighting in September 1989.

TABLE 1.2

Composition of the European Currency Unit

Currency	Currency Units 1979	1984	1989	Weights (%) 1979	1984	1989
Belgian franc	3.66	3.71	3.43	9.3	8.2	8.1
Danish krona	0.217	0.219	0.198	3.1	2.7	2.5
French franc	1.15	1.31	1.33	19.8	19.0	19.3
Deutschemark	0.828	0.719	0.624	33.0	32.0	30.2
Irish punt	0.00759	0.00871	0.00855	1.1	1.2	1.1
Italian lira	109.0	140.0	151.8	9.5	10.2	9.8
Luxembourg franc	0.14	0.14	0.14	0.4	0.3	0.3
Netherlands guilder	0.286	0.256	0.220	10.5	10.1	9.4
Pound Sterling	0.0885	0.0878	0.0878	13.3	15.0	12.8
Greek drachma	-	-	1.44	-	1.3	0.7
Spanish peseta	-	-	6.885	-	-	5.3
Portuguese escudo	-	-	1.047	-	-	0.8

Source: Office for Official Publications of the European Communities (1987) and Giavazzi and Giovannini (1989)

The functions assigned by the EU to the ECU in the EMS are as follows:-

a) the numeraire for the exchange rate mechanism;

b) the basis for the divergence indicator;

c) the denominator for operations in both the intervention and credit mechanisms; and

d) a reserve instrument and a means of settlement between monetary authorities in the community.

The primary function of the ECU is to act as the numeraire for the ERM of the EMS. Each currency has an ECU central rate, expressed as the price of one ECU in terms of the domestic currency. ECU central rates are fixed and are revised only when there is a realignment or the weights in the ECU are changed.

The ratio of any two ECU central rates is the bilateral central rate of any pair of currencies, which when combined with all the other bilateral central rates forms the parity grid of the system. Bilateral margins are set for most currencies at 2.25 per cent on each side of the central parity (so that the width of the 'target zone' is 4.5 per cent), and at present, for the Spanish peseta, UK sterling and the Portuguese escudo, the margin of fluctuation is 6 per cent (giving a target zone of 12 per cent). The Greek drachma belongs to the ECU basket, and thus has an ECU central rate, but does not observe the exchange rate margins. Clearly the ECU itself is just the numeraire of the system.

The second function of the ECU is as the basis for a divergence indicator. This indicator signals the divergence of each currency from its ECU central rate - when breached, the country concerned is expected to act through "diversified intervention, measures of domestic monetary policy, changes in central parities, or other measures of economic policy" (EC Monetary Committee 1986, Article 3). There is, however, no compulsion to undertake any of these measures, and in practice breaching the divergence indicator threshold rarely in itself prompts any action on the part of the country concerned. The value of the indicator of divergence for a currency i at each point in time is given by:-

$$a_t^i = \sum_j w_t^j \, d_t^{j,i} \tag{1.1}$$

where w_t^j is the weight of currency j in the ECU basket and $d_t^{j,i}$ is the deviation of currency j from its central parity versus currency i. This is summed over all currencies in the basket, where by definition $\sum_j d_t^{j,i} = 0$. The threshold a^* for the indicator for currency i is set at:-

$$a^{*i} = 0.75\ (\ 2.25\ (1 - w^i)) \qquad (1.2)$$

which is 75 per cent of the divergence that would be observed if currency i had deviated by the 2.25 per cent from all the other currencies.

The third function of the ECU is as the denominator for operations in both the intervention and credit mechanism. Each country has to fulfil its requirement not to breach its margin against any other currency by intervening in the foreign exchange market or by some other means (normally adjusting interest rates accordingly). When the bilateral exchange rate of a country diverges by more than its prescribed limits from the central parity and the monetary authority intervenes, this is called marginal intervention. Marginal intervention must be carried out by both monetary authorities involved (see below for further details). In theory there are no limits to the extent of marginal intervention, as by the rules of the system the stronger currency monetary authority has to grant the weaker currency monetary authority an unlimited credit line. This credit line is known as a Very Short-term Credit Facility (VSTF), and was conducted through the European Monetary Cooperation Fund (EMCF) which was established in 1973, but now is conducted through the European Monetary Institute (EMI). All amounts granted and the interest payable on amounts granted from the EMI are expressed in ECU, thus there is a sharing of the exchange rate risk between the two monetary authorities concerned.

The fourth function of the ECU is as a reserve instrument and a means of settlement between monetary authorities. Since the inception of the EMS, participants have deposited 20 per cent of their gold reserves and 20 per cent of their dollar reserves with the EMI (or its predecessor). In exchange, the EMI credits participating countries with ECUs, created by the use of 3-month revolving swaps in the case of the dollar deposits, and otherwise by the sale of gold. Clearly then, the creation of ECU deposits, as Micossi (1985) points out, is related to the level of dollar reserves, the dollar exchange rate against European currencies and the price of gold. Interest only becomes receivable on these credits when Member States use their ECU credits for payment purposes. The rate of interest charged on ECU credits is set as a weighted average of the discount rate of each country with a weight in the ECU.

Apart from the VSTF financing facility described above, there are two other financing mechanisms available in the EMS: the Short Term Monetary Support (STMS) and the Medium Term Financial Assistance (MTFA) mechanisms. As noted above,the VSTF is meant to provide unlimited financing for marginal intervention. The STMS is meant to provide financing for Member

States when they experience transitory difficulties with balance of payments problems. The STMS requires that Member States deposit a specified quota into a fund, and then the monetary authority concerned is permitted to draw on a yearly maximum of 90 per cent of the quota (except in "special circumstances"). The MTFA is designed to provide longer term financing.

The Divergence Indicator

A discussion regarding the workings of the EMS would not be complete without consideration of the divergence indicator. The divergence indicator was introduced into the EMS as a result of a compromise. As the above sections suggest, when a composite currency is introduced into an adjustable peg exchange rate system, there is a choice between using either the bilateral parity grid or the ECU parities to determine when corrective action becomes necessary. When the EMS was first launched as an idea (by the EC Monetary Committee in 1976), it was stated that "the ECU will be at the centre of the system". In the negotiations which established the EMS, the French interpreted this as implying that the intervention obligation would be defined in relation to the average of European currencies in the form of divergence from the ECU parities. This would place the burden of intervention upon the currency that diverged most from the European average, thus, the French argued, promoting convergence. The Bundesbank, however, argued for intervention based on divergence around the bilateral parity grid, on the basis that the complexity of using the ECU to define intervention limits would be too complex and unwieldy. Joined by the Dutch and the Danes, the Germans also argued against "any triggering of mandatory interventions by movements in a currency's ECU rate" because of the perceived inflationary impact of such rules. "It was clear that the DM was prone to diverge upwards and that an ECU-based system would push Germany more often to the front line of intervention with unfortunate consequences for monetary stability". (Quotes from Thygesen (1979)). After lengthy debates (described in detail in Ludlow (1982)), a compromise was proposed by the Belgians, which superimposed the 'presumption of action' associated with triggering the divergence indicator with the discipline (carried over from the "snake") of the obligations based on the bilateral parity grid. The Bundesbank was still not entirely in favour of Germany joining the EMS, because of its unease at the possibility of being forced to compromise its unerring commitment to domestic price stability. Politically, the central bank was concerned that as the decision to join the EMS lay with the German Finance Ministry, the government might be indirectly attempting to reduce the monetary autonomy of the Bundesbank. Only after a visit by Chancellor Schmidt to the Bundesbank Council was the German opposition overcome, and the Germans conceded by adopting the Belgian compromise in December 1978.

In fact, the EMS has ended up functioning around the bilateral parity grid, not only because triggering the indicator carries no obligations, but also because the indicator was flawed. Spaventa (1982) first showed this flaw by demonstrating that two currencies can reach their bilateral margin before either reaches its threshold of divergence. Spaventa also showed that if two currencies are positioned at their bilateral margin without either having reached their divergence threshold, a third currency, though keeping within its bilateral margins, may reach its threshold.

To illustrate why the divergence indicator is viewed as flawed as a policy indicator, the example given in Salop (1981) is followed. Currency x and currency y have reached their bilateral 2.25 per cent margin, but their divergence from all other currencies is less than 2.25 per cent. From the equation above, the value of the divergence indicator for currency x is:-

$$a^x = 2.25\ w^y + b^x(1 - w^x - w^y) \qquad (1.3)$$

where b^x is the weighted average of the divergence of currency x from the central parity versus other currencies. To find the value of b^x for which $a^x = a^{x*}$, the threshold value, first obtain b^{x*}:-

$$b^{x*} = 2.25(0.75 - \frac{0.25w^y}{(1 - w^x - w^y)}) \qquad (1.4)$$

It can easily be seen that for every value of w^y, b^{x*} is a decreasing function of w^x. By symmetry, the same argument would apply for currency y. Using the above expression the ratio of the average deviations of the two currencies can be computed with respect to the rest of the system, where both currencies are at their respective thresholds:-

$$\frac{b^{x*}}{b^{y*}} = \frac{1 - w^y/\beta}{1 - w^x/\beta} \tag{1.5}$$

where $\beta = 3(1 - w^x - w^y)$. Now consider the above ratio for two countries of considerably different size. The larger the relative size of country x, the larger is the left-hand side of this equation, so the larger is the deviation allowed for currency x relative to the other currencies in the system before the two divergence indicators cross their respective thresholds. Thus there is an asymmetry in the treatment for currencies with different weights in the ECU.

Another problem with the divergence indicator was highlighted by Salop (1978). From its inception, the EMS has had a core of currencies which tend to move in tandem with the Deutschemark (DM) - often labelled the DM bloc. Assume that the two currencies x and y have currency 'allies' in the system that tend to move in tandem with these currencies. Let $\hat{w}^x$ be the weight of country x's allies in the ECU basket and let $\hat{w}^y$ be the weight of country y's allies (for convenience sake only - in fact non-DM bloc currencies have tended to operate independently). Suppose that currency x moves by α% against currency y but stays constant against its own allies. Then the divergence registered by x will be:-

$$a^x = \alpha(w^y + \hat{w}^y) \tag{1.6}$$

and to penetrate the threshold of divergence, then:-

$$\alpha(w^y + \hat{w}^y) \geq 0.75(\ 2.25\ (1 - w^x)) \tag{1.7}$$

Now, by substituting $(w^y + \hat{w}^y + \hat{w}^x)$ for $(1 - w^x)$, we obtain the condition for α as:-

$$\alpha \geq 0.75 \left(2.25 \left(1 + \frac{\hat{w}^x}{(w^y + \hat{w}^y)} \right) \right) \qquad (1.8)$$

So for this condition to hold, then the threshold will be crossed, if at all, by the member of the currency group that has x as a member with the smallest weight for $\left(\frac{\hat{w}^x}{(w^y + \hat{w}^y)}\right)$, that is the currency with the largest value of w (here assumed to be currency x). If 2.25 per cent is now substituted for α in the above equation then this condition simplifies to:-

$$w^y + \hat{w}^y \geq 3\hat{w}^x \qquad (1.9)$$

So, x's divergence threshold can only be penetrated if the combined weight of y plus its allies in the ECU is at least 3 times the weight of x's allies. This idiosyncrasy in the divergence indicator, together with the other flaws described above, have limited its use as a policy indicator in the EMS.

Lastly, it should be noted that whilst several currencies in the EMS (with weights in the ECU basket) remained outside the ERM (as did UK sterling until October 1990), any divergence indicator, however well designed, would be inappropriate for a binding policy indicator. This phenomena is accentuated, the smaller the subgroup of currencies participating in the ERM compared to the number of currencies included in the ECU.

Realignments in the EMS

One of the frequently cited problems with the Bretton Woods system was that realignments were problematic, in that they were neither automatic on request nor decided on a multilateral basis. Requests to realign were considered by the IMF, which often meant considerable delays, with consequent speculation in the foreign exchange market, and other members were not consulted as to the magnitude of realignments leading to an incentive to use realignments to gain a competitive advantage in the system. In the 'snake', the magnitude of realignments was essentially decided by the Bundesbank, often resulting in currencies leaving the system. On the part of the more inflation-prone countries of the 'snake', realignments were seen as an escape route to attain an improved balance on the external account and greater competitiveness. As control of inflation became a policy priority in the late 1970s, these countries began to favour domestic policy adjustment rather than devaluing or depreciating their currencies. As Thygesen (1979) made clear, if the EMS was to be successful it "must imply above all a willingness to make exchange-rate policy increasingly a matter for joint decision and to use that policy instrument less than in the past". The basic underlying economic reason for all realignments has been the inflation-rate differential. In 1978, Germany's inflation rate was the lowest in the EEC at 2.7 per cent, whereas Italy's inflation rate was 12.1 per cent. This 9.4 per cent inflation rate differential on the eve of the inception of the EMS implied that if the system were to survive, realignments would indeed be necessary, at least in the early years of its operation.

There were no specific procedures adopted for realignments when the EMS was first established. Indeed, legally, the provisions incorporated were identical to those incorporated in the snake. The first realignment of the EMS in September 1979, was very similar to the pattern established under the 'snake'. Germany called a meeting and presented a 'fait accompli' by informing the other participants of the new parities against the ECU. The next two realignments were unilateral in nature, with Denmark and Italy devaluing in November 1979 and March 1981 respectively. From this point on, though, realignment meetings became multilateral in nature, with most participants compromising their requests in the light of the views of other members of the system. It is in this regard that Padoa Schioppa (1985) made the distinction between ad-hoc cooperation and institutionalised cooperation. The former consists of discussions between the interested parties, but joint action is taken only if agreement is reached, and the latter consists of discussions where decisions and actions are taken at the multi-country level, even when there is not unanimous agreement. Clearly the snake was characterised by ad-hoc cooperation, whereas the EMS has, since its third realignment, been characterised by institutionalised cooperation.

To date, as table 1.3 documents, there have been 18 realignments of the EMS, with 7 of these realignments occurring within the first five years of its' establishment. Only 4 realignments occurred during the period 1984-89, with the frequency of realignment falling markedly towards the end of this period (only 1 realignment occurred in the period 1987-89).

TABLE 1.3

Realignments of the ERM of the EMS

Date	Bfr	Dkr	DM	Ffr	I£	Il	Hfl	Spta	Pesc
24.09.79	-0.97	-3.80	+1.01	-0.97	-0.97	-0.97	-0.97		
30.11.79	+0.14	-4.63	+0.14	+0.14	+0.14	+0.14	+0.14		
23.03.81	-2.47	-2.47	-2.47	-2.47	-2.47	-8.32	-2.47		
05.10.81	+0.10	+0.10	+5.61	-2.90	+0.10	-2.90	+5.61		
22.02.82	-8.81	-3.33	-0.34	-0.34	-0.34	-0.34	-0.34		
14.06.82	-0.61	-0.61	+3.61	-6.32	-0.61	-3.34	+3.61		
21.03.83	+1.36	+2.36	+5.36	-2.63	-3.63	-2.63	+3.36		
18.05.83	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19		
22.07.85	+0.15	+0.15	+0.15	+0.15	+0.15	-7.70	+0.15		
07.04.86	+2.65	+2.65	+4.68	-1.42	+1.63	+1.63	+4.68		
04.08.86	+1.30	+1.30	+1.30	+1.30	-6.80	+1.30	+1.30		
12.01.87	+1.54	-0.45	+2.54	-0.45	-0.45	-0.45	+2.54		
08.01.90	+0.69	+0.69	+0.69	+0.69	+0.69	-3.01	+0.69	+0.69	
08.10.90	-0.55	-0.55	-0.55	-0.55	-0.55	-0.56	-0.55	-0.56	
14.09.92	+0.01	+0.01	+0.01	+0.01	+0.01	-6.40	+0.01	+0.01	
17.09.92	+0.00	+0.00	+0.00	+0.00	+0.00	(+0.0)	+0.00	-5.30	+0.00
23.11.92	+3.16	+3.16	+3.16	+3.16	+3.16	(-3.58)	+3.16	-3.03	-3.03
01.02.93	+0.01	+0.01	+0.01	+0.01	-10.15	(+0.01)	+0.01	+0.01	+0.01

Source: Table 14, Statistische Beihefte zu den Monatsberichten der Deutschen Bundesbank, Nr. 5 - Reihe Die Währungen der Welt: November, 1991; and
Table 51, European Economy No. 54, Annual Economic Report, 1993.

Notes:
1. All figures are % changes against the ECU central parities.
2. + = revaluation; - = devaluation against the ECU.
3. The following currency abbreviations are used:-
   Bfr = Belgian franc, Dkr = Danish krona,
   DM = Deutschemark, Ffr = French franc,
   I£ = Irish punt, Il = Italian lira,
   Hfl = Dutch guilder, Spta = Spanish peseta,
   Pesc = Portuguese escudo.
4. Parentheses indicates a notional ECU rate as the currency left the ERM.

The reader will note that Table 1.3 details 18 realignments rather than the 16 claimed in the preceding paragraph. This is because certain realignments took place (for example in May 1983 and October 1990) for extraordinary events. In May 1983, the notional central rate of UK sterling was revalued and the other central rates devalued as part of an adjustment to arrive at new common agricultural prices. In October 1990, UK sterling joined the ERM of the EMS and so the ECU was adjusted to reflect the level of sterling at the time of entry. In these cases, no change in bilateral central rates and intervention limits of participating currencies occurred. Hence only 16 realignments have occurred up to the beginning of 1993 which have altered the bilateral parity rates between member currencies.

To evaluate the extent of bilateral realignments in the ERM of the EMS, it is instructive to reconstruct Table 1.3 for bilateral adjustments against the DM, as the DM has been the strongest currency in the EMS. Table 1.4 shows the results of this exercise.

TABLE 1.4

Bilateral Realignments of the ERM of the EMS vs. the DM

Date	Bfr	Dkr	Ffr	I£	Il	Hfl	Spta	Pesc
24.09.79	2.0	5.0	2.0	2.0	2.0	2.0		
30.11.79		5.0						
23.03.81					6.4			
05.10.81	5.5	5.5	8.8	5.5	8.8			
22.02.82	9.3	3.1						
14.06.82	4.3	4.3	10.6	4.3	7.2			
21.03.83	3.9	2.9	8.2	9.3	8.2	1.9		
22.07.85					8.5			
07.04.86	2.0	2.0	6.2	3.0	3.0			
04.08.86				8.7				
12.01.87	1.0	3.0	3.0	3.0	3.0			
08.01.90					3.8			
14.09.92					7.0			
17.09.92							5.0	
23.11.92							6.0	6.0
01.02.93				10.0				

Source: Table 14, Statistische Beihefte zu den Monatsberichten der Deutschen Bundesbank, Nr. 5 - Reihe Die Währungen der Welt: November, 1991.
Table 51, European Economy No. 54, Annual Economic Report, 1993.

Notes: 1. All figures are % changes against the DM bilateral central parities.
2. All figures are devaluations against the DM.

Table 1.4 shows that in the realignments, the Italian lira had the greatest frequency of devaluations against the DM, with a total cumulative devaluation of 45.9 per cent in the bilateral central parity: conversely the Dutch guilder has had the smallest cumulative devaluation against the DM, with only a value of 3.8 per cent for the total cumulative devaluation. Also noteworthy are the realignments where only one currency has altered its bilateral central rate against the DM - 8 out of the 16 bilateral realignments were of this nature. In other words, in the 14 years since the inception of the ERM of the EMS, only 8 general (non country-specific) realignments of bilateral central rates has taken place, an average of one realignment every two years.

Recent Developments in the EMS

Several important developments have taken place since the inception of the EMS in March 1979. These are as follows:-

i) The Nyborg Agreement of 1987;

ii) The merging of the MTFS and the Community Loan mechanism;

iii) The liberalisation of capital controls in 1993;

iv) The additional membership of the ERM of Spain and Portugal.

v) The currency turbulence of 1992 and the widening of the fluctuation bands to +/-15% in 1993.

The 'Nyborg' (also known as the 'Basle' or 'Basle-Nyborg') Agreement of 1987 sought to bolster the facilities available to member states to defend their fluctuation bands both against the ECU and on a bilateral basis. Marginal intervention occurs when two currencies reach their bilateral margins, and is compulsory. Intra-marginal marginal intervention can occur before the outer limits of the bilateral band have been reached. Before the Nyborg Agreement, such intervention was not actively supported by any automatic borrowing facilities. In the agreement, the Very Short Term Financing (VSTF) facility was extended to cover intra-marginal intervention, with limits set as twice the debtor quota, the duration of such financing was extended from 2.5 months to 3.5 months, and payments can be made completely in ECU if desired (previously, payments in ECU were limited to 50% of the total amount). Such intervention cannot take place without the prior consent of the central bank whose currency is being used in the intervention, but in practice permission has rarely been refused. Further, VSTF loans can, in exceptional circumstances, be carried over for up to another six months.

Also in the same year, but under a different agreement (see Commission of the European Communities COM(88)0279 Final), the Medium Term Financial Assistance (MTFS) facility and the Community Loan Mechanism were merged into a single facility. MTFS loans are now to be repaid in installments, and the effective financing capacity of loans is expanded by increasing the amounts of loans financable by EU borrowings on the capital markets by 75%. Further, the direct contributions to the EMI of all member states may be called upon as a last resort, with the European Council making this decision, rather than the monetary authority whose contribution was being borrowed (as happened pre-1987). The ceiling on the total amount of MTFS loans outstanding at any time cannot exceed ECU16 billion. The MTFS can now be provided quickly, especially when action is necessary to provide medium term finance for member states experiencing balance of payments difficulties.

The liberalisation of capital flows in the EMS has been a by-product of the Single European Act (or SEA). The 1988 Capital

Liberalisation Directive was enacted to ensure that there would be free mobility of capital in the EC by the end of 1992. The legislation provides for a modest reversal of this situation if a foreign exchange crisis conspired to cause exchange rate instability. To date, most EU Member States have successfully removed all remaining foreign exchange controls, Belgium has scrapped its dual exchange rate system and Portugal and Greece have both dismantled the vast majority of their previous restrictions.

The effects of capital liberalisation appeared to have provided an enhancement of credibility for the system as a whole. Interestingly, arguments as to the fate of the system under free capital mobility mirrors a debate which took place in the early 1970s in Europe concerning the economic nature of the EEC at that time. Those advocating free capital mobility, thought that the act of liberalisation in itself would enhance the credibility of the system as a whole (they were labelled the 'monetarists' in the 1970s), confounding many, who only recently had forecast that southern European countries would experience considerable problems when exchange controls were lifted (this group was confusingly labelled the 'economists' in the 1970s debate). Now, only Portugal and Greece retain any form of control on the mobility of capital. De Grauwe (1990) speculated that there would be a subtle interaction between capital mobility and monetary policy cooperation, in that the latter is necessary to allow capital to move more freely. Perhaps then, the 1992 ERM crisis was indicative of the lack of the lack of monetary coordination in the EU.

In the late 1980s the EMS saw a broadening of the membership of the ERM of the EMS to several key currencies. Firstly, Spain's surprise membership of the ERM of the EMS occurred on the 19 June, 1989, with the peseta opting for a wider 6 per cent margin of fluctuation. Membership of the ERM caused surprising developments in the Spanish balance of payments, with large inflows of capital into Spain in the early 1990s keeping the peseta towards the upper end of its fluctuation band. The Portuguese escudo followed suit, entering with a wide (+/- 6 per cent) band on 6 April, 1992. Perhaps most controversially, membership of UK sterling occurred on the 8 October 1990, after a prolonged and at times, bitter debate in the UK, ensuring that all major European currencies are members of the ERM. Unfortunately UK sterling and the Italian lira left the ERM on 17 September 1992. Only the Greek drachma, Italian lira and UK sterling were left outside the ERM of the EMS as of the beginning of 1995.

The ERM currency crisis of 1992 brought to an end the period of tranquility that had begun in 1987. Concerns about various referenda taking place in EU Member States to ratify the Maastricht Treaty (1991) on economic and monetary union (EMU) triggered several speculative attacks, which resulted in massive intervention on the part of the Bank of England, the Banque de France and the Bank of Spain (among others) to support their currencies. A domino effect emerged where speculative attacks focused on the weakest currency in the ERM and then moved to the next weakest currency. On what has been called "Black Wednesday" (September 17, 1992), the UK and Italian governments decided to withdraw their currencies from the ERM. Other speculative attacks were rebuffed, or realignments were quickly negotiated. In August 1993, the narrow margins were abandoned (with the exception of the German mark and the Dutch guilder) and wide +/- 15 per cent margins of fluctuations were adopted.

III. Europe's Economic Performance in the 1980s

Several studies have attempted to evaluate the economic achievements, if any, of the ERM of the EMS. The major problem that researchers encounter in such an evaluation, is separating out those effects which can be genuinely attributed to the ERM of the EMS, and those effects which emanate from the international economy (such as the business cycle, the effects of oil shocks etc.). The evidence from an IMF study by Ungerer et al (1986) suggested that membership of the ERM of the EMS helped inflation-prone countries to reduce their inflation rates more quickly (towards that of the then West Germany) than if they remained outside the system. As Collins (1988) points out, however, many other non-EMS countries (whether they tied their currency to the DM or not) experienced a lowering of inflation rates, and the Ungerer et al results were not statistically significant. Table 1.5 shows some aggregate inflation rates for EMS and non-EMS countries.

TABLE 1.5

Price Deflator - GDP at Market Prices

Years		B	DK	D	E	F	IRL	I	NL	UK	E12	US	J
1961-70:	μ	3.4	6.4	3.7	6.4	4.4	5.5	4.5	5.2	4.2	4.4	3.0	5.4
	σ	1.3	1.2	1.7	2.3	1.4	2.9	2.3	1.8	1.5	1.7	1.7	1.1
1971-80:	μ	7.[illegible]	[illegible].7	5.3	15.2	9.9	13.8	14.8	7.6	14.0	11.0	7.4	7.6
	σ	3.1	1.9	1.5	4.8	2.1	4.4	4.9	2.1	5.9	2.5	1.8	5
1981-90:	μ	4.4	5.8	2.8	9.3	6.3	7.2	10.4	2.3	6.5	6.8	4.2	1.[illegible]
	σ	1.7	2.7	0.9	2.9	3.5	5.4	4.8	2.0	2.3	2.4	2.2	0.9
1991		2.7	2.9	4.2	6.6	3.1	1.2	7.3	3.0	6.7	5.4	4.0	1.9
1992		3.6	2.5	5.3	6.3	2.9	2.9	5.2	2.7	4.6	4.8	2.6	1.9
1993		3.1	1.7	4.3	4.7	2.9	2.3	4.5	2.8	3.4	4.0	2.6	1.8

Source: European Economy No. 54, 1993, Annual Report, Table 23 (published by the Commission of the European Communities).

Notes: 1. B = Belgium, DK = Denmark, D = West Germany, E = Spain, F = France, IRL = Ireland, I = Italy, NL = Netherlands, UK = United Kingdom, E12 = above plus Greece, Luxembourg and Portugal, US = USA, J = Japan.
2. Standard deviations are calculated using annual inflation rates.
3. The figures for 1993 are estimates.

As Collins (1988) points out, the figures show no significant reduction in inflation rates in the EMS until 1983-86, and also the non-EMS figures are lower (both in mean and standard deviation). Thus table 1.5 neither confirms nor refutes the hypothesis that inflation rates were lower as a result of the EMS, and if anything suggests higher and more volatile rates than in the US or Japan. Note also that convergence in inflation rates between the European countries has lowered the range of inflation rates from 9.9 per cent in the 1970s to 8.1 per cent in the 1980s - in fact by 1990 the range had been reduced to 6.8 per cent.

But economic performance of the European countries may have been enhanced in other ways, perhaps by higher and more consistent growth levels. Table 1.6 documents real GDP growth.

<u>TABLE 1.6</u>

<u>GDP at constant market prices</u>

Years		B	DK	D	E	F	IRL	I	NL	UK	E12	US	J
1961-70:	μ	4.9	4.5	4.5	7.3	5.5	4.2	5.7	5.1	2.9	4.8	3.8	10.5
	σ	1.3	2.5	2.2	2.4	0.9	2.2	1.6	1.7	1.3	0.8	1.9	2.2
1971-80:	μ	3.2	2.2	2.7	3.5	3.2	4.7	3.8	2.9	1.9	3.0	2.7	4.6
	σ	2.4	2.5	2.2	2.9	1.7	2.1	2.9	1.7	2.9	2.0	2.5	2.7
1981-90:	μ	2.0	2.1	2.1	2.9	2.2	3.1	2.3	1.8	2.6	2.3	2.9	4.3
	σ	1.7	1.8	1.6	1.9	0.9	2.2	1.2	1.8	1.9	1.1	2.5	1.1
1991		1.9	1.2	3.7	2.4	1.1	2.5	1.4	2.2	-2.2	1.4	-1.3	4.4
1992		1.0	1.0	1.9	1.2	1.9	2.9	1.1	1.3	-0.9	1.2	2.0	1.5
1993		0.5	1.8	0.0	1.0	1.0	2.1	0.8	0.6	1.4	0.8	2.4	1.5

Source: European Economy No. 54, 1993, Annual Report, Table 10 (published by the Commission of the European Communities).

Notes: 1. Country symbols as in table 1.5.
2. Standard deviations are calculated using annual growth rates.
3. The figures for 1993 are estimates.

Table 1.6 shows that the GDP growth figures for European countries were consistently below that of both previous decades - and only in the US did the average growth rates increase from the 1970s to the 1980s. Interestingly though, even though the growth rate was lower in Europe than in the US, it was more consistent in Europe than in the US. Again, note the convergence in growth rates in Europe - in the 1970s the range in rates was 2.8 per cent, whereas in the 1980s, the range was 1.3 per cent. The issue of convergence, since the signing of the Maastricht agreement to move to a single currency, has taken on added importance in Europe, as convergence in economic performance is seen as a major factor in allowing monetary policy to be decided upon by a single European central bank. If economic performance has not converged by the time that there is widespread introduction of the single currency (the ECU) to replace national currencies, then the concern is that individual member states may not be able to use fiscal policy to restore balanced growth without undermining the credibility of the ECU.

Next, in order to evaluate whether the EMS has had a restraining influence on monetary policies, annual increases in money supply are tabulated in table 1.7 below.

<u>TABLE 1.7</u>

<u>Money Supply (M2/M3)</u>

Years	B/L	DK	D	E	F	IRL	I	NL	UK	E12	US	J
1961-: μ	8.6	8.0	10.4	na	12.7	10.4	14.1	9.1	na	na	7.2	18.3
1970 σ	1.3	3.0	1.5	na	3.7	3.5	1.5	3.0	na	na	1.7	2.7
1971-: μ	12.4	10.2	9.8	20.4	14.8	19.0	19.7	11.0	15.6	15.1	10.1	15.7
1980 σ	3.4	5.1	2.8	2.7	2.9	5.1	3.6	7.7	4.2	2.1	3.0	5.2
1981-: μ	8.2	11.2	5.6	15.3	9.8	8.8	10.7	8.3	15.3	10.4	7.5	9.2
1990 σ	1.9	6.9	0.8	2.1	2.0	5.6	2.8	3.4	3.0	1.1	2.9	1.7
1991	5.3	6.4	6.3	10.9	2.5	3.1	9.0	4.7	5.8	6.5	3.0	2.3

Source: European Economy No. 54, 1993, Annual Report, Table 46 (published by the Commission of the European Communities).

Notes: 1. Country symbols as in table 1.5, except B/L = Belgium and Luxembourg.
2. Standard deviations are calculated using annual growth rates.
3. Money supply definitions are as follows: B/L: M2N, DK: M2, D: M3, E: ALP, F: M3R, IRL: M3, I: M2N, NL:M2N, UK: M4, US: M2, J: M2+CDs, E12: chain-weighted arithmetic mean, using GDP as weights.

The table shows that the general trend in Europe was for the rate of increase in money supply to rise from the 1960s to the 1970s, but then to fall in the 1980s to below the average level of growth achieved in the 1960s. Denmark and Germany, as well as the U.S. appear to be exceptions to this rule, although in the latter half of the 1980s Denmark's money growth rate was consistently below 9.0 per cent, and Germany's rate has been on a long-run downward trend. In the U.S., money supply growth fell to remarkably low levels in the late 1980s, which led to calls, in some quarters, for an expansionary fiscal stimulus. As for the extent of convergence in money supply growth rates in Europe, the range narrowed only slightly, from 10.6 per cent in the 1970s to 9.5 per cent in the 1980s (the figure for 1990 was also 9.5 per cent).

The variability of growth rates in money supply shows no clear consistency in Europe, but with the exception of Ireland and Denmark, however, standard deviations fell between the 1970s and the 1980s. It is interesting to note that the standard deviation for the U.S., where monetary targeting was abandoned fairly early on in the 1980s, has not changed much between the two decades, but in Europe and Japan, where monetary targeting is taken more seriously, standard deviations have tended to fall.

Other performance indicators have not been tabulated because of inter and intra-data compatibility problems. In general though, short term interest rates rose in Europe and the U.S. between the 1970s and the 1980s, with weaker EMS members tending to experience larger increases between the two decades. As exchange rate policy was the primary objective in Europe during the 1980s, this may explain the lower average rates of growth experienced in comparison with the U.S. and Japan. Japan bucked the trend in interest rates, experiencing lower short-term interest rates on average in the 1980s than in the 1970s.

German reunification in 1990 also had a profound effect on the EU. Germany's sudden pre-occupation with former East Germany and the fiscal stimulus that accompanied reunification led to increased interest rates in Germany, and through the ERM, in the Member States whose currencies were members of the mechanism. Furthermore, the international business cycle turned down at the end of the 1980s causing lower growth throughout the EU, but most particularly in the U.K. where the recession was severe.

IV. A Brief Overview of the Academic Literature

Several salient points about the literature need to be made at the outset. The main thrust of the literature has been to establish the extent to which the ERM has contributed to greater monetary stability within Europe, and by extension to establish the desirability, or otherwise, of EMU. The literature itself has three strands - one that attempts to fill the gap in the theoretical international economics literature between fixed and floating exchange rate regimes - one that takes a more empirical stance which attempts to address such questions as whether the EMS is a greater Deutschemark zone, and whether it is possible to explain and quantify the benefits of membership of the system -

and one that explores the approach to, and potential benefits from, EMU. Further, because the system has only been in existence for 15 years, statistical and econometric analysis was only possible after the mid-1980s, and in any case, only after 1985 has the system exhibited a relatively high degree of stability (measured by the frequency of realignments), which earned it the label the 'New EMS'.

Because the subject does not fall neatly into one specific area of economics, the literature employs a hybrid of various approaches to the subject, encompassing international economics theoretical models, game theory, econometrics, model simulations, trade theory and statistical theory.

The last strand of the literature, that of EMU now takes the spotlight in the general thrust of the international research program in Europe, and it is reviewed in Chapter six. A brief overview of the main elements of research on the ERM of the EMS follows.

a) The ERM's effect on Volatility

The first papers to appear in the literature on the ERM of the EMS focused on the effect of the system on stabilisation of exchange rates and interest rates. Williamson (1985) was first to make the distinction between volatility (short-term variability) and misalignment (real divergence from fundamentals) of exchange rates in the literature. Most early studies that analysed the ERM's effects on the volatility of exchange rates and interest rates used simple statistical measures of volatility (see Ungerer et al (1983), Ungerer et al (1986), Ungerer et al (1990), Padoa-Schioppa (1985) and Gros and Thygesen (1988)). Their evidence pointed to less volatility in intra-ERM rates, but more volatility between ERM and non-ERM currencies, with ambiguous results overall. Recently, several studies have attempted to account for the fact that exchange rate returns are fat-tailed and so use conditional volatility measures that take into account exchange rate uncertainty (see Artis and Taylor (1988), MacDonald and Taylor (1990) and Pesaran and Robinson (1993)). These studies tend to confirm and strengthen the results of the earlier studies. Batchelor (1983) first advanced the argument that reduced volatility of exchange rates might lead to a process of 'volatility transfer' whereby the volatility of some other macroeconomic variable, such as interest rates, rise. This hypothesis has been tested by Artis and Taylor (1988) and Ungerer et al (1986) and has not been accepted; indeed, their results indicate that most countries (after a period of time) have either displayed the same level of volatility in interest rates or lower levels of volatility. The issue of whether the ERM of the EMS has fostered more or less misalignment of exchange rates has received little attention in the literature, partly because of the continuing debate as to the reference point from which misalignment should be measured.

b) Exchange Rate Behaviour in a Target Zone

The apparent success of the ERM of the EMS in fostering a reduction in exchange rate uncertainty and the convergence in monetary policy led to the emergence of a strand of the literature which aimed to understand the behaviour of exchange rates within an announced target zone. Miller and Weller (1989) constructed a stochastic model based on a standard dynamic IS-LM model (see Dornbusch (1976)), and found that, assuming perfect credibility, if the money supply were fixed and the exchange rate allowed to float freely within the zone, then when and if the exchange rate hits the edge of the band, the money supply jumps without affecting the current spot exchange rate. This implies that monetary policy cannot be set independently of a targeted exchange rate zone. Miller and Weller (1991) extended their model to incorporate the case when prices adjust sluggishly to shocks in the economy and conclude that with a realignment rule that accommodates cumulative price shocks there is a change in the behaviour of the exchange rate within the target zone. Krugman (1991) obtained similar results using a different approach which uses only a minimalist monetary model of the exchange rate. Krugman found that a target zone has a stabilising effect on the exchange rate within the band (in relation to the movements of underlying fundamentals), as when the exchange rate moves toward the extremum of the band, regressive expectations that the authorities will act to defend the band tend to move the exchange rate back toward the centre of the band. With imperfect monetary authority credibility, however, the stabilising effect of the target zone is reduced. This leads to the 'honeymoon' effect when announcing an exchange rate target zone, as credibility can only be tested by the market on the first occasion that the exchange rate reaches the edge of the target zone. In this sense intra-marginal intervention may, in fact, enhance the credibility of the monetary authority, extending the 'honeymoon' period.

Froot and Obstfeld (1991) note that realignments imply exchange rate regime shifts which will invariably induce a non-stationary exchange rate. Also, with an exchange rate that follows a random walk, the unconditional distribution of the exchange rate will be bimodal, with modes towards the edge (but nevertheless within) the target zones. Also, as Buiter and Pesenti (1990) show, there is an incompatibility between the existence of a target zone and the presence of rational (non-speculative) bubbles, which leads to the finding that speculative bubbles can invalidate the Miller and Weller results.

c) Asymmetries in the ERM

In its original blueprint, the ECU was intended to act as the numeraire of the system, and it was anticipated that the divergence indicator would be a device which would place the onus of adjustment on a single country. In this sense, the system would be tied to a basket of currencies, rather than one currency, and the workings of the system would be operationally symmetric. In theory, the properties of a system of a currency baskets are fairly easy to evaluate, as shown by Asheim (1984). In fact though, over the last decade, the Deutschemark, in the *modus operandi* of the foreign exchange market, has become the *de facto* anchor for the ERM, as bilateral rates against the Deutschemark have become the dominant indicator of divergence within the system. Also, the divergence indicators have been little utilised in practice, which has led many to suggest that the system operates on an asymmetric basis. In the literature, this has been proposed as a German-dominance hypothesis (see Giavazzi and Pagano (1988) and de Grauwe (1989a)). Several studies, using a variety of econometric techniques, have attempted to test the German-dominance hypothesis, but the results have been somewhat mixed. Fratianni and von Hagen (1990) and Weber (1990) have rejected a strong form (that Germany monetary policy affects all other members but is unaffected by monetary policy of other participants) of the hypothesis, but were unable to reject any weaker forms of the hypothesis (that Germany's role is dominant, but not unique). This suggests that Germany takes a dominant role in monetary policy within the system, but is not immune to changes in monetary policies in other participating states (see MacDonald and Taylor (1990) and Weber (1990)). Two schools of thought have emerged as to why such asymmetries have arisen. The first views the asymmetries as intentional, in that other ERM members have consciously decided to adopt a policy of pegging exchange rates to the Deutschemark so as to gain central bank credibility by forcing monetary policy to shadow Bundesbank monetary policy. This has been termed 'the advantage of tying one's hands' in the seminal paper by Giavazzi and Pagano (1988), and explains why some inflation-prone countries (notably Belgium, France and Ireland) have surrendered some sovereignty over monetary policy to the Bundesbank. The other school of thought has stressed the intrinsic nature of a bias towards asymmetry in adjustable-peg exchange rate systems (see Wyplosz (1989) and Mastropasqua et al (1988)). With a fixed exchange rate, those countries which build up reserves fastest will tend to be those countries following the most restrictive monetary policies and vice-versa. As currency reserves are depleted in higher inflation rate countries, the incipient pressure on the exchange rate begins to build, forcing a contractionary adjustment of monetary policy. The consequence is a convergence within such a system towards a strong currency 'standard', with the Bundesbank targeting interest rates and other ERM countries targeting foreign exchange reserves. In reality, it is unlikely that either school possesses the weightier argument, and it is generally accepted that the ERM fostered both convergence (particularly between 1985 and 1990) and a tacit acceptance of the Bundesbank's dominance in European monetary policy. This does not, however, answer the question as to why a traditionally low inflation country, such as Germany, should want to act as the lynchpin of such a system.

d) EMS Credibility

The reputational benefits from tieing nominal exchange rates to that of the member state with the highest anti-inflation credibility has been termed the 'EMS Credibility Hypothesis' (see Collins (1988) and Giavazzi and Giovannini (1988,1990)). This hypothesis directly parallels Rogoff's (1985) claim that the temptation for governments to gain one-time benefits from pursuing inflationary policies can be countered by leaving monetary policy in the hands of a conservative central bank. The effect is to lower the equilibrium level of inflation expectations by altering policy preferences of the monetary authorities.

Much of the literature in this area is set in a game-theoretic framework, but has had limited success in determining whether credibility is enhanced by adopting a fixed rather than a floating exchange rate regime. If credibility is to be gained by membership in the ERM then several conditions have to be satisfied; firstly, the system must work asymmetrically - it should be centred on a low inflation currency; secondly, the commitment to a target zone must be credible; thirdly, the credibility gap between the high and low inflation currencies must be large relative to the incentive to adopt a policy of maintaining a high nominal exchange rate policy so as to 'export' inflation (see Fratianni and von Hagen (1990) and Giavazzi (1989)). In reality, the political cost of permitting a devaluation, if sufficiently high, may lead in itself, to a higher level of credibility in an adjustable peg system (see Melitz (1988)). Testing for empirical evidence for the EMS Credibility Hypothesis has been problematic: researchers have either tried to capture shifts in agents' inflation expectations (see Giavazzi and Giovannini (1988), Kremer (1990) and Artis and Nachane (1990)) or attempted to quantify the expected lower costs (with enhanced credibility) of disinflation in terms of output lost (see De Grauwe (1989b) and Dornbusch (1989)). In general, the approach which tests for shifts in agents' inflation expectations suggests that the adjustment in expectations is only achieved as agents learn and are convinced that the policy preferences of the monetary authorities have indeed changed. Conversely, the 'cost of disinflation' approach leads to a rejection of the EMS Credibility Hypothesis in its strongest form. De Grauwe finds that ERM membership has probably lengthened the process of acquiring credibility (because of the inability to administer a 'short sharp shock'), but once acquired, credibility is more robust and sustainable under an adjustable peg system than under a floating rate regime. Most of the problems related to empirically discerning the credibility benefits of membership stem from an ability to disentangle the effects of the disinflationary environment of the 1980s from the effects of the EMS. Most studies which focus on inflation convergence reach mixed conclusions (see Artis and Nachane (1990) and Barrell et al (1990)).

More recent attempts to evaluate the successes of the EMS in terms of enhanced credibility, have focused on the possibility of a higher cost to membership of the ERM as the fostering of convergence is a once-and-for-all act. Following on from the arguments which stress the advantages of greater certainty, there may be benefits to membership from lower economic volatility in general. Robertson and Symons (1991) pose the question as to whether membership of the ERM of the EMS has meant that previously high-inflation member states have paid a higher or lower price in terms of output loss for the reduction in inflation achieved, than they otherwise would have outside the system. Using an econometric model (a fixed-effect autoregressive residual model), they evaluate this question and find that there is only weak evidence that ERM countries have paid a higher price for a given reduction in inflation than non-EMS countries. Robertson and Symons also found that member states had lower output and inflation variability once the EMS was in force, but that membership of the system increased the costs of deflation for low-inflation members and vice-versa.

Lower inflation and output variability implies convergence in economic policy within the EMS. In keeping with the original aims of the EMS ("to establish a zone of monetary stability"), MacDonald and Taylor (1990) used cointegration test procedures applied to EMS and non-EMS country groups for nominal and real exchange rates and nominal money supplies. The results suggested that long-run convergence of these variables had progressed, and that continuing convergence would, at some point, eliminate asymmetries in the system.

e) Capital Controls

Capital controls are much more likely to be introduced when the exchange rate is pegged or managed (see Alesina, Grilli and Milesi-Ferretti (1993)). Much has been made in the literature of the contribution of capital controls to the ability of high inflation countries to pursue tight domestic monetary policies. Capital controls were important during the early years of the system, as exploiting a differential between onshore and offshore interest rates allowed monetary authorities to decouple exchange rate policy from domestic monetary policy. Indeed, there is also some truth in the claim that capital controls played a significant role in the early years of the EMS by preventing capital flight when currencies reached the edge of their target zones (see de Grauwe (1989a) and Giavazzi and Giovannini (1990)). Any speculation surrounding the possibility of a realignment should be evident in the onshore-offshore interest rate differential for those countries with capital controls. Artis and Taylor (1988) show that both France and Italy experienced an increase in the volatility of the onshore-offshore interest rate differential from 1979 to 1986, which suggests that the role of capital controls was significant in fostering exchange rate stability in the EMS. Concern over the role of capital controls in the operations of the EMS led many to forecast the demise of the system once capital controls were lifted as part of European

Commission's drive towards a single European market in 1993. But in fact, in 1990, the act of removal of capital controls throughout the EU did not have any apparent adverse effects upon the operation of the EMS until the 1992 currency crisis. Indeed, in the more recent literature, little support has been found for the mutual incompatibility of fixed exchange rates, monetary independence and perfect capital mobility (see Rose (1994)).

f) The New EMS

The effects on the EMS of the liberalisation of capital controls should have narrowed the onshore-offshore interest rate differential, which Giavazzi and Spaventa (1990) have found to be the case. Also, Giavazzi and Spaventa found that the reduction in the volatility of offshore rates, post-1987, was largely responsible for the narrowing of the differential. This increased stability was probably due to several factors: firstly the enhanced credibility pertaining to the increased commitment to the EMS in terms of more stable exchange rate expectations, secondly the Basle-Nyborg Agreement (1987), which was likely beneficial to those countries which had problems in maintaining their currencies within their permitted margins of fluctuation, and thirdly, the feedback effect of domestic financial liberation which led to capital inflows seeking high (interest rate) returns. This led to upward pressure on such currencies as the peseta and the lira, and led to a reversal of the usual ERM configuration which places low inflation rate currencies towards the top of the system and high inflation rate currencies towards the bottom. Giavazzi and Spaventa (1990) speculated that this marked a new regime shift in the EMS and termed it 'The New EMS'. This new system configuration, though, had macroeconomic implications, as Artus and Dupuy (1990) noted. Currency appreciation within the ERM bands can lead to an easing of monetary policy in high inflation countries, which could cause dynamic instability. This currency appreciation has been explained as 'excessive credibility' of the system in financial markets over labour markets (labour unions will tend not to adapt quickly to the new economic policy environment, thereby maintaining relatively high wage claims), which results in a transient fall in real interest rates. In the longer term, though, as the labour force adapts to the fixed exchange rate policy environment, this argument is difficult to sustain.

g) Realignments

The frequency with which realignments have occurred, post-1985, was much reduced, but was still a political concern, particularly to high inflation countries. Padoa-Schioppa (1985) notes that within the EMS, the decision to realign is not made unilaterally, but rather by 'institutionalised cooperation'. This explains the oft-cited empirical observation that devaluing realignments are nearly always less than the request of the devaluing country. Indeed, most realignments of the ERM have been 'non-provocative', that is, the shift in the bands has been overlapping with the new band encompassing the existing market rate (see Artis (1989)). This empirical observation implies that low inflation countries take a restraining stance in discussions concerning realignments, and therefore have something to gain from possible exchange rate misalignments. Two possibilities arise: firstly low inflation countries benefit from a gain in competitiveness with their ERM partners, and secondly, there may be a desire to stabilize competitiveness in low inflation countries by imposing additional monetary policy constraints on high inflation countries. Frattianni and von Hagen (1990) also suggest that the timing of realignments is important, because they claim that if the foreign exchange market is obfuscated in its learning process, then there may be some trade- off between short-run variability and longer run uncertainty. The authors also note that in a four-week period before a realignment, the realignment was not unexpected in the foreign exchange market. They omit, though, to analyse whether failed speculative attacks occurred between realignments. Rose and Svensson (1991) take a different approach and use the uncovered interest parity condition (i.e. the interest differential equals the expected devaluation of the exchange rate) to construct a model of French franc-Deutschemark realignments based on expectations of a devaluation. The model predicts realignments with only limited success. The problem with the authors' approach lies in the empirically observed fact that with this particular cross rate, on realignment, actual devaluations are less than actual realignments of central rates, so the exchange rate jumps from the bottom of its previous band to the top of its new band. Clearly, this accounts for some 'shock' element that is not accounted for by the model. Neely (1994) reviews some of the recent econometric work in this area.

V. Conclusions

The EMS was established in 1979 as a system of semi-fixed exchange rates, with the aim of promoting a greater degree of monetary stability in Europe. The system has developed since its inception to intensify the coordination between the member states of the European community who participate in the exchange rate mechanism (ERM) of the system. In addition several new members have been added to the participants of the ERM, and several key members of the EU have suspended their membership of the mechanism after the currency turbulence experienced in recent years.

Over the last decade of operation, the ERM of the EMS has fostered convergence between the member states of the European community, in areas where cooperation has been forthcoming. Most notably, the operation and development of the system went hand in hand with the dismantling of capital controls between member states of the EU. In terms of real convergence, in the preparation for Economic and monetary union (EMU) in recent years, the trend appears to have reversed, as the economies of the EU dealt with recession and the change in the German political agenda.

Due to the fact that the development of the operational framework of the EMS has occurred spasmodically over time, the academic literature on the subject has tended to be diffuse, straddling various areas of economics. This has led to problems in determining an optimal analytic approach to studying the system in operation. Nevertheless, several conclusions from the literature appear to be unambiguous. Firstly, the system promoted a significant reduction in volatility in inter-ERM member state exchange rates. Secondly, it led relatively low inflation countries (notably Germany) within the ERM to have an impact upon the monetary policies of other ERM member states, which in turn has, until recently, encouraged economic convergence within the EU. And thirdly, the credibility of the system has challenged the foreign exchange market, in that the institutional arrangements have buttressed the system, to some degree, so as to rebuff speculative attacks.

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Chapter Two: THE NATURE OF VOLATILITY OF EXCHANGE RATES IN THE ERM OF THE EMS.

The word "volatility" can be interpreted in many ways, not only in the context in which it is used, but also to the phenomena to which it is applied. Such words as 'divergence', 'fluctuation', 'undulation', 'instability' and 'inconstancy' are sometimes utilized in an attempt to describe changes in variables. For a statistician, for instance, when considering a stable symmetric distribution, volatility might be best captured by a single measure such as the range, standard deviation or variance, or perhaps the inter-quartile ranges. To a physicist, volatility may best be characterised not only by the amplitude of fluctuation, but also by the velocity at which some object or series moves over time. Volatility for a meteorologist might be captured both by the rapidity with which weather patterns alter, and also by the extent to which conditions (such as temperature or humidity) change over a given period of time.

The belief that volatility of exchange rates is important provides the motivation for this chapter. It may be important, not just because it may affect trade flows, but also because it affects governments, to the extent that they seek ways in which to restrain foreign exchange movements when they are deemed undesirable. Furthermore, within the foreign exchange market itself, volatility has been an important (if not the most important) factor in the rapid development of derivative markets in exchange rates. Such derivative markets have sought to reduce exposure to foreign exchange rate risk, as well as central bank and government policy uncertainties associated with international trade and investment. These risks and uncertainties can differ in their nature and effects on market behaviour, but are undoubtedly to a large degree contingent on the exchange rate regime in effect at any given point in time. The exchange rate regime and its effects on volatility is therefore the focus of this chapter.

This chapter is devoted to the study of the volatility of exchange rates, with particular emphasis on the behaviour of exchange rate fluctuations pre- and post-inception of the EMS. Part I discusses the concept of volatility as applied to economic time series; then in part II the volatility of exchange rates is considered, in terms of its effects on the rest of the economy. Part III presents a review of the literature concerning exchange rate distributions and part IV provides a statistical description of the data under consideration. Part V is devoted to testing for a structural changes in volatility post-1979. Part VI concludes.

I. The Nature of Volatility in Economic Time Series

a) Volatility and Economic Behaviour

Volatility is not an easily defined concept. In the financial markets, volatility normally refers to the extent to which a time series fluctuates from a given reference point (such as the mean or median) or reference trajectory. If the trajectory is determined by economic fundamentals, volatility has been measured by any departures from this trajectory which are not warranted by the fundamentals pre-supposed to determine the trajectory. In the case of fluctuations from a reference point, volatility has often been characterised by the standard deviation or variance of the series. Then, under certain conditions (such as there being no tendency for the mean to change through time and the distribution of changes from the mean not altering through time), the sample standard deviation (or variance) measure might appear most suitable (- indeed, if it exists).

In econometrics, it is often assumed that there exists some process that generates the observed data, which then allows the econometrician to appeal to some underlying distribution (or assumed stochastic process) to facilitate using a specific applied technique to illustrate and capture the dynamic properties of the series. The most commonly-made distributional assumption is that of normality, which implies symmetry, with a stable mean and variance and a certain degree of peakedness and fatness of tails. But many financial and economic time series do not seem to possess all of these properties, or perhaps any of them! If such a situation arises, then any empirical analysis will be severely weakened by an incorrect distributional assumption. Even if the assumption of normality is correct, the sample standard deviation may fail to capture the 'restlessness' or velocity of change of the series in question and cannot capture qualitative aspects of volatility, such as the intensity level of the volatility (high frequency or low frequency). In this sense, even if the particular distributional assumptions are valid, the standard deviation or variance of an empirical distribution might be considered inadequate to reflect a given definition of volatility.

There are other problems associated with this probabilistic approach. If a specific distribution is chosen to represent the data-generating process, but the parameters of the empirical distribution change through time (continuously or discretely), then the researcher must allow for the parameters of the modelling distribution to also change through time for the assumption to be valid. This non-constancy can also limit the usefulness of using measures such as the standard deviation or variance to show the volatility of a time series, although time-varying parameter models (such as Autoregressive Conditional Heteroskedastic Models - ARCH or Generalised ARCH, known as GARCH) may be appropriate.

If one rejects the notion of a single underlying distributional data-generating process, then other alternatives for the bases of analysis exist, such as reliance on chaotic, or non-linear deterministic and stochastic generators. Work by Hsieh (1989) and others, for example, suggests that exchange rate changes might indeed be nonlinear because of changing variances.

In contrast with much ongoing research in non-linear dynamics, it may be that for many economic and financial time series, non-reversible path-dependent switching between various data-generating processes may best characterise these phenomena. This behaviour may be due to institutional changes or event-related reactions in the market-place, which in turn affect the series in a specific way. This path-dependent switching may or may not be determinable, *ex ante*, but once the impact has affected the series, could possibly be predictable, *ex post*.

Thus the question as to what is the best way to represent an economic or financial series is difficult to resolve. Perhaps it is foolhardy to believe that any series can be adequately represented by some notional process, as it could be claimed that economic variables are mostly behavioural in nature. In this vein, it might be that psychology or sociology has more to offer in explaining the behaviour of the financial markets rather than a statistically-based approach.

It is worth noting at this juncture that to a great extent, the financial markets are not operating under any pretense of obeying any economic theory or hypothesis relating to the functioning of these markets. Moreover, this could be perceived as the main weakness of economics as a social science - the inability to simultaneously incorporate all contingencies and facets of human economic behaviour. This view would apparently belittle the influence of economic fundamentals on the financial markets, but other factors inevitably play a leading role in determining the actions of market agents.

Indeed, as markets are only collections of agents or firms, for the most part, the financial markets are fickle (if not non-rational), to say the least. Following this logic, agents are more likely to operate from a perspective of collective market psychology than from economic fundamentals or other 'rational' considerations. In this vein, Schiller (1989) notes that excess volatility (i.e. greater volatility than fundamentals would dictate) most likely results from what he denotes as 'popular models'. These models are not systems of equations, but rather, are models or views of the economy held by the general public (or subgroups of the general public e.g. market traders). These 'models' consist of qualitative information, anecdotal evidence, posited correlations, consensus descriptions relating to the causes of specific events, and at the most simple level, trend extrapolations. Davidson (1985) shows that the excess volatility phenomenon is indeed the case with exchange rates, and a whole area of the literature has been devoted to explaining this, being broadly classified as the speculative bubble approach.

b) <u>Stationarity and the Characterisation of Economic Processes</u>

Before assuming a specific data-generating process it is important to know whether the series exhibits stationarity. The concept of stationarity has been a key concept in the analysis of time series in recent years, but originates from the School of Russian Probabilists (such as Slutsky (1927)).

A stochastic process $\{X(t), t\in\mathbb{T}\}$ is said to be (strictly) stationary if for any subset $(t_1, t_2, \ldots, t_n)$ of $\mathbb{T}$ and any τ,

$$F(X(t_1),\ldots,X(t_n)) = F(X(t_1+\tau),\ldots,X(t_n+\tau)) \tag{2.1}$$

so that the distribution function, $F(X(t))$, of the process remains unchanged when shifted in time by an arbitrary value τ. Usually, econometricians appeal to a weaker form of stationarity, known as second-order stationarity. $\{X(t), t\in\mathbb{T}\}$ is said to be (weakly) stationary if $E(|X(t)|^2) < \infty$ for all $T\in\mathbb{T}$ and:-

$$E[X(t)] = E[X(t+\tau)] = \mu_1 \tag{2.2}$$

$$E[\{X(t)\}^2] = E[\{X(t+\tau)\}^2] = \mu_2 \quad \text{and} \tag{2.3}$$

$$E[\{X(t_1)\}\{X(t_2)\}] = E[\{X(t_1+\tau)\}\{X(t_2+\tau)\}] \tag{2.4}$$

which implies that the mean and variance of $X(t)$ are constant and the covariance only depends on the time interval between t_1 and t_2. For a normal distribution, weak stationarity is equivalent to strict stationarity.

As Spanos (1986) and Cuthbertson et al (1992) note, if a series is stationary then, it will tend to always return to its mean value (i.e. be 'mean-reverting') and will fluctuate around the mean with a roughly constant amplitude. For a non-stationary series, the mean and/or variance (if they exist) do not stay constant over time. In the last decade much work has been undertaken in economics to establish whether economic variables are stationary, or if not, the form of their nonstationarity. Nelson and Plosser (1982) demonstrated that many macroeconomic series are non-stationary, including (in log terms) the money stock, industrial production, consumer prices and bond yields. Meese and Singleton (1982) showed that exchange rates are non-stationary, but their first differences are stationary. If a series must be differenced d times before it becomes stationary, then it is said to be integrated of order d, which is sometimes denoted I(d) (Granger (1986)). Thus it has been claimed that empirically, exchange rates are integrated of order one.

The issue of whether exchange rates (and other economic variables) can be characterised as having a specific (or mix of specific) underlying distributions is extremely important in this context, as much of the past exchange rate modelling and the more recent work on exchange rate distributions assumes that such an underlying distribution exists. It may, however, not exist. It should also be noted that acceptance of first order integration of exchange rates does not necessarily imply the existence of a unique underlying distribution. The celebrated 'Lucas Critique' (Lucas (1981)), for example, might be used as one reason why the behaviour of certain economic variables changes over time. In this case the exchange rate regime (and other factors such as actions of the ruling government, and the type of monetary policy adopted) at any given period of time, for example, can affect the behaviour of exchange rates and other economic variables.

It is important to distinguish as well between high-frequency and low-frequency volatility. For example, exchange rates are, in a sense, continuous variables, as they are prices which are quoted on a second-by-second basis, 24 hours a day, so they inevitably tend to exhibit a lot of high-frequency (on a day-to-day basis) volatility, whereas price inflation data is only available on a month-by-month basis, at most, so is more likely to display low-frequency volatility, even if the country in question suffers from chronically high inflation.

In connection with exchange rates, Williamson (1985) attempts to make the (somewhat arbitrary) distinction between volatility and misalignment. He defines volatility as a 'high frequency' concept, referring therefore to movements in foreign exchange rates over relatively short periods of time. Misalignment is defined as the capacity for an exchange rate to depart from its fundamental equilibrium value (Williamson uses the FEER, or Fundamental Equilibrium Exchange Rate measure) over an extended period of time. Regardless of whether one accepts Williamson's distinction between volatility and misalignment, the two concepts differ substantially, the former being a relative concept and the latter being an absolute concept (if at all measurable). In addition, the two concepts are not necessarily mutually exclusive: for example, correcting a misalignment is likely to increase volatility, but on the other hand, a fixed or semi-fixed exchange rate regime will naturally tend to reduce volatility, regardless of whether exchange rates are misaligned or not. In this study, weekly exchange rates are used, so the high-frequency definition of volatility is more appropriate.

So, empirical analysis of economic and financial data necessitates some assumptions to overcome the difficulty of postulating a specific distribution. 'Non-parametric' distribution-free tests will be used to avoid this particular pitfall. Using these tests, it is possible to test, with the above caveats regarding regime breaks, etc., for changes in the location (analogous to the mean in the normal distribution) and scale (analogous to standard deviation) of fluctuations in economic variables.

II. The Transmission of Volatility

Volatility in exchange rates has been seen by policy-makers as a problem since the floating of most exchange rates in the early 1970s. What are the likely results of exchange rate volatility in an economy? The possible response to this question falls under two categories; a microeconomic response and a macroeconomic response. Firstly, as with volatility in any series that might be used by economic agents as a basis for making an economic decision, this might provoke, in risk-averse agents, a decision not to trade when they otherwise would have done; this is the micro response. Secondly (the macro response), it has been argued that if one restrains or restricts an economic system at one point, then (following the idea behind the 'Le Chatelier Principle' in physics) this will only lead to increased volatility in some other variable in the economy. We examine each response in turn.

The micro response, when applied to exchange rates, implies that reducing the volatility of an exchange rate would increase the amount of real trade between two countries, so would therefore, ceteris paribus, be welfare-increasing. Up until recently, little empirical work has been done in this area. Akhtar and Hilton (1984) found that with the U.S. and Germany, trade creation occurred when exchange rate volatility diminished, but their results were not confirmed by other studies using different trade flows and volatility measures (see for example IMF (1983)). Cushman (1986), however, found that there were volatility effects on trade when 'third country' effects were controlled for (i.e. changes in third country exchange rates may also affect the amount of trade between two countries). More recent work, specifically in relation to the EMS, has noted that after the inception of the system, trade in real terms shrank (see De Grauwe (1987)). This, however, was mostly due to the general cyclical downturn in the rate of increase in output in most developed countries. After allowing for this 'growth effect', De Grauwe obtained only a small net positive level of trade creation due to the increased stability in exchange rates. Bini-Smaghi and Vona (1989) used an econometric trade model to try and estimate the effects of the EMS on the trade-imbalances among the EMS countries. They ran a simulation with this model to stabilise a weighted average of exports and imports at an average level of competitiveness for 1978 in Italy, Germany and

France. The results showed that the trade creation effect is positive, but is only small in relation to the size of the intra-EMS trade imbalances.

The second (macro) response is that the restraining of one economic variable will only exacerbate the volatility in some other macroeconomic variable in the economy. In relation to the EMS, this view was stated most eloquently by Artis and Taylor (1988), in terms of a possible increase in interest rate volatility following the inception of the EMS. To quote:

> "Insofar as the burden of increased interest rate volatility falls more widely on the general public than that of exchange rate volatility (which presumably falls mainly on the company or more particularly the tradable goods sector), then the welfare argument must hinge on which sector would find it easier to hedge the induced risk."

The conclusion from this line of reasoning is clearly not in favour of EMS membership. The authors then go on to non-parametrically test whether volatility for monthly changes in onshore short-term interest rates has increased or reduced since the inception of the EMS. The results reveal that if anything volatility of interest rates has reduced within the EMS, although the results are not strongly confirmatory. There are also some problems here as capital controls clearly affect the results.

Two interesting points follow from the above paragraphs. Firstly, it may be that there are no systematic differences in the behaviour of macroeconomic variables or international trade flows under alternative exchange-rate regimes. This view is that of Baxter and Stockman (1989), who used a postwar sample of 49 countries to compare the behaviour of output, consumption, trade flows, government consumption spending and real exchange rates for the pre- and post-1973 periods. They did not attempt a similar assessment for the EMS. Further, there are significant institutional and qualitative differences between the Bretton Woods arrangement and the EMS. In addition, they did not account for the series of exogenous shocks that buffeted the world economy post-1973, and so their results could be biased.

The second point in relation to the empirical evidence on the transmission of volatility pertains to research on exchange rates. The standard exchange rate equation always uses an interest rate or interest rate differential as an explanatory variable. Inverting such an equation may suggest that the interest rate would be the only variable free to respond to exogenous shocks, so would therefore likely be more volatile if exchange rates were pegged. But this argument ignores other qualitative factors such as the credibility of following such a policy and perhaps a reduction in the frequency of speculative attacks on a currency. But it also begs the question as to what determines exchange rates. Meese (1990) shows that the correlations of changes in two exchange rates (DM/\$ and Y/\$) with their respective economic fundamentals are all insignificant except in a few isolated cases. This suggests that if fundamentals are at all affected by exchange rates, then changes in these rates, which characterise the degree of volatility, impinge on other macroeconomic variables in a fairly inconsistent manner. Logically, then, the 'exchange rate equation' approach is unlikely to yield any useful results.

III. The Empirical Exchange Rate Distribution

a) Empirical Distributions of Financial Variables

The first contribution to the literature, which noted that financial market data (in particular, stock and commodity price changes) are not well characterised by the normal distribution, was made by Mandelbrot (1963) with a specific application to the cotton commodity market. He proposed the stable Paretian family of distributions (which will be described later) as an alternative to the normal distribution, as these distributions tend to exhibit more kurtosis than a normal distribution. In this instance, as with most financial data, the type of kurtosis of interest is leptokurticity, that is, a more peaked distribution with fatter tails than the normal distribution. This means that if the data are first differenced, there are long stretches of time for which the absolute values of the changes are small, but interspersed in the series there will be (perhaps series of) an occasional extremely large (absolute) value. Kurtosis is related to the fourth moment of a distribution, and is normally expressed as a standardised coefficient, η_4, which can be defined as:-

$$\eta_4 = \frac{\mu_4}{\sigma^4} \tag{2.5}$$

where σ^2 is the variance, and μ_4 the fourth moment = $E(x-\mu)^4$ (if they exist). μ is just the mean or expected value of the distribution. Even if the moments do not exist, financial series often can be seen to exhibit behaviour characteristic of leptokurtic distributions, such as outliers, etc.

Many studies have consistently shown that, relative to the normal distribution, the empirical density functions of short-term variations in speculative price series are characterised by leptokurticity (see Fama (1965), Deaton and Laroque (1992)).

It should be noted at this juncture, that the three major non-derivative markets, namely commodities, exchange rates and the stock market, have slightly different characteristics from each other. Commodity prices can be affected by stockpiling, the weather and other factors (industrial action, business cycles). The stock market can be affected by the business cycle and political factors. Further, both these markets will exhibit long-term non-stationarity in prices, as prices in the long-run will tend to rise over time, implying that the distribution of price changes will be positively skewed. The foreign exchange market though, is largely immune to the international business cycle as it tends to affect all currencies. It is a market where prices are quoted as relative prices and also stockpiling of currency is largely confined to central bank holdings of US dollars, rather than other currencies. Moreover, if inflation rate differentials are constant between countries, theory predicts that exchange rates should be stationary, implying that the distribution of exchange rate changes would be symmetric rather than skewed. Even with all these differences, empirical studies have been remarkably consistent in their findings of leptokurtic empirical distributions for all three speculative price markets.

The leptokurticity evident in most financial data is now a stylised empirical fact, but has not really been adequately explained in the literature. Schiller (1989) claims that this phenomena is due to a tendency for new information to come in 'big lumps' on an infrequent basis. Indeed, in most financial markets, information (or 'news') tends to come in lumps, but in the context of financial markets, 'news' comes more or less in a continuous stream (although certain economic data does tend to be released together): but more importantly, economic news is also not the only type of news that 'moves' the markets. So Schiller's proposition may hold some water, but does not encompass all possible scenarios. Nevertheless, the evidence points to news on economic fundamentals having a significant effect on the exchange rate (see Macdonald (1988) for a summary of the research in this area), but an influence perhaps less great than that of other factors (such as political pronouncements, chartist advice, trading rules etc.). Pesaran and Robinson (1993) attempt to explain the characteristics of the

Sterling-Deutschemark exchange rate in terms of the behaviour of fundamentalists and technical analysts (chartists). This new strand of the research suggests that changes in the degree of kurtosis of an empirical distribution might be caused by a change in behaviour of technical analysts (chartists), given the exchange rate regime in force. This proposition has yet to be explored for other currencies.

The lumping phenomena of large disturbances, it might be claimed, is more likely because financial market participants limit their open positions, and the corresponding futures market participants always limit their exposures by marking to market the settlements of accounts on a daily basis. Thus, one large exchange rate movement can cause a complete re-adjustment of most if not all market positions, which, in turn, triggers more disturbances, rendering a reinforcement effect. Further, when large movements occur, central banks are more likely to intervene (in order to invoke an 'orderly market') causing further responses (or challenges!) in the financial markets.

b) Empirical Research on Exchange Rates

The first major study of the distribution of exchange rate changes was Westerfield (1977). She tested the null hypothesis of normally distributed exchange rates against an alternative hypothesis that exchange rates are drawn from the stable Paretian distribution family (of which the normal distribution is a special case). The family of stable-Paretian (or sum-stable) distributions is defined by the log of the characteristic function:-

$$\ln \phi_x(t) = \ln \int_{-\infty}^{+\infty} e^{itx}\, dF(x) \tag{2.6}$$

$$= i\delta t - \gamma |t|^{\alpha} \tag{2.7}$$

where $i = \sqrt{-1}$. Symmetric stable distributions have three parameters - δ, a location parameter (analogous to the mean in the normal distribution), γ, a dispersion parameter (analogous to the standard deviation) and α, the characteristic exponent. The characteristic exponent measures the thickness of the tails of the density function, and varies between 0 and 2. When $\alpha = 2$ the distribution is normal, and the smaller the value of α, the fatter the tails. At $\alpha = 1$ the distribution is Cauchy. Further, only moments of order r, $r < \alpha$, exist, except when $\alpha = 2$. Thus, if the Stable Paretian distribution is non-normal, then the second moment of the distribution does not exist (it is infinite). Westerfield used weekly foreign exchange data for West Germany, Switzerland, the Netherlands, U.K. and Canada, for the period 1962-1975 (with the exception of Canada - 1953-1975), and found that in all cases the characteristic exponent had a value between 1.0 and 1.6. This result suggests that the parameters of the normal distribution are not likely to be good statistical measures of foreign exchange rate distributions. Westerfield (1977) then went on to estimate the location and scale parameters using a technique developed by Fama and Roll (1968, 1971). She found that the location parameters in each case were close to zero, but were larger for the flexible rate period (generally 1973-1975) than the fixed rate period (generally 1962-1971). The scale parameters were found to be ten times larger for the flexible rate period than for the fixed rate period. To test the stability of this result, the observations were split into non-overlapping subsets, and then the characteristic components were again estimated. As the Paretian distribution is sum-stable, that is the sum of Paretian distributions with the same characteristic exponent belong to the same family, then the result that the estimates of α varied little in the subsamples seemed to support the view that exchange rates were indeed distributed as stable paretian distributions.

The next contribution to this strand of the literature was made by Rogalski and Vinso (1978). They noted that studies of stock returns (see Blattberg and Gonedes (1974) and Praetz (1972)) had found that the Student-t distribution gave a better fit compared with the symmetric (stable) Paretian distribution. Thus they attempted to evaluate the fit of the t distribution versus the symmetric Paretian distribution using the Westerfield data. The density function for the student-t distribution is given by:-

$$f(x) = \frac{c}{\sigma^n}\left[1 + \frac{\gamma^{-1}}{\sigma^2}x^2\right]^{-1/2(n+\gamma)};c = \frac{\Gamma\left[\frac{(n+\gamma)}{2}\right]}{(\pi\gamma)^{(n/2)}\Gamma(\gamma/2)} \qquad (2.8)$$

where Γ is the gamma function, γ is the degrees of freedom and n and σ are parameters. Note that if γ=1, then we obtain the

Cauchy distribution, and if $\gamma=\infty$, then the t distribution tends to a normal distribution. For the t distribution, existence of moments depends on γ, the degrees of freedom parameter; the t has $\gamma-1$ moments.

Rogalski and Vinso's findings (which used estimates of the log-likelihood functions) were that the observed frequency distribution was better approximated by a Paretian distribution during fixed rate periods, whereas a Student-t distribution provided a better description for flexible rate regimes. The explanation for this result was that when there is a shift from fixed to flexible regimes, the peakedness of the distribution appears to fall.

As both the stable-Paretian distribution and the Student-t distribution have the property of leptokurticity, both appear valid candidates to represent the underlying empirical distribution of exchange rates. But there are important differences between the two distributions. Firstly, the Paretian distribution has infinite variance, so does not normally lend itself well to empirical applications, whereas the Student-t distribution may have finite variance if the degrees of freedom are greater than two. Another difference is that sums of independent stable-Paretian variables are themselves stable-Paretian variables, whereas the Student-t distribution is non-stable - that is, sums of independent identically distributed t variables converge to a normal distribution rather than another t distribution.

Islam (1982) made the next contribution to the literature, again on the question of whether the empirical distribution of exchange rates more closely resembles the Student-t or the stable Paretian distribution. Islam uses daily DM/US dollar spot rates from March 1973 to May 1981 and finds that the Student-t distribution is more appropriate for describing the short-term (daily and weekly) movement of exchange rates, whereas the longer-term (monthly and quarterly) variations were found to be adequately described by the normal distribution.

Arguably the seminal paper in this strand of the exchange rate literature was written by Boothe and Glassman (1987), two Canadian economists. The authors used daily noon spot rates for the period from January 2, 1973 to August 8, 1984 for the British pound, Canadian dollar, German mark and Japanese yen versus the U.S. dollar. The authors were particularly interested in how the observed distribution might change as the differencing interval increases. Indeed, they found that normality was rejected for all the data, except when the data was averaged to a quarterly level and then differenced (- the results for the monthly data were mixed). They interpreted this as implying that the distribution is unstable. Using a non-linear optimisation method, they calculated the parameters for the normal, stable Paretian, Student-t and a mixture of normal distributions by maximum likelihood. The values of the log-likelihood functions, though, were not directly comparable, as sore of the distributions are nested. So to augment the maximum likelihood results, they used a Pearson goodness-of-fit test statistic. They found that the Student-t distribution fits best for the Canadian dollar and the German mark, whilst the mixture of two normals fits best for the British pound and the Japanese yen. But this conjecture suggested that a proposal made in an earlier paper by Friedman and Vandersteel (1982) that the distribution parameters may be time-varying, might have some validity. This prompted Boothe and Glassman to split their sample into two halves and test for the equality of the distributions using the non-parametric median quartile test. In every case the hypothesis that the distributions were the same in each subsample was rejected. The Pearson statistics were re-estimated for each sub-sample and it was found that the Student-t ranked first most often.

As the tails of the distribution have generally been of most interest to economists, the focus of research shifted somewhat following Boothe and Glassman's paper in 1987, to look solely at tail behaviour. Koedijk, Schafgans and de Vries (1990) seek to estimate the tail index (α) using the theory of extreme values (see Mason (1982)), which contains certain limit laws relevant to all statistical distributions that possess a limit. In this sense the authors avoid the issue of the non-nestedness of the stable-Paretian and the Student-t distributions. They use data for all the EMS currencies (excepting the Greek drachma, Portuguese escudo and Spanish peseta) against the US dollar from March 26, 1971 to February 6, 1987. On the basis of an asymptotic estimator (see Hill (1975)), the authors conclude that only in some instances can the Student-t distribution be rejected, but in all instances, the stable-Paretian is never rejected.

Following on from this work, Hols and de Vries (1991) continued looking at the tails of the distribution, but using only non-parametric test statistics. They used weekly data for the C$/US$ exchange rate from the end of 1973 to the end of January 1983, and found that the evidence weakly favours a Student-t distribution or an ARCH(1) process, but rejects a stable-Paretian distribution. An ARCH(1) process is a process which is autoregressive of order one in the second moment.

To sum up, three 'stylised facts' can be gleaned from the exchange rate distribution literature. These stylised facts are as follows:-

i) exchange rates are non-stationary, but first-differences in exchange rates are stationary (Meese and Singleton (1982));

ii) empirical (first-differenced) exchange-rate distributions do not resemble the normal distribution, but rather exhibit fat-tailedness (i.e. they have fatter tails than the normal distribution) (e.g. see Westerfield (1977)): and

iii) the lower the frequency of the data, the less marked the departure from normality. This implies that the extreme values which make up the tails of the distribution are not 'bunched' over long periods of time. That is, if they occur, they are bunched over short periods of time, but with low-frequency data, these extreme values get 'averaged-out' (see Boothe and Glassman (1987)).

Lastly, in terms of alternative possible distributions which appear to fit the data best, most of the literature has focused on the stable Paretian, Student-t and a mixture of normal distributions, with some researchers exploring the possibility of time-varying distribution parameters.

IV. Description of the Data

The data used in the research were obtained from the Datastream 'Worldview' service. The data consists of exchange rates collected on a weekly basis from 1970 onwards. The countries concerned are Germany, France, Italy, United Kingdom, the Netherlands, Belgium, Spain, Denmark and Ireland.

To illustrate the data graphically, five of the exchange rates have been selected and graphed, as well as their week-on-week percent change. The actual exchange rates are shown in Figures 2.1a to 2.5a and the percent changes are shown in Figures 2.1b to 2.5b. The exchange rates illustrated are the DM/US$, the DM/£, the Ffr/DM, the Lira/DM and the Hfl/DM. It is fairly apparent that the volatility of the latter three exchange rates has reduced significantly in recent years.

As the focus of this study is the EMS, and in particular the volatility of exchange rates, it is instructive to begin with an analysis of the exchange rate data. An analysis of interest rate and exchange rate forward data is undertaken in Chapter 3. Because of the stationarity problem, the exchange rates were logged and differenced. All exchange rates were for cross rates against the German mark, with the exception of the German mark, where the values are for the DM/US$ exchange rate. Table 2.1 shows the values of the mean, variance, skewness and kurtosis for these differenced logged exchange rate variables.

The skewness and kurtosis coefficients are modified according to the formulas given in Kendall and Stuart (1958) for appropriate sample sizes. These formulas are for skewness and kurtosis, are as follows:-

$$\eta_3 = \frac{N^2}{(N-1)(N-2)} \quad \frac{\mu_3}{\sigma^3} \tag{2.9}$$

$$\eta_4 = \frac{N^2}{(N-1)(n-2)(N-3)} \quad \frac{(N+1)\mu_4 - 3(N-1)\mu_2^2}{\sigma^4} \tag{2.10}$$

It is also instructive to compare the pre-EMS period for each currency with the post-EMS inception period. Table 2.2 repeats Table 2.1 for the period August 1971 to March 1979 and Table 2.3 further repeats this table for the EMS period.

TABLE 2.1 - Descriptive Statistics (1971-1992)

Currency	μ	σ^2	Sk	Ku
Ffr	0.00076	5.56e-5	1.83	24.16
UK£	-0.00105	14.00e-5	-0.83	4.18
Il	0.00138	8.75e-5	2.57	21.60
Dkr	0.00058	4.19e-5	2.02	26.80
I£	-0.00112	7.35e-5	-2.11	16.09
Hfl	0.00013	1.65e-5	1.25	18.61
Bfr	0.00038	3.93e-5	2.78	35.67
Spta	0.00111	6241.00e-5	-0.02	86.17
DM/US$	-0.00076	23.9e-5	-0.27	1.86

TABLE 2.2 - Descriptive Statistics (1971-1979)

Currency	μ	σ^2	Sk	Ku
Ffr	0.00106	11.4e-5	0.85	10.87
UK£	-0.00213	15.8e-5	-1.21	6.06
Il	0.00247	18.9e-5	1.77	10.01
Dkr	0.00077	8.5e-5	1.61	15.57
I£	-0.00214	15.8e-5	-1.21	6.08
Hfl	0.00023	3.3e-5	1.03	10.34
Bfr	0.00036	5.0e-5	2.11	21.25
Spta	0.00168	27.4e-5	7.02	84.76
DM/US$	-0.00171	18.1e-5	-0.32	5.18

TABLE 2.3 - Descriptive Statistics (1979-1992)

Currency	μ	σ^2	Sk	Ku
Ffr	0.00058	2.1e-5	5.55	58.94
UK£	-0.00041	12.9e-5	-0.49	2.24
Il	0.00075	2.7e-5	2.41	19.36
Dkr	0.00047	1.7e-5	1.58	12.67
I£	-0.00052	2.3e-5	-4.15	46.56
Hfl	0.00007	0.7e-5	0.79	15.53
Bfr	0.00038	3.3e-5	3.44	51.91
Spta	0.00078	9893.4e-5	-0.01	53.52
DM/US$	-0.00021	27.2e-5	-0.28	0.84

It is interesting to note that the degree of kurtosis is higher for pre- as compared with post-EMS inception for the French franc, Italian lira, Irish punt, Dutch guilder and Belgian franc, but it falls for Sterling, Danish krona and Spanish peseta. The variance, however, if accepted as an approximate measure of volatility, unequivocally falls for all the currencies that have been long-standing members of the exchange rate mechanism (ERM) of the EMS. Further, the mean values for all currencies except the Belgian franc are lower post-1979 than pre-1979. The kurtosis result is, on reflection, to be expected. When currencies are restricted in their movements, it is likely that the distribution will be more peaked, and the apparently fatter tails will result from the inclusion in the data of the realignments of currencies against the DM. In this sense, though, the result for the Danish krona is puzzling, as it goes against the change in kurtosis for all the other ERM currencies. These results have only recently been noted in the literature, and are of significant interest in terms of the empirical distribution of exchange rates under different exchange rate regimes.

It is also noteworthy that as the majority of the period post-1979 was characterised by the pound Sterling, the Spanish peseta and the DM (against the US$) in a managed floating regime, so the variance should be higher than for the other currencies. This is indeed borne out by the data, but it is also the case prior to 1979, so cannot be directly attributed to the EMS. This is a good example of how simple data interpretation with a system such as the EMS might be misleading.

Analysing the data in two subsamples reveals a fair amount about how the behaviour of exchange rates altered but does not indicate the evolution over time of the relevant moments. To illustrate this evolution, which can lead to important insights as to how the nature of the time series is developing, the five illustrative exchange rates are once more used to graph the sequential mean, variance and kurtosis (as first done by Mandelbrot (1963)). These graphs are shown as Figures 2.6a,b and c respectively to Figures 2.10a,b and c. Generalising these results is unadvisable, to say the least, but the graphs do appear to bear out the tentative conclusions made from Tables 2.2 and 2.3 above. Using the fact that the EMS was introduced when the sample size is at 395, it is interesting to note that the gradual lowering of variance attained through membership of the ERM of the EMS appears to have been bought at the expense of an increase in the level of kurtosis. The Dutch guilder is particularly interesting here, as it has the least number of realignments against the German mark, so suffers less from the problems of the relatively large changes associated with the period before and after a realignment. Figure 2.10c shows that even for this currency, the kurtosis measure has been on an increasing trend.

Having analysed the exchange rate data and illustrated selected rates graphically, it is interesting to view the empirical distributions of the exchange rates. Again, the five illustrative exchange rates are used to generate empirical exchange rate distributions both for the data as a whole and for the period since the inception of the EMS. Figures 11a and b to Figures 15a and b show these empirical density functions. The functions were generated by taking a grid across the differenced (logged) exchange rates from a value of -0.1 to +0.1 using a grid width of 0.001, which gives 200 intervals over this range to plot the histogram. The value 100 on the x axis of each plot thus represents the value 0.0 for the histogram.

Why should the increasing trend in the kurtosis measure be observed? The increased fatness in the tails of the distribution could possibly be explained by 'jumps' in the exchange rate upon realignment, or by increased speculative activity in the run up to a realignment, but then there would be a marked difference between the Ffr and the Hfl as these two currencies have experienced very different frequencies of realignments - this is clearly not the case. Conversely, it might not be due to increased tail-fatness at all, but rather to increased peakedness in the empirical distributions. This possibility cannot be ruled out without further analysis. The histogram for the DM/$ is remarkably dissimilar from the other ERM currency histograms, as also was the DM/£ histogram - this phenomenon may be due to computer trading, particularly as these two currencies are heavily traded by market participants. Otherwise, it is difficult to explain why the gaps around the mode in the histograms occur.

Given that exchange rates are generally known to exhibit fat-tailedness, the weekly data used in the study is first examined to see if it exhibits this property. This is done by testing for normality. Two approaches were used in testing: the first group of tests following the usual parametric test procedures, and the second test being non-parametric. The parametric tests consist of a skewness test, a kurtosis test and the Bera-Jarque test for normality (which itself can be derived from the skewness and kurtosis tests - see Spanos (1986)). The non-parametric test for normality is the Smirnov test (see Randles and Wolfe (1979)), which compares the distance between the observed cumulative distribution and the normal distribution. The results of both tests are shown in table 2.4, for the whole period, tables 2.5 and 2.6 for 1971-79 and 1979-92 respectively.

TABLE 2.4

Tests for Normality (1971-92)

Currency	Skewness	Kurtosis	Bera-Jarque	Smirnov
Ffr	59.67	668.82	19232	0.183
	(0.0)	(0.0)	(0.0)	
UK£	-27.01	20.10	138.44	-0.104
	(0.0)	(0.40)	(0.0)	
Ilira	83.61	585.72	15460	0.164
	(0.0)	(0.0)	(0.0)	
Dkr	65.78	754.72	242455	0.129
	(0.0)	(0.0)	(0.0)	
I£	-68.82	407.02	7692	-0.176
	(0.0)	(0.0)	(0.0)	
Hfl	40.81	488.70	10229	0.148
	(0.0)	(0.0)	(0.0)	
Bfr	90.69	1043	46667	0.122
	(0.0)	(0.0)	(0.0)	
Spta	-0.511	2682	299725	0.439
	(0.93)	(0.0)	(0.0)	
DM/$	-8.74	-55.11	139.27	-0.091
	(0.15)	(0.02)	(0.0)	

Footnotes: i) 1068 observations.
ii) Figures in parenthesis are marginal significance levels.
iii) Smirnov test significance levels: 5% = 0.042, 1% = 0.050

TABLE 2.5

Tests for Normality (1971-79)

Currency	Skewness	Kurtosis	Bera-Jarque	Smirnov
Ffr	16.80 (0.005)	211.59 (0.0)	1912.5 (0.0)	0.127
UK£	-23.96 (0.0)	117.66 (0.0)	672.5 (0.0)	-0.139
Ilira	34.85 (0.0)	194.96 (0.0)	1786.1 (0.0)	0.146
Dkr	31.77 (0.0)	303.43 (0.0)	4004.4 (0.0)	0.136
I£	-23.96 (0.0)	118.11 (0.0)	676.9 (0.0)	-0.137
Hfl	20.39 (0.001)	201.32 (0.0)	1758.0 (0.0)	0.140
Bfr	41.71 (0.0)	414.26 (0.0)	7440.6 (0.0)	0.114
Spta	138.4 (0.0)	1654.3 (0.0)	117217 (0.0)	0.197
DM/$	-6.45 (0.28)	100.63 (0.0)	428.8 (0.0)	-0.105

Footnotes: i) 395 observations.
ii) Figures in parenthesis are marginal significance levels.
iii) Smirnov test significance levels: 5% = 0.068, 1% = 0.082

TABLE 2.6

Tests for Normality (1979-92)

Currency	Skewness	Kurtosis	Bera-Jarque	Smirnov
Ffr	143.48	1512.7	98772	0.180
	(0.0)	(0.0)	(0.0)	
UK£	-12.64	57.09	162.41	-0.083
	(0.035)	(0.017)	(0.0)	
Ilira	62.21	496.56	10919	0.111
	(0.0)	(0.0)	(0.0)	
Dkr	40.87	324.81	4674.3	0.082
	(0.0)	(0.0)	(0.0)	
I£	-107.23	1194.93	61411	-0.128
	(0.0)	(0.0)	(0.0)	
Hfl	20.50	398.18	6676.2	0.119
	(0.001)	(0.0)	(0.0)	
Bfr	88.82	1332.3	75269	0.125
	(0.0)	(0.0)	(0.0)	
Spta	-0.255	1373.5	78607	0.463
	(0.96)	(0.0)	(0.0)	
DM/$	-7.24	21.08	27.27	-0.088
	(0.22)	(0.38)	(0.0)	

Footnotes: i) 673 Observations.
ii) Figures in parenthesis are marginal significance levels.
iii) Smirnov test significance levels: 5% = 0.052, 1% = 0.063

The tables 2.4-2.6 show that according to the parametric tests, none of the exchange rate distributions can be characterised as normal, and that the level of kurtosis in the exchange rates participating in the ERM of the EMS far exceeds that of the normal distribution. Only in the case of the DM/£ in the pre-EMS period and the DM/$ post-1979, is the level of kurtosis similar to that of a normal distribution (that is, a coefficient of 3). Using the non-parametric test (this used the histogram, which was created by imposing a grid of width 0.001 across the data), normality is also rejected in all cases.

As rejection of normality implies the fat-tailedness or peakedness of the empirical distributions, the next step is to proceed with non-parametric techniques to test for any changes in the scale variable.

V. Testing for Changes in Exchange Rate Volatility

In light of the 'stylised facts' about exchange rates, and the non-conclusive results of the research in this area with regard to actual distributions, it appears sensible to assume the distribution to be fat-tailed, without specifying any particular distributional form. This implies that perhaps the best methodological approach to testing for any changes in location or scale parameters would be to adopt non-parametric distribution-free techniques, such as rank tests. These tests are performed upon ordinal measures relating to the data, rather than actual data values.

Two distinct approaches are used to test for a reduction in the scale variable post-1979. The first method uses a variety of linear rank tests, for example see Randles and Wolfe (1979). All the tests covered in this study are examined in Annex 2A. The second approach uses a technique that was first proposed by Hajek and Sidak (1967), and was first used in relation to exchange rates by Artis and Taylor (1988); this method is designed to be optimal for certain possible underlying distributions. Artis and Taylor (1988) adopted rank tests in relation to exchange rates in a study using monthly data, and the results they obtained suggested that volatility was indeed reduced. Some of the tests used here for weekly data reconfirm their results.

a) Two-Sample Linear Rank Tests

A two-sample linear rank test can be undertaken in the following way: merge the two samples, assign ranks to observations in the merged sample, then construct the rank statistic. The general form of the linear rank test statistic (LRT) is as follows:-

$$LRT = \sum_{i=1}^{n} c_i a(R_i) \tag{2.11}$$

where c_i = 1 or 0 depending on whether the observation is within the subsample under consideration or not, and a(.) is a function of the ranks. In most of the linear rank tests considered below a( ) is chosen to take account of the test alternatives available. If the combined sample can be considered to come from an exchangeable absolutely continuous distribution (for example, i.i.d.), then the distribution of the LRT, under very general assumptions, is independent of the original distribution. The LRT can be computed and its critical values are tabulated for many known statistics. Further, its asymptotic distribution is normal. A typical test considers the two random subsamples x_i and y_i to be generated independently under the null hypothesis by two distributions with the same median.

Three issues need to be addressed when using linear rank tests to test for changes in scale - firstly that of a change in the distributional form between the two samples, secondly that of tied observations, and thirdly, a possible simultaneous change in location between the two subsamples.

The first issue is that of a change of empirical distribution between the data subsamples. None of the linear rank tests account for any change in distribution that occurs with a change in regime. So as to test for a change in distribution between the two subsamples, a Kolgomorov-Smirnov test was employed (see Randles and Wolfe (1979)). The Kolgomorov-Smirnov test takes the maximum absolute probability density value and employs a test statistic on this value. The results of using this test are given in Table 2.7 below.

TABLE 2.7
Testing for a Change in Distributional Form between the Two Subsamples

Currency	Maximum Distance
Ffr	0.182
UK£	0.085
Ilira	0.174
Dkr	0.131
I£	0.192
Hfl	0.130
Bfr	0.069
Spta	0.059
DM/$	0.160

Note: Kolmogorov-Smirnov test significance levels: 5% = 0.086, 1% = 0.108

Table 2.7 suggests that in fact all the ERM currencies, with the exception of the Bfr, underwent a change in distribution on entering the ERM of the EMS. The problem here is to evaluate the cause of this change. It could be due to a variety of reasons -

change in the form of the empirical distribution, change in location parameter, change in scale parameter or any combination of these reasons. As classical linear rank tests for a change in the scale parameter do not allow a change in location or the form of the empirical distribution, this should be noted where relevant when evaluating the rank test results. The above results may also only serve to reinforce any rank test results obtained for a change in scale, as a significantly different scale variable should also be apparent in a Kolmogorov-Smirnov test for a change in type or form of empirical distribution.

The second problem is that of tied observations. The existence of ties indicates a discontinuity in the distribution and complicates distribution theory for test statistics. On eyeballing the data on exchange rates, the most serious problem with tied data-points tends to occur at about the mode of the empirical distribution. This mode tends to occur at zero, implying no change in an exchange rate from one week to the next. This might not be of major concern if the proportion of zeros were roughly equal between the two subsamples. Table 2.8 reports the number of zeros in each subsample and a standard test for the difference between the proportion of zeros.

TABLE 2.8

Testing for A Difference in the Proportion of Zero Observations

Currency	Zeros 71-79	Zeros 79-92	Test for Proportion diff.
Ffr	2	4	-0.385
UK£	11	27	-2.165
Ilira	1	1	0.790
Dkr	1	4	-1.633
I£	20	28	1.424
Hfl	9	15	0.109
Bfr	2	7	-1.908
Spta	1	3	-1.030
DM/$	84	105	4.850

Notes: i) number of observations 71-79 = 395
79-92 = 673

ii) the test statistic uses a normal approximation to the binomial. A positive test statistic implies a lower proportion of zeros in the post-1979 period and vice-versa.

The incidence of tied observations in the data does not seem to pose a problem for most of the ERM currencies, with the exception of the I£, but is clearly a serious problem when conducting linear rank tests for the DM/UK£ and the DM/$ rate, where the difference in proportions between the two subsamples is significant. If there is no median change between the two sub-samples, then as a zero indicates no change in the nominal exchange rate week-on-week, a significant increase in zero observations might suggest that the central part of the empirical distribution has 'narrowed', implying a lowering of 'small-scale' volatility and an increase in kurtosis. The issue of ties is important when conceptualising the form of the empirical distribution, as tied observations result from a mass point in the distribution. Here, it might be more appropriate to think of the empirical distribution as a mixture of an absolutely continuous distribution and a mass point in the centre. Other than excluding all of the zeros from the data set for the currencies where ties are a problem, there is little alternative than to accept the fact that the rank tests may not yield completely unbiased results.

The third issue is a change in median between the two periods. This is important as many of the scale-change linear rank tests are not valid if significant location changes are observed. Therefore a test for a change in the median was first conducted. The test statistic used was the Mood-Westenberg statistic (see Gibbons (1985) and Annex 2A for a description). The results are reported in Table 2.9 below.

TABLE 2.9

Testing for a Change in Median between Subsamples

Currency	Mood-Westenberg test value
Ffr	-3.375
UK£	0.316
Ilira	-3.598
Dkr	-2.659
I£	-1.687
Hfl	-2.259
Bfr	-1.962
Spta	-1.755
DM/$	1.348

Note: The asymptotic distribution of this statistic is standard normal.

It is apparent that the Ffr, Ilira, Dkr and Hfl all undergo significant changes in location pre- and post- the inception of the EMS. A change in location is not surprising in the case of all of these currencies with the exception of the Hfl, which maintained a fairly close link with the DM throughout the sample period. Given that a currency has a significant change in location pre- and post-1979, this could seriously bias the linear rank test statistics for these currencies. Given that this change in the location parameter could pose problems for the validity of the linear rank tests, one approximate corrective measure might be to subtract the sub-sample medians from the respective sub-sample data values. This is addressed below in section V, part c).

Bearing the above three issues in mind, it is now possible to test for a change in volatility between the two subsamples. The linear rank tests that are used assume that the property of exchangeability holds. Exchangeability can be defined as follows:-

> a set of random variables $X = (X_1,...,X_n)$ is called exchangeable if the distribution of $X_1,...,X_n$ is the same as $X_{d_1},...,X_{d_n}$, for all permutations $d_1,...,d_n$.

Clearly as the data set is first differenced exchange rates, it is not important that the actual data is exchangeable, but rather that the differences are exchangeable. A suitable non-parametric test for the somewhat stronger assumption of independence is the runs test - if it holds then exchangeability holds. The runs test was applied to the data and the results are tabulated in table 2.10.

TABLE 2.10

Runs Test - Exchange Rates
(1971-92)

Currency	Exchange Rates
Ffr	-0.674
UK£	-1.225
Ilira	-0.184
Dkr	3.857
I£	2.327
Hfl	5.204
Bfr	7.286
Spta	-0.918
DM/US$	-3.429

Note: i) The asymptotic distribution of this statistic is standard normal.
ii) The one-sided 5% level of significance is 1.68.

Of the long-standing ERM members in table 2.10, only the Ffr and the Ilira have no significant degree of runs. This mirrors the observation by Hall et al (1989), that the temporal ordering of observations on exchange rate futures, gives rise to the leptokurtic empirical distribution. In other words, the serial dependence in the scale variable arises because of the temporal ordering - if the observations are randomised, then the distribution of the first differences most closely approximates the normal distribution. This is clearly another source of bias in the use of rank tests.

Three types of linear rank test were used, the Ansari-Bradley test, the Siegel-Tukey test and the Mood test. These tests are all described in detail in Annex 2A. Due to the size of the data set, normal approximations were employed rather than the exact distributions of these test statistics. The results are shown in Table 2.11 below, where the null hypothesis is of no change in the scale parameter.

TABLE 2.11
Linear Rank Tests for a Change in Scale
(1971-79 and 1979-92)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	-0.27	-0.14	-15.71
UK£	-12.61	-12.27	-2.64
Ilira	-1.95	-1.82	-13.73
Dkr	-1.37	-1.24	-14.10
I£	-0.33	-0.21	-15.97
Hfl	-3.65	-3.49	-12.08
Bfr	-5.01	-4.88	-9.91
Spta	-8.31	-8.18	-7.03
DM/$	-13.06	-12.94	-1.34

The Ansari-Bradley test and the Siegel-Tukey test assigns ranks which increase in magnitude towards the median of the empirical distribution. The Mood test, however, assigns ranks which increase in magnitude towards the tails of the empirical distribution. This partially explains the disparate results between the Ansari-Bradley, Siegel-Tukey and the Mood statistics. The Ansari-Bradley test rejects the null hypothesis for the floating currencies and the Hfl and Bfr, with the most emphatic rejection reserved for the DM/$. The Siegel-Tukey test results are similar to those of the Ansari-Bradley in that it rejects the null at the 5% level for the UK£, Hfl, Bfr, Spta and the DM/$ rate, but accepts the null for the I£, Dkr, Lira and Ffr. The Mood test rejects the null hypothesis for all currencies with the exception of the DM/$ rate. It should also be noted that the only currencies that reject the null hypothesis for all three linear rank tests are the UK£, Hfl, Bfr and Spta.

At first sight, these results appear puzzling, particularly in the acceptance of the alternative hypothesis of a reduction in scale parameter for the floating rate currencies (the DM/$, and for most of the post-1979 period the DM/£ and Spta) in the case of the Ansari-Bradley and the Siegel-Tukey tests, which largely contradicts what the variance (in Tables 2.2 and 2.3) implies about volatility. But as these empirical distributions are not normal, but rather, are fat-tailed, then the reduction in scale in relation to the shape of the empirical distribution as a whole, becomes important. In particular, a reduction in scale may occur at the centre of the distribution, making it more peaked, or could occur at the extremities of the distribution 'thinning-out' the fat-tailedness. Hence, it is important to consider what happens to the kurtosis measure and also if there is a marked increase in the peakedness of the histograms. The former is achieved by comparing Tables 2.2 and 2.3, while the latter might be proxied by looking at the increase in zeros (Table 2.8). It is noteworthy that if this line of inquiry is followed, the only two currencies that undergo a significant increase in the number of zero observations are two of the three currencies that observe a fall in kurtosis measure (the Bfr being the other currency to observe a fall in kurtosis post-EMS). If this line of inquiry is correct, then it implies that the centre of the distribution does not become significantly more peaked, but rather the the tails of the distribution become fatter.

The inconsistency in the results of the linear rank statistics suggests that the weights attached to the ranks are of significant import. The Ansari-Bradley and Siegel-Tukey test results imply that only the Bfr and Hfl have had a reduction in volatility when we consider small-scale movements. This actually concurs with official exchange rate policy in these two countries, as both have attempted to tie their currencies more closely to the DM than the ERM fluctuations bands warrant. The Belgian central bank went as far as to publicly announce that it was targeting the Bfr within a +/-1% band rather than the +/-2.25% band stipulated by the ERM rules.

On a more general note, these linear rank tests suggest that post-1979 there was a general fall in the volatility of exchange rates, with the ERM members of the ERM enjoying the greatest fall in the incidence of outliers, but the floating rates enjoying the higher degree of concentration around the median exchange rate change.

The next logical step here might be to construct some order statistics, to see what has happened to the tails of the empirical distributions, or perhaps to eliminate some outliers (see David (1970) for some non-parametric tests for outliers and slippage). Although Koedijk, Shafgens and de Vries (1990) have performed some order statistic tests on the tails of these empirical distributions, they have not considered the dynamic nature of changes in the shape or length of the tails in the context of a regime change. Instead another form of rank test is used which attempts to take into account the fat-tailedness of empirical distributions by 'maintaining' different fat-tailed distributions.

b) Hajek and Sidak 'Maintained' Distribution Test

One of the problems with the classical linear rank tests described above, is that although the actual empirical distribution need not be known by the researcher, the rank tests vary in their power according to the nature of the actual underlying distribution. Hajek and Sidak (1967) developed a rank test procedure that permits a uniformly most powerful test, given knowledge of the underlying distribution. This test was applied by Artis and Taylor (1988) to monthly exchange rates, over the period January 1973 to December 1986. One would expect better performance with the Hajek-Sidak tests for maintained distributions such as fat-tailed Student-t or Cauchy, given the fact that previous studies appear to support the choice of this type of distribution to characterise exchange rates.

Using the notation from (11) again, define a test statistic S:-

$$S = \sum_{i=1}^{n} c_i a^{\varphi}(R_i, d) \tag{2.12}$$

where $a^{\varphi}(R_i,d)$ is a score function dependent on the 'maintained' density of the underlying distribution. Hajek and Sidak (1967, page 70-71) show that this test will be locally most powerful against alternatives of two samples differing in location or scale, or regression differing in location or scale. Under H_0, the statistic S is asymptotically normal with mean:-

$$\mu_c = \bar{c} \sum_{i=1}^{n} a^{\varphi}(R_i, d) \tag{2.13}$$

and variance:-

$$\sigma^2 = \left(\sum_{i=1}^{n} (c_i - \bar{c})^2\right) \int_0^1 \left(\varphi(u) - \bar{\varphi}\right)^2 du \tag{2.14}$$

All that remains to be done is to define the asymptotic score function for various underlying density functions. A table of these functions can be found in Hajek and Sidak (1967, page 16). Note that the value of the statistic S under different 'maintained' distributional assumptions necessitates no knowledge about what the actual underlying empirical distribution looks like, or theoretically what it most closely resembles.

Table 2.12 presents the results of the Hajek-Sidak test for a reduction in dispersion given certain maintained distributions. Note that compared with the Artis and Taylor (1988) results, weekly nominal exchange rates are used, and the Student-t distributions with 2 degrees and 3 degrees of freedom have been added to the list of maintained distributions (a derivation can be found in Annex 2B).

TABLE 2.12

'Maintained' Distribution Test Statistics for a Shift in Volatility

Currency	Logistic	D-Exp	Normal	Cauchy	t(2)	t(3)
Ffr	13.13	12.98	12.57	11.80	13.23	13.47
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
UK£	-0.34	-0.40	0.02	-1.62	-1.12	-0.87
	(0.37)	(0.34)	(0.49)	(0.05)	(0.13)	(0.19)
Ilira	11.11	11.06	10.93	9.09	10.47	10.90
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Dkr	9.88	9.98	9.73	8.64	9.42	9.70
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
I£	13.41	13.23	13.04	11.27	13.04	13.47
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Bfr	4.95	4.96	4.89	4.17	4.66	4.84
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Hfl	10.23	10.19	9.95	9.05	10.03	10.26
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Spta	2.92	2.82	2.67	2.58	3.09	3.19
	(0.002)	(0.002)	(0.004)	(0.005)	(0.001)	(0.0)
DM/$	-5.15	-5.19	-4.57	-6.32	-6.09	-5.83
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)

Notes: i) Statistics are asymptotically standard normal variates under the null hypothesis. Figures in parentheses are marginal significance levels. Positive figures indicate a reduction in volatility.

ii) The derivation of the asymptotic score for the two t distributions is located in Annex 2B.

Table 2.12 suggests that only the UK£ might not have undergone a change in its dispersion parameter. The DM/$ rate has had a significant increase in volatility, whilst all other currencies have undergone a significant decrease in volatility. This mirrors the changes in the variances noted in Tables 2.2 and 2.3, with the exception of the Spta, which showed a large increase in variance, but in Table 2.12 it registers a significant fall in volatility. There are two caveats that must be placed upon these results - firstly, the incidence of tied observations (particularly at zero) may be biasing the results, and secondly, table 2.7 suggested that maintaining a specific distributional assumption when assigning weights may not accord with the properties of the data. It is informative to reconstruct the tests which were done by Artis and Taylor (1988) using monthly DM real rates, but with the observation that the Artis and Taylor data set is sourced differently, and their data ends in 1986. This exercise is to be found in Annex 2C, with additional tests for monthly DM nominal rates.

Why do the linear rank tests, with the exception of the Mood test, and the Hajek-Sidak methodology yield such different results? The answer lies in the fact that the tests put different weights on different parts of the empirical distribution, so tending to emphasise certain characteristic changes. Of note here, is the fact with the exception of the UK£, the Mood test and the Hajek-Sidak test give the same qualitative results, indicating that both emphasise the changes in the tails of the distribution rather than in the centre of the distribution.

Also, there exists some debate about when a change in regime actually took place. In particular, in the early years of the EMS, exchange rate turbulence was commonplace, as were realignments, so that large outliers will still exist in the data up until the middle of 1983, when the system achieved a greater level of stability (and credibility). This then questions whether the change in regime date of EMS inception on March 1979 is the most appropriate date. Giavazzi and Spaventa (1990) claimed that the most significant event in the ERM of the EMS was not the founding of the EMS itself, but rather the removal of capital controls between the major ERM member countries at the beginning of April 1983. Annex 2D presents results for a change in volatility as of April 1, 1983, using post-EMS-inception data. The results from Annex 2D suggest that post-1983, lower-order volatility increased, but higher-order volatility decreased. In other words, the increase in kurtosis was due to fatter-tails rather than to more peakedness in the distribution.

c) Accounting for a Change in Median across Sub-samples

Apart from the issue of ties, the most substantive problem with both the linear rank tests and the 'maintained' distribution approach is that of a shift in median between the two subsamples. In this section, another rank statistic is presented which is not conditional upon identical medians, and also the linear rank tests and the Smirnov test are repeated following the simple corrective measure of subtracting the median from all observations in each subsample.

The Moses test (see Annex 2A for a detailed description) essentially takes random samples from each subsample and calculates the squared deviations from the mean of each sample. The squared deviations are then ranked according to size and then the Mann-Whitney test is applied (again, see Annex A for a description of this test). The results of three estimates of the Moses statistic are given in Table 2.13 below, for 8 random samples from the pre- and post-EMS period with random sample size of 10 observations.

TABLE 2.13

Moses Rank Test

Currency	1	2	3	Mean
Ffr	5.0	1.0	3.0	3.0
UK£	27.0	40.0	29.0	32.0
Ilira	12.0	0.0	18.0	10.0
Dkr	0.0	6.0	3.0	3.0
I£	0.0	0.0	7.0	2.3
Hfl	3.0	10.0	4.0	5.7
Bfr	10.0	44.0	19.0	24.3
Spta	24.0	8.0	21.0	17.7
DM/$	52.0	36.0	53.0	47.0

Notes: i) The test was performed with 10 data points randomly selected from the subsamples under consideration. Eight random samples were collected for each subsample.
ii) The null hypothesis of no change in scale is accepted at the 5% level if the Moses Rank test has a value greater than 14 and less than 50.
iii) The null hypothesis of an increase in scale is accepted at the 5% level if the Moses Rank test is above 15 in value.

Because the Moses test selects observations randomly (without replacement), the results are different each time that the Moses test statistic is calculated. To observe how consistent the Moses test is in its results, the test program was run three times (these are the columns of the table, numbered 1 to 3), and then the average of the three values of the test statistic was taken as indicative of the eventual outcome after running the test many times.

Using the mean of the three values of the Moses statistic, the test of the null hypothesis of no change in the scale parameter is accepted only in the case of the UK£, Bfr, Spta and the DM/$ rate (with the latter rate rejecting the null hypothesis on 2 out of the 3 runs), and it is rejected in favour of a fall in the scale parameter for all other currencies under consideration. The test of the null hypothesis of an increase in the scale parameter after the inception of the EMS is accepted for values of the test statistic greater than 15 in value. The same currencies as for the two-sided test above reject the null hypothesis in favour of the alternative hypothesis, which is for a fall in the value of the scale parameter.

This rank test does not assume identical medians, but does assume that the underlying distribution does not change between the two subsamples. The results from table 2.7, though, suggested that many of the currencies had undergone a change in distribution, although it was noted above that as many of the exchange rates had also significantly different location variables post-EMS inception. Table 2.9, however, suggested that the apparent change in distribution might have been due to a change in location parameter, which was not accounted for in table 2.7.

To adjust for a possible change in the location parameter between the two subsamples (pre- and post-EMS inception), a simple correction was undertaken by subtracting the location parameter for the two subsamples. The Kolmogorov-Smirnov test for a change in empirical distribution, originally conducted in table 2.7, was repeated for the location-adjusted data, and is reported in table 2.14 below.

TABLE 2.14
Test for Distribution Change
(location-adjusted data)

Currency	Maximum Distance
Ffr	0.207
UK£	0.050
Ilira	0.161
Dkr	0.126
I£	0.185
Hfl	0.130
Bfr	0.073
Spta	0.063
DM/$	0.160

Note: Kolmogorov-Smirnov test significance levels: 5% = 0.086, 1% = 0.108

Interestingly, the results from table 2.7 are unchanged. Even after adjusting for a change in location between the two subsamples, the ERM currencies (again with the exception of the Bfr) apparently underwent a change in distribution on entering the exchange rate mechanism.

On reflection, perhaps this results is to be expected; most European currencies have been on a depreciating trend against the DM, so the location parameter (as was shown in figures 2.6a-2.10a) has been changing through time. Moreover, rates of depreciation slowed between the two subsamples, which largely accounts for the significant difference in location parameters between subsamples, due to the credibility effect of the EMS and the convergence in inflation rates between European countries (thereby exerting less downward pressure on ERM currencies). Indeed in all cases, European currencies experienced a fall in the median of the empirical distribution between the two subsamples (the only exception is for Hfl, where the median was the same between the subsamples). This gradual change in location, even when a correction is attempted by subtracting the location for each subsample, combined with a change in the scale parameter, still leads to a suggested change in distribution between the two subsamples.

Next, the linear rank tests were repeated with the location-adjusted data. The results of this exercise are reported in table 2.15. It should be noted that the distributions of the test statistics in table 2.15 are no longer distribution-free under the null.

<u>TABLE 2.15</u>
<u>Linear Rank Tests for a Change in Scale</u>
(1971-79 and 1979-92: location-adjusted data)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	-13.50	-13.38	1.05
UK£	4.14	4.27	-20.28
Ilira	-13.58	-13.45	-0.25
Dkr	-14.22	-14.10	1.43
I£	-1.80	-1.70	-13.69
Hfl	-9.75	-9.29	-4.02
Bfr	-0.23	-0.13	-16.75
Spta	-12.03	-11.90	-0.93
DM/$	-2.92	-2.81	-13.41

The results for the linear rank statistics are now completely different from those given in table 2.11. The only ERM currency showing a consistent fall in scale under all three test statistics is Hfl (- the DM/$ rate also shows a fall in scale for all test statistics). Particularly intriguing is the apparent significant increase in scale for the UK£ under the Ansari-Bradley and Siegel-Tukey, and the significant fall in scale when the Mood statistic is used! It should now be noted that both the Ansari-Bradley and Siegel-Tukey tests suggest that the ERM currencies, with the exception of the Bfr and the I£, experienced a fall in volatility post-EMS inception. Interestingly, from table 2.9, these two exceptions, the Bfr and the I£, were both currencies that had not suffered a large change in their median, pre- and post-EMS inception (i.e. their rate of depreciation against the DM, in and out of the ERM of the EMS, did not alter appreciably). This suggests that when a change in the location parameter is adjusted for, the main part of the empirical distribution that contracts on joining a regime such as the ERM of the EMS, is the central portion, rather than the tails. When the 'maintained' distribution tests of section Vb) were repeated they gave similar qualitative results to that of the Mood statistic above.

Why from an economic point of view, might the rate of depreciation of a statistic affect the nature of the volatility of the empirical distribution? The answer to this question probably lies in an understanding of the institutional nature of the exchange rate regime. In a floating-rate exchange-rate regime, volatility is mostly market-agent induced, so depends more on the volatility of exchange rate expectations of the market participants, nevertheless the rate of depreciation is unconstrained at any point in time. (The exception here is central bank intervention aimed at slowing depreciation to maintain 'orderly markets'). In an adjustable-peg exchange rate system, however, exchange rate depreciation is largely constrained as interest rates are more frequently adjusted to defend the target zone bands. Once a devaluation is announced, there is then a brief time during which the currency is allowed to depreciate (in isolated cases, it has 'jumped' to a new level), perhaps faster than would have been the case under a flexible-exchange rate regime, as maybe interest rates are also allowed to fall now that the exchange rate is no longer at the edge of its band.

This implies that on average, rates of depreciation are lower under an adjustable-peg system, but that the brief period when exchange rates are allowed to 'settle' into their new bands gives rise to large movements in exchange rates. This occasional large run of movements in the exchange rate implies an asymmetric fat tail of outliers in the empirical distribution.

VI. Conclusions

This chapter has attempted to assess whether the ERM of the EMS enabled a reduction in volatility of member exchange rates using a variety of methods. Several issues concerning the data were apparent - the non-normality of exchange rates, the increase in kurtosis on entering the mechanism and the problems of tied observations, particularly at zero. The non-parametric methods for assessing whether exchange rate volatility fell post-1979 also gave different results, not only between tests, but also when a simple correction was performed on the data to take into account any change in the location parameter. The different linear rank tests considered gave useful insights into the nature of the volatility change that took place in the empirical distributions after the inception of the EMS. Future research could address the problem of the nature of the change in the empirical exchange rate distributions, the incidence of tied observations, the behaviour of exchange rates immediately before and after a realignment and the general behaviour of exchange rates between realignments. Also it might be of interest to attempt to characterise any relationship that exists between the location parameter (rate of depreciation) and the scale parameter (volatility).

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Chapter Three: INTEREST RATE AND FORWARD EXCHANGE RATE VOLATILITY: AN ASSESSMENT OF VOLATILITY TRANSFER IN THE EMS.

I. Introduction

Little research has been done on the interplay between exchange rate volatility and other economic variables, and also the volatility of forward exchange rates in relation to the underlying spot exchange rate. It has been proposed that a change in volatility of exchange rates, if affected by a more constraining exchange rate regime, would induce greater volatility in interest rates. This notion has sometimes been labelled "volatility transfer" following a 1980 article by Frenkel and Mussa and a lucid exposition of the effect by Batchelor (1983,1985) in evidence to a UK House of Commons Committee. The crux of the idea is that if the economy can be treated as a physical system (in and of itself a *non-sequitur*), then, following the types of principles encountered in the natural sciences (in this case the 'Le Chatelier' principle), if a "lump" of uncertainty is removed in one part of the system, it will show up elsewhere in the system.

In the context of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS), this notion has been particularly attractive to those who claim that such "volatility transfer" is endemic in the mechanism due to institutional rules and the experience of many central banks. The institutional rules for the ERM of the EMS state that if a currency reaches its divergence limit, action must be taken to correct the situation. The most frequently used defensive action is to raise interest rates to defend the currency, sometimes to extreme levels in the case of unexpected speculative attacks. Detractors of the ERM of the EMS argue that if volatility is just passed to other variables in the system, the aims of the EMS will never be realised (a "zone of monetary stability") and thus there is no net macroeconomic payoff to membership of the mechanism.

From a behavioural point of view, the notion of exchange rate volatility and uncertainty need to be separated. A greater degree of exchange rate volatility does not necessarily imply greater uncertainty, given the availability of hedging instruments such as exchange rate derivatives. One of the arguments against volatility-reducing policies is that economic benefits will not be forthcoming as economic agents will tend to increase their use of derivates. During the course of the 1980s, the trend in increased usage of derivatives was certainly observed in the data (see Remolona (1992)), and now spot transactions in the foreign exchange market represents only about 50% of total trading. This trend is cited as one reason why spot exchange rate volatility might not have had any significant effect on trade flows, as increased awareness of derivative markets has led to a partial abandonment of spot transactions as a means of sourcing foreign trade flows.

In this chapter, the analysis of chapter two is repeated for offshore interest rates and one month and three month forward interest rates. Together with the results of chapter one, this allows an assessment of the extent of volatility transfer in the ERM of the EMS.

II. The Literature on Volatility Transfer

Although the hypothesis of volatility transfer clearly has its roots in the physical sciences, recent economic theory related to exchange rate zones (see Svensson (1992) for a survey), also suggests that interest rates under an adjustable-peg regime will be more volatile than under a floating-rate regime. The exchange rate zone model (see Krugman (1990)) dictates that the unconditional distribution of the exchange rate will be bi-modal with the modes at the edges of the permitted fluctuation margins. By incorporating uncovered interest parity, as Flood, Rose and Mathieson (1990) show, the interest rate differential, and therefore the interest rate itself, should possess a uni-modal distribution. Thus the target zone model has a trade-off between conditional exchange rate volatility and conditional interest rate volatility. Testing volatility transfer to interest rates is therefore not just a test of the validity of traditional (linear) exchange rate models and target zone models, but is also a test of the theoretical approach that economists have used to determine exchange rates. Much of what follows provides variations and additional commentary on this general theme.

The first reference to volatility transfer appeared in Frenkel and Mussa (1980). To quote:-

> "Such ('fixed' foreign exchange rate) policies may only transfer the effect of disturbances from the foreign exchange market to somewhere else in the economic system. There is no presumption that transferring disturbances will reduce their overall impact and lower their social cost. Indeed since the foreign exchange market is a market in which risk can easily be bought and sold, it may be sensible to concentrate disturbances in this market, rather than transfer them to other markets, such as labor markets, where they cannot be dealt with in as efficient a manner."

There are several noteworthy points here. First, there is an implicit assumption in the quote that the economy can be viewed as a physical system in which disturbances will inevitably emerge in some market or another. In philosophical terms, the economy might not be most appropriately characterised as a physical system, in which disturbances are propagated through to other parts of the system if one market is constrained. Further, there is an implicit rejection of the possibility that disturbances might be absorbed, or at least dampened in their transmission. Secondly, insofar as the volatility transfer falls on interest rates, it is not clear that such a transfer cannot be dealt with more efficiently in the money and bond markets than in the foreign exchange market. Indeed, the burden of increased volatility might fall more heavily on domestic economic agents (such as mortgage-holders and corporations) rather than on the tradeable goods sector. But this surely assumes that all domestic borrowing and lending takes place under flexible interest rates. In most countries, economic agents often have some choice as to the financial arrangements under which borrowing and lending is undertaken (for example fixed-rate mortgages, saving bonds, and interest rates on domestic deposits), not to mention the possibility of using the derivative markets to hedge such interest rate risk. Lastly, although the notion of volatility transfer follows directly from inverting a standard exchange rate equation (which was the motivation for the Frenkel and Mussa (1980) article), the generally dismal forecasting performance of linear exchange rate equations suggests that this line of argument, is at most, hypothetical.

A change in exchange rate regime, may, in fact, significantly alter the process underlying the 'determination' of exchange rates. Artis and Taylor (1988) propose that a volatility transfer effect from a change in exchange rate policy may not emanate from an inversion of an exchange rate equation because the equation itself may have changed (following the Lucas (1976) critique). Further, they argue that enhanced policy credibility may significantly reduce speculative attacks and therefore reduce interest rate volatility. Artis and Taylor (1988) went on to show that monthly onshore interest rate volatility had reduced post-1979 in the case of Italy, Holland

and the UK, had increased in the case of the U.S. and was unchanged in the case of France and Germany. The results neither confirmed nor denied the existence of volatility transfer.

Volatility transfer may not appear in the interest rate, but perhaps it could show up in output, money or consumption data - this would still be confirmatory for the hypothesis of volatility transfer. In fact Baxter and Stockman (1989) analysed how the choice of exchange-rate system affects the character of economic fluctuations by comparing data for before and after 1973 - their findings were that any changes in real behaviour in any of the 14 industrialized countries could not be traced to the exchange-rate regime, the only exception to this being the real exchange rate. They also repeated their analysis for one country in the EMS (Ireland) and another country outside the EMS (Canada) that had undergone a change in exchange rate regime, and they obtained the same results. This suggests that domestic economic variables are not important determinants of exchange rate volatility, but also viewing the problem in reverse, that volatility transfer to economic variables is regime-independent, and apparently does not show up in a transparent fashion in the data. Of course, although the pre- and post-Bretton Woods periods should adequately test this hypothesis, different regimes have different characteristics and the Bretton Woods system and the EMS differ significantly in their institutional arrangements. Thus, it may be that the Baxter and Stockman (1989) results do not hold for the EMS as a whole, but do hold for Ireland in particular. Flood and Rose (1993) approached the same problem in the context of the design of a simple specification test for empirical models of exchange rates, but included four ERM currency countries (France, Germany, Holland and Italy) using monthly data from 1975 to 1990. They concluded that there is no inverse relationship between exchange rate volatility and interest rate volatility, stock market volatility, money supply volatility or inflation volatility. They did, however, find a weak inverse relationship between exchange rate and output volatility (with an R^2 approximately equal to 0.2), and a strong relationship between exchange rate volatility and international reserves volatility (it could only be rejected at the 40% level).

Why might volatility transfer to interest rates or real economic variables not be apparent? Firstly, with interest rates, as Artis and Taylor (1988) note, the effective operation of capital controls by both France and Italy for much of the post-ERM inception period would tend to suggest a reduction in onshore interest rate volatility, and this is borne out by their results. They also test for an increase in the volatility of the onshore-offshore interest rate differential and find that it has indeed significantly increased for France and Italy and significantly decreased for Germany and Holland. In this study offshore interest rates are used throughout, thereby avoiding consideration of the effects of capital controls on domestic interest rates as an issue. Secondly, with respect to other variables in the economy (as Bertola (1989) has recognised), it is difficult to verify from an empirical standpoint whether lower exchange rate volatility contributes to higher or lower volatility of real economic variables because the intensity of economic disturbances in different time periods is difficult to control for.

The interplay between perfect capital mobility, an independent monetary policy and exchange rate volatility in an adjustable peg system has been labelled by Mundell as the "Holy Trinity" using a clear theological parallel. Many economists believe that there is a mutual incompatibility between the three elements of the Holy Trinity, particularly in view of the ERM crisis of 1992, which occurred so soon after capital controls were removed and when desirable monetary policies in the EU were divergent. Rose (1994) conducted various tests on the three elements of the Holy Trinity and found that there is no strong evidence to support incompatibility.

To summarise, volatility transfer, has only recently come to the fore again in the literature, partly because of the difficulties in quantification, and partly because of the lack of a suitable theoretical framework from which to proceed. Indeed, volatility transfer, if it exists at all, may be extremely difficult to quantify: it may dissipate through many channels in the economy, and it could be extremely ephemeral in nature.

III. The Relevance of Volatility Transfer

In this section the question of whether volatility transfer is an important issue is addressed, both in relation to transfer to interest rates and also in relation to a transfer to other real economic variables.

First, in relation to interest rates, there is a link to monetary policy which is emphasised in much of the literature concerning the inherent advantages of fixed versus flexible exchange rates (for examples of this literature see Mundell (1961), Tower and Willett (1976) and Taylor (1988)). The essence of the arguments made in the literature are as follows: on one hand fixing the nominal exchange rate could increase interest rate volatility and therefore interfere with stabilising monetary policy, hence implying wider fluctuations of interest rates and economic activity than otherwise would have been the case under flexible exchange rates. The opposing position depends on the nature of the departures from uncovered interest parity:-

$$e_{t+1} = e_t + (r_t - r_t^{*}) + \varepsilon_t \tag{3.1}$$

where e_t represents the log exchange rate between two currencies, r_t and r_t^{*} represent the domestic interest rate and foreign interest rate respectively and ε_t represents an innovation 'shock' or more simply, a departure from uncovered interest parity. If ε_t has higher variability with flexible exchange rates because of its endogeneity to this type of regime, perhaps due to frequent reassessments of risk premia, then this implies that under fixed exchange rate regimes ε_t would vary less and so interest rates, and therefore prices and output as well, will be more stable than under flexible exchange rates. Note here that if ε_t is the same size under both flexible and fixed exchange rates then under fixed exchange rates, the domestic interest rate would continually be having to adjust to offset changes in ε_t, thereby implying more volatile interest rates than under flexible exchange rates. Hence less volatile interest rates under fixed exchange rates would imply, in this model, that innovations endogenous to flexible exchange rates could be eliminated by moving to a fixed exchange rate regime.

Second, in relation to real economic variables, on first inspection, the fact that less volatile exchange rates appear to have no impact on trade flows, may suggest that output would not be affected by the exchange rate regime. Of course this does not necessarily imply that economic agents are not affected by less volatile exchange rates, as hedging, and the costs associated with such a course of action, may be reduced in these circumstances. If, however, more stable exchange rates encourage less variability in interest rates, then the consumption and investment components of output might be expected to be less variable.

Third, in relation to equation (3.1) above, a distinction should also be made between stability in interest rate differentials and the domestic interest rate itself. If the incidence of demand and supply shocks are broadly equal in magnitude and timing between the two countries, then if fixed exchange rates implied less volatile interest rate differential volatility, then this would also imply less volatility in output, given stabilising monetary policy. If, conversely, monetary policy in the foreign country was aimed at stabilising output in response to country-specific shocks, then given less volatile interest rate differentials, this could indeed increase output volatility. In the context of the ERM of the EMS, this was an argument used frequently by countries such as Italy and France to justify capital controls, as a means of temporarily diverging from the strictures imposed by German monetary policy. The observation that disturbances might be common to a set of countries is the basis of much of the optimal currency area literature. In the light of the discussion above, the distinction between nominal interest volatility and volatility of the interest rate differential becomes crucial in much of the analysis presented below.

In the preceding paragraph, one of the assumptions made was that less interest rate volatility would imply less output volatility. Little appears in the literature on this subject, but Evans (1984) finds that in the case of the U.S., unanticipated interest rate volatility reduces output, but he does not consider the impact on output volatility. The only study to consider the EMS in this context is Flood and Rose (1993), and they find evidence of a reduction in output volatility under non-flexible exchange rate regimes, although they find no evidence of a reduction in interest rate volatility.

So current research suggests that there is no obvious link that would confirm the line of argument that less interest rate volatility implies less output volatility.

IV. The Data and its Distributional Characteristics

The data used for interest rates are weekly 3-month Euro-interest rates for the French franc, Dutch guilder, German mark, all ERM members for the 1979-1992 period, and UK sterling and the US dollar, both floating currencies for the post-1979 period (with the exception of UK sterling which briefly joined the ERM of the EMS during the latter part of the period). Except for the Italian lira, the data begins in January 1975 and runs to the end of January 1992 (for the Italian lira the data begins in June 1978). The data was obtained from the Datastream service, with the exception of the U.S. data and the German data which were obtained from the Federal Reserve and the Bundesbank respectively, but in both these cases, the data were originally sourced from the Bank for International Settlements.

The data used for forward exchange rates are both 1-month and 3-month weekly forward rates for the French franc, Italian lira, Irish punt, Dutch guilder, Belgian franc, all ERM members for the whole of the post-1979 period, and UK sterling, and the German mark against the US dollar, both rates lying outside the purview of the ERM (again with the caveat made above for UK sterling). All the data in this instance was taken from the Datastream service, from January 1976 up until the end of January

1992.

The tables 3.1 to 3.8 give descriptive statistics for the data for the whole period and then for the prior- and post-EMS inception subsamples separately.

TABLE 3.1
Descriptive Statistics for Changes in Euro-interest Rates
(1975-1992)

Currency	μ	σ^2	Sk	Ku
Ffr	-0.00933	2.068	-4.94	111.43
UK£	-0.00933	0.242	-0.42	10.72
Ilira	0.01305	1.091	2.07	38.36
Hfl	0.00140	0.215	0.73	18.34
DM	0.00198	0.039	1.27	29.15
US$	-0.00687	0.142	-0.52	14.07

Notes: i) Total number of observations = 891
ii) Data are 3-month Eurointerest rates

TABLE 3.2
Descriptive Statistics for Changes in Euro-interest Rates
(1975-79 and 1979-92)

Currency	μ	σ^2	Sk	Ku
Ffr	-0.04623	0.692	-0.20	8.10
ERM	0.00251	2.515	5.55	50.94
UK£	-0.03025	0.647	-0.59	3.89
	-0.00195	0.111	1.13	8.08
Ilira	0.05963	0.926	10.15	130.63
ERM	-0.00204	1.145	0.19	18.74
Hfl	0.00627	0.630	0.59	6.64
ERM	-0.00353	0.080	0.24	10.24
DM	-0.01521	0.033	-1.95	8.02
ERM	0.00781	0.041	2.03	33.39
US$	0.00224	0.058	-0.32	2.82
	-0.00967	0.169	-0.50	12.72

Number of observations pre-EMS inception = 219
Number of observations post-EMS inception = 673

TABLE 3.3

Descriptive Statistics for Changes in Euro-interest Rate Differentials

(1975-1992)

Currency	μ	σ^2	Sk	Ku
Ffr	-0.01130	2.105	-4.78	109.61
UK£	-0.01130	0.275	-0.28	8.52
Ilira	-0.01107	1.097	2.07	36.04
Hfl	-0.00057	0.240	0.51	14.84
US$	-0.00884	0.163	-0.33	12.21

Notes: i) Total number of observations = 891
ii) Differentials are against the DM
iii) Data are 3-month Eurointerest rates

TABLE 3.4

Descriptive Statistics for Changes in Euro-interest Rate Differentials

(1975-79 and 1979-92)

Currency	μ	σ^2	Sk	Ku
Ffr	-0.04623	0.692	-0.20	8.10
ERM	-0.00531	2.557	-4.74	98.13
UK£	-0.03025	0.647	-0.59	3.89
	-0.00977	0.149	0.55	7.66
Ilira	0.07569	0.944	9.77	124.62
ERM	-0.00986	1.146	0.23	16.42
Hfl	0.01089	0.654	0.47	6.00
ERM	-0.00429	0.106	-0.19	8.77
US$	-0.01784	0.076	-0.22	1.48
	-0.01749	0.191	-0.32	11.41

Number of observations pre-EMS inception = 219
Number of observations post-EMS inception = 673

TABLE 3.5
Descriptive Statistics for 1-month Forward Rates
(1976-1992)

Currency	μ	σ^2	Sk	Ku
Ffr	0.00082	3.1e-5	2.03	21.02
UK£	-0.00072	13.1e-5	-0.51	2.47
Ilira	0.00126	6.7e-5	2.95	27.27
I£	0.00081	4.8e-5	1.33	13.88
Hfl	0.00011	8.1e-5	0.25	10.17
Bfr	0.00037	2.4e-5	1.97	21.02
Spta	0.00120	12.4e-5	6.34	87.42
DM/US$	-0.00057	22.3e-5	-0.14	1.55

Notes: i) Total number of observations = 839
ii) Data are log change in forward rates

TABLE 3.6
Descriptive Statistics for 1-month Forward Rates
(1976-79 and 1979-92)

Currency	μ	σ^2	Sk	Ku
Ffr	0.00183	8.2e-5	0.84	10.03
ERM	0.00057	1.8e-5	3.04	19.64
UK£	-0.00206	13.9e-5	-0.14	3.09
	-0.00039	12.9e-5	-0.60	2.40
Ilira	0.00336	21.5e-5	1.95	10.31
ERM	0.00074	2.9e-5	1.50	7.22
I£	0.00206	13.9e-5	0.14	3.09
ERM	0.00050	2.5e-5	3.11	28.48
Hfl	0.00033	1.7e-5	-0.05	8.40
ERM	0.00005	0.6e-5	0.43	6.12
Bfr	0.00031	2.7e-5	0.86	5.37
ERM	0.00038	2.3e-5	2.32	26.24
Spta	0.00298	33.7e-5	6.25	54.52
	0.00076	7.1e-5	1.88	16.53
DM/US$	-0.00211	11.6e-5	1.46	11.55
	-0.00020	24.8e-5	-0.30	0.87

Number of observations pre-EMS inception = 166
Number of observations post-EMS inception = 673
See table 3.5 for data description.

TABLE 3.7

Descriptive Statistics for 3-month Forward Rates
(1976-1992)

Currency	μ	σ^2	Sk	Ku
Ffr	0.00082	3.7e-5	1.65	18.79
UK£	-0.00071	13.5e-5	-0.48	2.58
Ilira	0.00125	7.8e-5	2.91	25.81
I£	0.00080	5.3e-5	1.08	12.80
Hfl	0.00011	0.9e-5	0.25	8.31
Bfr	0.00036	2.5e-5	1.42	13.88
Spta	0.00119	10.6e-5	3.85	39.20
DM/US$	-0.00056	21.9e-5	-0.12	1.49

Notes: i) Total number of observations = 839
ii) Data are log changes in forward rates

TABLE 3.8

Descriptive Statistics for 3-month Forward Rates
(1976-79 and 1979-92)

Currency	μ	σ^2	Sk	Ku
Ffr	0.00183	9.8e-5	0.49	8.78
ERM	0.00056	2.2e-5	2.86	18.06
UK£	-0.00205	15.4e-5	-0.11	3.38
	-0.00038	13.0e-5	-0.58	2.38
Ilira	0.00338	24.7e-5	1.96	9.79
ERM	0.00073	3.5e-5	1.50	8.12
I£	0.00205	15.4e-5	0.11	3.38
ERM	0.00049	2.8e-5	2.40	21.43
Hfl	0.00034	2.0e-5	0.85	5.84
ERM	0.00005	0.6e-5	0.26	5.33
Bfr	0.00031	3.2e-5	0.82	5.66
ERM	0.00038	2.4e-5	1.64	17.29
Spta	0.00296	25.8e-5	4.00	27.12
	0.00075	6.8e-5	1.73	15.89
DM/US$	-0.00215	11.9e-5	1.36	10.67
	-0.00017	24.3e-5	-0.29	0.83

Number of observations pre-EMS inception = 166
Number of observations post-EMS inception = 673

Several interesting observations can be gleaned from the tables above. Firstly, in relation to tables 3.1 and 3.2 above, both France and Italy had significantly higher Euro-interest rate volatility over the 1975-1992 period than did other countries and also their skewness and kurtosis measures were also larger than for other countries. This could reflect both the imposition of capital controls and also the fact that capital controls allowed substantially different domestic monetary policy to be pursued by these countries for much of the sample period. When the descriptive statistics are repeated for the pre- and post-EMS inception subsample periods a different story emerges. Table 3.2 suggests that the Ffr, Ilira, DM and US$ Euro-interest rates are more volatile post-1979, but that Hfl and the UK£ are less volatile post-1979. Furthermore, the statistics suggest that kurtosis increased for all currencies post-1979, with the exception of the Ilira rate.

As capital controls began to be removed in 1983, perhaps Euro-interest differentials give a better indication of the nature of the change in offshore interest rate volatility, as countries began to adapt to the greater influence of Bundesbank policy. Tables 3.3 and 3.4 tell a similar story, however, with interest rate differentials shrinking, but less so after 1979, more volatility for the Ffr, Ilira and US$ vs DM, but less volatility for UK£ and Hfl. Kurtosis also increased post-1979, again with the exception of the Ilira. It should also be noted that the average change in differential with the Euro-DM interest rate is lower in all cases post-1979, that is to say, interest rates did tend to move more in concert with those in Germany both within and outside the EMS.

In the case of forward exchange rates descriptive statistics, as might be expected over the period 1976-1992 all average changes in forward rates, with the exception of the Ffr and Spta, were lower than for spot rates (reported in Chapter two). Interestingly, the average change in the I£ changed sign from being negative in the spot market to being positive in both the 1- and 3-month forward markets. Looking at the 1-month forward rates in table 3.6, volatility as measured by the variance appears to have fallen for all currencies with the exception of the DM/$ rate, but kurtosis does not appear to have fallen consistently for the ERM currencies as was the case for spot currencies. When comparing the kurtosis measure with spot rates, however, with the exception of the Ilira and Spta, kurtosis appears to have fallen for 1-month forwards compared with spot rates. When comparing the 3-month forward rates with the 1-month forwards, the above results still hold, but there are some interesting qualitative differences. Firstly, with the exception of UK£, kurtosis falls when moving from 1-month forwards to 3-month forwards. Secondly in general skewness also falls. Thirdly, the variance measures are roughly the same for all currencies.

The descriptive statistics above allow an interesting investigation into a phenomena that De Grauwe (1990) has noted.

If speculative attacks are mounted on a weak currency that enjoys capital controls, sharp increases in offshore interest rates are likely to be observed - such changes would not be apparent in domestic interest rates. De Grauwe's argument is that in the absence of capital controls onshore and offshore interest rates would be virtually identical, so monetary policy would be constrained by external factors. In the light of this argument, the measure of skewness gives a good indication of the extent of speculative attacks, both with and without capital controls. From tables 3.1 to 3.4 it is apparent that speculative attacks have mostly affected the Ffr and the Ilira, and most interestingly, the incidence of speculative attacks for the Ffr occurs after the inception of the EMS and for the Ilira before the inception of the EMS. Perhaps the reasons for this apparent inconsistency stem from the different band widths used by these two currencies post-EMS inception and the frequent speculative attacks mounted against the Ffr before the Mitterand government decided to reverse its economic policies in 1982.

As interest rates are financial variables, they are likely to exhibit fat-tailedness, as do exchange rates. Two approaches were used when testing for normality, the first being the usual parametric test procedures, and the second being non-parametric. The parametric tests consist of a skewness test, a kurtosis test and the Bera-Jarque test for normality. The non-parametric test used is the Smirnov test which tests the maximum distance between the observed cumulative distribution and the normal distribution.

The results are tabulated in tables 3.9 to 3.12.

TABLE 3.9

Tests for Normality - 3-month Euro-interest Rates
(1975-79)

Currency	Skewness	Kurtosis	Bera-Jarque	Smirnov
Ffr	-2.87 (0.63)	114.27 (0.0)	545 13 (0.0)	-0.114
UK£	-8.48 (0.16)	54.54 (0.02)	135.95 (0.0)	-0.093
Ilira	2.94 (0.62)	5.89 (0.81)	2.89 (0.24)	0.405
Hfl	8.53 (0.15)	93.54 (0.0)	376.76 (0.0)	0.154
DM	-28.47 (0.0)	114.03 (0.0)	676.89 (0.0)	-0.140
US$	-4.65 (0.0)	39.26 (0.10)	67.83 (0.0)	-0.068

Footnotes: i) 218 observations.
ii) Figures in parenthesis are marginal significance levels.
iii) Smirnov test critical values: 5% = 0.092, 1% = 0.110

TABLE 3.10

Tests for Normality - 3-month Euro-interest Rates
(1979-92)

Currency	Skewness	Kurtosis	Bera-Jarque	Smirnov
Ffr	-126.36 (0.0)	2558.34 (0.0)	275373.28 (0.0)	-0.270
UK£	29.23 (0.0)	206.88 (0.0)	1925.70 (0.0)	0.118
Ilira	4.96 (0.41)	480.77 (0.0)	9634.75 (0.0)	0.165
Hfl	6.29 (0.29)	262.51 (0.0)	2877.96 (0.0)	0.120
DM	52.36 (0.0)	856.73 (0.0)	31039.68 (0.0)	0.123
US$	-12.86 (0.03)	326.13 (0.0)	4459.38 (0.0)	-0.143

Footnotes: i) 673 observations.
ii) Figures in parenthesis are marginal significance levels.
iii) Smirnov test critical values: 5% = 0.052, 1% = 0.063

TABLE 3.11

Tests for Normality - 3-month Euro-interest Rates
(1975-79)

Currency	Skewness	Kurtosis	Bera-Jarque	Smirnov
Ffr	-2.75 (0.65)	105.87 (0.0)	468.30 (0.0)	-0.090
UK£	-6.94 (0.25)	48.81 (0.04)	127.27 (0.0)	-0.087
Ilira	142.30 (0.0)	1780.89 (0.0)	135524.42 (0.0)	0.275
Hfl	6.88 (0.25)	85.01 (0.0)	309.01 (0.0)	0.121
US$	3.21 (0.59)	20.32 (0.40)	18.92 (0.0)	-0.061

Footnotes: i) 218 observations.
ii) Figures in parenthesis are marginal significance levels.
iii) Smirnov test critical values: 5% = 0.092, 1% = 0.110

TABLE 3.12

Tests for Normality - 3-month Euro-interest Rates Differentials
(1979-92)

Currency	Skewness	Kurtosis	Bera-Jarque	Smirnov
Ffr	-122.34 (0.0)	2518.92 (0.0)	266867.52 (0.0)	-0.247
UK£	14.25 (0.02)	196.15 (0.0)	1637.01 (0.0)	0.093
Ilira	6.00 (0.32)	421.14 (0.0)	7395.85 (0.0)	-0.144
Hfl	-4.87 (0.42)	224.76 (0.0)	2108.73 (0.0)	0.098
US$	-8.32 (0.17)	292.60 (0.0)	3578.78 (0.0)	-0.134

Footnotes: i) 673 observations.
ii) Figures in paranthesis are marginal significance levels.
iii) Smirnov test critical values: 5% = 0.052, 1% = 0.063

The tables above confirm that both interest rates and interest rate differentials do not exhibit normality, although some of the interest rates do not have skewness measures that depart too far from those that would be obtained for a normal distribution. As with exchange rates, the main reason for the departure from normality is the kurtosis measure, which indicates peakedness or fatness of the tails of the distribution. The tables for forward exchange rates are not reported here, but the results are qualitatively identical to those obtained for spot exchange rates.

V. Testing for Changes in Interest Rate Volatility and Forward Exchange Rate Volatility

As the above section shows, the distribution of interest rate changes would clearly not be best characterised by the normal distribution. It therefore appears pragmatic to avoid making any distributional assumptions about the form or shape of the empirical distribution. This implies that the best m. lological approach to testing for any changes in the loca..on or scale parameters would be to adopt non-parametric distribution-free techniques, such as rank tests (- these tests are performed upon ordinal measures relating to the data, rather than to actual data values). This was the approach also taken by Artis and Taylor (1988).

Two separate approaches are used to test for a reduction in the scale variable post-1979. The first method uses a variety of linear rank tests [see Randles and Wolfe (1979) and for all the tests covered here see also Annex 2A], and a second uses a technique that was first proposed by Hajek and Sidak (1967), and was used in Chapter two. Artis and Taylor also used these tests as applied to monthly changes in onshore short-term interest rates and found a reduction in interest rate volatility for France, Italy, UK and the Netherlands and an increase in interest rate volatility for the US. In this section a variety of rank tests are applied to weekly data to attempt to explore in depth the issues surrounding interest rate and forward exchange rate volatility in the ERM of the EMS.

a) Linear Rank Tests

A two-sample linear rank test statistic can be defined in the following way: merge the two samples, assign ranks to observations in the merged sample, then construct the rank statistic. As the following repeats similar analysis to that of Chapter two, the properties of linear rank statistics will not be reported here (- see Annex 2A for more about these tests).

Three issues, though, do need to be addressed when using linear rank tests to test for changes in scale - firstly that of a change in the distribution or the form of the distribution between the two samples, secondly the problem of ties and thirdly a simultaneous change in location between the two subsamples.

The first issue is that of a change in the form of the empirical distribution between the data subsamples. None of the linear rank tests account for any change in the form of the distribution that occurs with a change in regime. So as to test for a change in distribution between the two subsamples, a Kolgomorov-Smirnov test was employed (see Randles and Wolfe (1979)). The results are given in table 3.13 to 3.16 for interest rates, interest rate differentials and exchange rate forwards.

TABLE 3.13
Test for Distribution Change
(Euro-interest Rates)

Country	Euro-interest rate	Differential
France	0.170	0.112
UK	0.234	0.200
Italy	0.374	0.219
Holland	0.204	0.158
Germany	0.049	-
US	0.045	0.047

Note: Kolmogorov-Smirnov test significance levels: 5% = 0.106, 1% = 0.127

TABLE 3.14
Test for Distribution Change
(Forward Exchange Rates)

Currency	1-month	3-month
Ffr	0.097	0.104
UK£	0.011	0.011
Ilira	0.120	0.157
I£	0.166	0.175
Hfl	0.082	0.057
Bfr	0.030	0.014
DM/US$	0.159	0.158

Note: Kolmogorov-Smirnov test significance levels: 5% = 0.118, 1% = 0.141

In table 3.13 on offshore interest rates, all the ERM countries, with the exception of Germany, appear to have undergone a change in empirical distribution, whilst the non-ERM countries (the UK and the US) appear to give no consistent result. The results for forward exchange rates in table 3.14 do not appear to show any distinct pattern, which is surprising, because Chapter two suggested that all the ERM currencies, with the exception of the Bfr, underwent a change in distribution. The problem here is that if a change in distributional form occurs, it is not possible using this test to identify whether the change is attributable to the form of the distribution or to only a change in scale.

The second problem is that of tied observations. As the Euro-currency market prices deposits using a discrete scale (which is subdivided into 32nds, and at the finest, 64ths), the distribution of changes will not be continuous, but rather will consist of masses at discrete intervals. There will therefore be ties throughout the distribution. This problem is not easily adjusted for without using some technique for smoothing the distribution, such as kernel estimation. In the context of the tests for a volatility shift that are used in this study, these ties will probably not significantly affect the results for two reasons: the first being that the empirical distributions are reasonably dispersed so that there are many mass points rather than just a few, and secondly, both subsamples suffer from the same problem of ties so that the volatility shift tests should still fairly accurately reflect a change in the form of the empirical distribution.

The problem of ties with forward exchange rates is somewhat different from that of interest rates. With forward exchange rates, as with spot exchange rates, quotes are made on almost a continuous scale, so there is unlikely to be a problem of ties, but with one exception - that of zero. A zero observation represents no movement in exchange rates from week to week, and occasionally, particularly during the post-EMS inception period this was the case. Further, with forward rates, when exchange rates are in an adjustable peg system, if market expectations do not change, one might expect the incidence of zeros to be high. Thus there could be a possibility of ties. Tables 3.15 and 3.16 give the number of zeros in each subsample and a test for a difference in proportion of zeros between the two subsamples in each case.

TABLE 3.15
Test for Differences in Proportion of Zeros
(1-month forward exchange rates)

Currency	Zeros 76-79	Zeros 79-92	Test for Proportion diff.
Ffr	0	0	-
UK£	5	13	2.126
Ilira	0	1	-1.249
I£	5	0	1.424
Hfl	0	0	-
Bfr	1	0	-1.908
DM/$	0	0	-

Notes: i) number of observations 76-79 = 167
79-92 = 673
ii) a positive test statistic implies a lower proportion of zeros in the post-1979 period and vice-versa.

TABLE 3.16

Test for Differences in Proportion of Zeros
(3-month forward exchange rates)

Currency	Zeros 76-79	Zeros 79-92	Test for Proportion diff.
Ffr	0	0	-
UK£	5	8	4.239
Ilira	0	0	-
I£	5	0	11.281
Hfl	0	0	-
Bfr	2	0	7.122
DM/$	0	0	-

Notes: i) number of observations 76-79 = 167
79-92 = 673
ii) a positive test statistic implies a lower proportion of zeros in the post-1979 period and vice-versa.

The results in the tables above go against our expectations: that is, expectations are not static - the forward exchange rate tends to shift from week to week, both for 1-month forwards and for 3-month forwards, even post-1979. In fact where there are observations at zero, there is a lower proportion of zeros post EMS-inception.

The third problem is a change in the median between the two subsamples. This is relevant to the testing procedure used as many of the tests are not valid if significant location changes are observed. The test statistic used is the Mood-Westenberg test (see Gibbons (1985)) and the results are reported in tables 3.17 and 3.18.

TABLE 3.17

Median Test - Euro-interest Rates
Mood-Westenberg Test Statistic

Currency	3month Eurointerest Rate	3m Eurointerest Differential
Ffr	-0.063	-0.095
UK£	0.580	0.916
Ilira	8.647	-0.951
Hfl	0.554	-0.407
DM	0.154	-
US$	-0.703	-0.992

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.18

Median Test - Forward Exchange Rates
Mood-Westenberg Test Statistic

Currency	1-month Forward Rates	3-month Forward Rates
Ffr	-1.230	-1.404
UK£	2.341	2.548
Ilira	-3.310	-2.790
I£	-1.577	-1.750
Hfl	-2.097	-1.404
Bfr	0.329	-0.191
DM/$	3.068	3.068

Note: The asymptotic distribution of this statistic is standard normal.

The results for a change in median between the two subsamples for interest rates show that with the exception of the lira Eurorate, there is no change in median pre- and post-1979. This is in direct contrast to the results for forward exchange rates, where there appears to have been a shift in median for many of the exchange rates.

Bearing the above three problems in mind, it is now possible to test for a change in volatility between the two subsamples. Following the process of testing used in chapter two, a non-parametric (runs) test for independence is now used. The runs test was applied to the data and the results are tabulated in tables 3.19 and 3.20.

TABLE 3.19
Runs Test - First Differenced Interest Rates
1975-92

Currency	3month Eurointerest Rate	3m Eurointerest Differential
Ffr	0.302	-0.503
UK£	-0.436	-0.436
Ilira	-4.525	1.710
Hfl	-1.173	1.307
DM	-2.045	-
US$	-5.397	-2.983

Note: i) The asymptotic distribution of this statistic is standard normal.
ii) The two-sided 5% level of significance is 1.96.

TABLE 3.20
Runs Test - Logged First Differenced Forward Exchange Rates
1976-92

Currency	1-month Forward Rates	3-month Forward Rates
Ffr	-0.104	-0.518
UK£	-1.347	-2.038
Ilira	1.140	1.416
I£	3.074	2.522
Hfl	5.562	5.285
Bfr	5.700	5.009
DM/$	-2.591	-1.900

Note: i) The asymptotic distribution of this statistic is standard normal.
ii) The one-sided 5% level of significance is 1.96.

The runs tests show that for ERM currency interest rates, with the exception of the Italian rate and perhaps the German mark, there is no evidence that the assumption of exchangeability will not be met. There does not appear to be a problem with runs for the interest rate differential. With certain forward exchange rates, however, there appears to be a problem with the assumption of exchangeability. On further inspection, it appears that the number of runs, post-1979, increases quite dramatically for the I£, Hfl and Bfr. As all these three currencies were subject to very tight management against the DM in the post-1985 period, this could perhaps be explained by a stabilisation of expectations, in the light of the low frequency of realignments, which gives rise to these long runs. The fact that change in median between the two subsamples is not significant in five out of six of these cases, suggests that this explanation may be appropriate. Interpretation aside, these possible violations of assumptions should be borne in mind when evaluating the tests results presented below.

Three types of linear rank test were used, the Ansari-Bradley test, the Siegel-Tukey test and the Mood test. These tests are all described in detail in Annex 2A. Due to the size of the data set, normal approximations were employed rather than the exact distributions of these test statistics. The results are shown in tables 3.21 to 3.24 below. The null hypothesis is of no change in the scale parameter.

TABLE 3.21

Linear Rank Tests for a Change in Scale in Interest Rates
(1975-79 and 1979-92)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	6.22	6.36	-5.79
UK£	10.18	10.32	-11.53
Ilira	-10.98	-10.80	10.52
Hfl	12.04	12.19	-11.17
DM	-1.01	-0.85	0.98
US$	-1.17	-1.00	1.45

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.22

Linear Rank Tests for a Change in Scale in Interest Rate Differentials
(1975-79 and 1979-92)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	5.36	5.53	-4.82
UK£	9.44	9.63	-10.60
Ilira	-10.14	-9.96	8.84
Hfl	8.15	8.32	-9.14
US$	-0.69	-0.52	0.96

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.23

Linear Rank Tests for a Change in Scale in 1-month Forward Exchange Rates

(1976-79 and 1979-92)

(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	8.81	9.04	-9.61
UK£	-0.46	-0.06	0.34
Ilira	8.05	8.28	-9.11
I£	8.90	9.13	-10.47
Hfl	5.82	6.04	-6.11
Bfr	2.34	2.58	-2.63
DM/$	-6.89	-6.64	6.16

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.24

Linear Rank Tests for a Change in Scale in 3-month Forward Exchange Rates

(1976-79 and 1979-92)

(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	7.50	7.73	-8.51
UK£	-0.13	0.12	-0.13
Ilira	9.34	9.59	-10.20
I£	8.49	8.73	-10.13
Hfl	7.18	7.41	-7.90
Bfr	2.59	2.83	-2.85
DM/$	-6.57	-6.32	5.93

Note: The asymptotic distribution of this statistic is standard normal.

Tables 3.21 and 3.22 yield several interesting unexpected results. Firstly, the Ansari-Bradley and Siegel-Tukey tests appear to give diametrically opposed results to the Mood test. As explained in Chapter two, this is due to the fact that these two types of rank test place different weights upon the ranks. The Ansari-Bradley and Siegel-Tukey tests give a higher weighting to the centre of the distribution, whereas the Mood tests gives greater weights to the tails of the distribution. So, for the Ffr, UK£ and the Hfl offshore rates and rate differentials, there was a volatility shift from the tails of the distribution in towards the centre of the distribution post-1979 (- a shift from higher-order volatility to lower-order volatility). For the Ilira, though, this is reversed - there is more volatility in the tails and less volatility at the centre of the distribution. As expected, for the US$ offshore rate there is no significant difference in the volatility of either the tails or towards the centre of the distribution. This result is probably due to capital controls in Italy, which were lifted far later than in any other of the countries under consideration - further, Italy suffered many more speculative attacks and devaluations during the post-1979 than other ERM countries. Two other observations can be made from the results above: firstly, the UK (which abolished capital controls in 1981), although briefly a member of the ERM of the EMS, exhibits the same shift in interest rate volatility as the other main ERM participants (excepting Italy): and secondly, German (or West German as it was in the 1980s) interest rates show no appreciable change in volatility post-1979. The implications are that the UK, by a combination of factors such as the lifting of its capital controls and its later shadowing of German monetary policy, reaped similar benefits to the ERM participants in terms of greater interest rate and therefore monetary policy stability. Further, the German interest rate result suggests that the burden of monetary policy adjustment to the strictures of the ERM fell squarely on the non-German ERM participants. This conclusion, therefore, tends to confirm the view that the ERM did operate, in monetary policy terms, as an asymmetric exchange rate regime (sometimes referred to as the German dominance hypothesis - see Fratianni and von Hagen (1990)) with the Bundesbank setting monetary policy.

Tables 3.23 and 3.24 also yield interesting results for forward exchange rates. Firstly, the forward rate results differ substantially from those obtained for spot rates, described in Chapter two. The results for spot rates generally show a significant fall in volatility in both the middle of the distribution and in the tails of the distribution for ERM currencies. Here, the results imply that forward rate volatility fell in the tails but increased in the central portion of the distribution. The flexible spot exchange rates showed a decrease in volatility at the centre of their distributions, with no change in their tail volatility, in contrast to the ERM spot exchange rate results. Above, with the flexible forward exchange rates, the UK£ shows no change in volatility and the DM/US$ shows an increase in tail volatility and a reduction in volatility towards the centre of the distribution. These results are more consistent with the results obtained from the rank tests for a change in scale in spot exchange rates before and after capital controls began to be dropped in 1983 (also reported in Chapter two). Why? If the removal of capital controls triggered the appropriate shift in volatility in the empirical distributions of spot exchange rates, then clearly this shift in volatility had already occurred in the forward market long before 1983. As the forward market reflects market expectations about expected future spot rates, it implies that the ERM encouraged greater stability in expectations, even though this was not necessarily reflected in greater stability in spot rates until after capital controls were lifted. A comparison of the nature of the volatility shift in expectations 1 month ahead and 3 months ahead is also of interest. The floating rates (US$ and UK£) undergo a slightly larger change in distribution form 1 month forward than 3 months forward. This is also true for the Ffr and the I£ offshore rates. Yet all the other ERM currencies undergo a slightly larger change in 3 month forwards (whether this is in terms of higher-order or lower-order volatility). What should be expected here? If the ERM were perfectly credible, then a greater change in distribution should be observed for 3-month forwards - indeed for countries like the Netherlands, which wholeheartedly tied its economic policies to maintaining ERM parities, this result holds true. The implication is that the foreign exchange market did not take the French and Irish commitment to the ERM as seriously as with countries such as Italy, the Netherlands and Belgium. Also it could be that the initial years of the EMS are having a disproportionate effect on the results, given that both France and Ireland took some time to make their economic policies consistent with ERM constraints.

In assessing the effects of capital controls on the ERM of the EMS, Giavazzi and Spaventa (1990) have claimed that effectively a change of regime took place as of April 1983, as countries commenced the process of dismantling capital controls. To explore the possibility that the empirical interest rate and exchange rate forward distributions under consideration underwent a significant change at this time, the linear rank tests are repeated for the EMS period to test for a change in volatility before and after 1983. The results are given below in tables 3.25 to 3.28.

TABLE 3.25

Linear Rank Tests for a Change in Scale in Interest Rates
(1979-83 and 1983-92)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	8.82	8.97	-9.57
UK£	8.06	8.26	-7.97
Ilira	12.08	12.27	-13.09
Hfl	10.16	11.73	-9.69
DM	8.28	8.47	-8.88
US$	12.81	12.98	-13.49

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.26

Linear Rank Tests for a Change in Scale in Interest Rate Differentials
(1979-83 and 1983-92)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	9.02	9.20	-9.62
UK£	7.18	7.36	-7.49
Ilira	12.09	12.25	-13.22
Hfl	9.24	9.40	-9.56
US$	9.94	10.12	-10.82

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.27

Linear Rank Tests for a Change in Scale in 1-month Forward Exchange Rates

(1979-83 and 1983-92)

(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	5.50	5.69	-6.04
UK£	2.15	2.35	-2.23
Ilira	6.20	6.39	-6.73
I£	2.31	2.50	-2.59
Hfl	8.18	8.38	-8.55
Bfr	1.08	1.26	-1.70
DM/$	-2.05	-1.86	2.06

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.28

Linear Rank Tests for a Change in Scale in 3-month Forward Exchange Rates

(1979-83 and 1983-92)

(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	5.60	5.79	-6.59
UK£	2.27	2.47	-2.28
Ilira	7.10	7.29	-7.52
I£	2.92	3.11	-2.82
Hfl	8.05	8.25	-8.91
Bfr	2.10	2.29	-2.56
DM/$	-2.45	-2.26	2.50

Note: The asymptotic distribution of this statistic is standard normal.

Comparing tables 3.21 and 3.22 with 3.25 and 3.26 offers some interesting insights for interest rates. The most obvious differences are with the Italian offshore rate, which now undergoes a similar distribution change to its ERM partners (less tail volatility and more volatility towards the centre of the distribution), and with the German and US offshore interest rates, which now appear to have undergone similar changes to the other ERM rates. Two important results are forthcoming from these observations. Firstly, in the ERM context, once capital controls were removed, higher-order volatility transfer to interest rates did not occur. Secondly, the US offshore interest rate also appears to have benefited from less higher-order volatility, but this cannot be attributed to the ERM - rather, the abandonment of strict monetary aggregate targeting appears to be a possible candidate for explaining this change. The UK, which was probably the most fervent adherent to strict monetary aggregate targeting, retains a similar shift in the form of its interest rate distribution, corroborating this view.

The results for forward exchange rates can be found by comparing tables 3.23 and 3.24 with 3.27 and 3.28. The results fall neatly into those pertaining to ERM currencies and those pertaining to floating rates. All ERM currencies had significant changes in the form of their empirical distributions post-1983 but this change was less significant than the one that occurred at the beginning of the EMS. Also, with the exception of the Hfl, the change was more significant for 3-month forwards than for 1-month forwards. This is perhaps a good reflection of the credibility effects afforded to ERM currencies, but also shows that full credibility effects are not granted until capital controls are removed. The results for floating rates are somewhat different: in 1983 the two floating rates changed in completely the opposite direction - the DM/$ rate acquired fatter tails while the UK£, instead of showing no appreciable change (as in 1979), tended to follow its European partners, and most noticeably against the DM. As the forward rate, under covered interest parity, just differs from the spot rate by the interest rate differential, and covered parity holds in most instances (see Taylor (1987)), less volatile spot exchange rates and domestic interest rates will automatically lead to less volatile forward rates. In this case, though, the result is remarkable, in that other lacuna, which would be expected to make covered interest parity irrelevant here, in the form of the continuation of capital controls by such countries as Italy, does not diminish the result in any way - the result for Italy is perhaps the strongest.

To complete this analysis, it is perhaps of interest to inquire as to whether the early years of the EMS afforded similar benefits to ERM currency countries. The linear rank tests were again repeated for the period before 1979 and the period 1979-1983. These results appear in tables 3.29 to 3.32 below.

TABLE 3.29

Linear Rank Tests for a Change in Scale in Interest Rates
(1975-79 and 1979-83)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	-0.93	-0.79	2.11
UK£	4.94	5.08	-5.47
Ilira	-12.08	-12.24	12.79
Hfl	3.42	3.52	-3.52
DM	-5.44	-5.31	5.72
US$	-8.72	-8.58	8.96

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.30

Linear Rank Tests for a Change in Scale in Interest Rate Differentials
(1975-79 and 1979-83)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	-1.66	-1.52	2.73
UK£	4.22	4.38	-4.40
Ilira	-12.80	-12.65	12.58
Hfl	2.12	2.25	-2.56
US$	-6.19	-6.04	6.99

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.31

Linear Rank Tests for a Change in Scale in 1-month Forward Exchange Rates

(1976-79 and 1979-83)

(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	4.60	4.79	-4.09
UK£	-1.56	-1.34	1.92
Ilira	3.56	3.74	-3.84
I£	6.58	6.78	-6.92
Hfl	0.16	0.33	0.13
Bfr	1.29	1.50	-0.60
DM/$	-4.66	-4.43	4.56

Note: The asymptotic distribution of this statistic is standard normal.

TABLE 3.32

Linear Rank Tests for a Change in Scale in 3-month Forward Exchange Rates

(1976-79 and 1979-83)

(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	3.30	3.50	-3.17
UK£	-1.36	-1.14	1.49
Ilira	4.18	4.37	-4.40
I£	6.10	6.29	-6.75
Hfl	1.64	1.82	-1.37
Bfr	0.97	1.18	-0.54
DM/$	-4.05	-3.82	4.06

Note: The asymptotic distribution of this statistic is standard normal.

The results from tables 3.29 and 3.30 show that only the Netherlands and the UK underwent a reduction in interest rate volatility, while the French and Italian offshore rates were more volatile in the early part of the EMS period, as was the US offshore rate. It is interesting to speculate whether the the UK would have had similar results to the US, had it not lifted capital controls in 1981, given its monetary policy.

The forward rate results given in tables 3.31 and 3.32 suggest that ERM forward rate volatility decreased post-1979, even though realignments were relatively frequent, and flexible forward rate volatility increased post-1979. It should be noted that the largest changes in volatility occurred with those countries that maintained capital controls - this points to the recognised trade-off between exchange rate volatility and offshore interest rate volatility under these circumstances.

b) Hajek and Sidak 'Maintained' Distribution Test

As stated in Chapter two, one of the problems with the classical linear rank tests described above, is that although the actual empirical distributions need not be known by the researcher, the rank tests vary in their power according to the nature of the actual underlying distribution. Hajek and Sidak (1967) developed a rank test procedure that permits a uniformly most powerful test, given knowledge of the underlying distribution. This test was described in Chapter two.

Tables 3.33 to 3.36 below show the results of running the

Hajek-Sidak tests for offshore interest rates and forward foreign exchange rates.

TABLE 3.33
Maintained Distribution Test Statistics for a Shift in Volatility in Interest Rates
(1975-9 and 1979-92)

Currency	Logistic	D-Exp	Normal	Cauchy	t(2)	t(3)
Ffr	3.56	3.57	2.59	6.76	5.69	4.93
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
UK£	11.96	11.80	11.72	10.05	11.51	11.89
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Ilira	1.36	1.38	1.20	1.74	1.65	1.55
	(0.09)	(0.08)	(0.11)	(0.04)	(0.05)	(0.06)
Hfl	11.32	11.19	11.19	9.72	10.80	11.12
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
DM	-0.80	-0.75	-0.73	-0.93	-0.93	-0.89
	(0.21)	(0.22)	(0.23)	(0.18)	(0.18)	(0.19)
US$	-2.20	-2.18	-2.46	-0.71	-1.39	-1.73
	(0.01)	(0.02)	(0.01)	(0.24)	(0.08)	(0.04)

Notes: i) Statistics are asymptotically standard normal variates under the null hypothesis. Figures in parentheses are marginal significance levels. Positive figures indicate a reduction in volatility.

ii) The derivation of the asymptotic score for the two t distributions is located in Annex 2B.

TABLE 3.34
Maintained Distribution Test Statistics for a Shift in Volatility in Interest Rate Differentials
(1975-9 and 1979-92)

Currency	Logistic	D-Exp	Normal	Cauchy	t(2)	t(3)
Ffr	2.96	3.02	2.09	5.94	4.87	4.19
	(0.0)	(0.0)	(0.02)	(0.0)	(0.0)	(0.0)
UK£	10.88	10.77	10.59	9.41	10.67	10.95
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Ilira	-7.19	-7.50	-6.35	-9.88	-8.82	-8.22
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Hfl	10.06	10.05	10.09	7.98	9.19	11.12
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
US$	-1.67	-1.63	-1.94	-0.71	-1.39	-1.73
	(0.05)	(0.05)	(0.03)	(0.24)	(0.08)	(0.04)

See notes under table 3.33

TABLE 3.35

Maintained Distribution Test Statistics for a Shift in Volatility in 1-month Forwards
(1976-79 and 1979-92)

Currency	Logistic	D-Exp	Normal	Cauchy	t(2)	t(3)
Ffr	9.77	9.75	9.53	8.67	9.58	9.78
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
UK£	-0.03	0.01	0.12	-0.37	-0.32	-0.25
	(0.49)	(0.50)	(0.45)	(0.35)	(0.37)	(0.40)
Ilira	9.98	9.98	10.06	7.81	9.04	9.49
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
I£	11.39	11.22	11.37	8.54	10.35	10.99
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Bfr	2.32	2.31	2.17	2.31	2.46	2.43
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Hfl	5.98	6.02	5.77	5.83	6.08	6.09
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
DM/$	-5.46	-5.64	-4.97	-6.58	-6.22	-5.99
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)

See notes under table 3.33

TABLE 3.36

Maintained Distribution Test Statistics for a Shift in Volatility in 3-month Forwards
(1976-79 and 1979-92)

Currency	Logistic	D-Exp	Normal	Cauchy	t(2)	t(3)
Ffr	9.03	9.75	9.53	7.48	8.51	8.82
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
UK£	0.49	0.51	0.66	0.05	0.16	0.23
	(0.31)	(0.31)	(0.26)	(0.48)	(0.44)	(0.41)
Ilira	10.96	11.02	10.95	9.06	10.16	10.57
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
I£	11.13	10.94	11.13	8.09	10.07	10.72
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Bfr	2.63	2.65	2.51	2.50	2.68	2.70
	(0.004)	(0.004)	(0.006)	(0.006)	(0.004)	(0.004)
Hfl	7.74	7.68	7.43	7.19	7.87	7.93
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
DM/$	-5.27	-5.42	-4.80	-6.32	-5.99	-5.77
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)

See notes under table 3.33

As might be expected, Hajek-Sidak tests yield nearly the same qualitative results as the Mood test. The only slight difference lies in offshore interest rates, and with the Ilira offshore rate in particular. In the linear rank tests, the higher-order volatility increases (as measured by the Mood test), whereas with the Hajek-Sidak test there is no significant change in volatility. This difference in result, however, is not maintained when interest-rate differentials are used.

V. Conclusions

The results of this chapter are tentative: volatility transfer as a phenomenon does not appear to occur between exchange rates and interest rates in an adjustable-peg exchange rate regime setting. These conclusions tend to confirm findings elsewhere that adjustable-peg exchange rate regimes do not significantly exacerbate interest rate fluctuations, and if anything, may dampen such volatility. In using a statistical approach to this problem though, it should be stressed that as interest rates under flexible exchange rate regimes are rarely set completely independently of the exchange rate, this must inevitably compromise the results. Further, in reference particularly to the benelux countries, it should also be noted that no account has been taken of the fact that the 'snake' was operating prior to 1979 - this may also have affected the results for these countries.

Also of interest was further confirmation of the view that the ERM likely operated, in monetary policy terms, as an asymmetric exchange rate regime (sometimes referred to as the German dominance hypothesis), given that German interest rate volatility did not alter post-1979 whereas volatility in other ERM countries showed a marked shift.

It also appears that forward rates do not react to the spot rate being tied into an adjustable-peg exchange rate regime, given that the regime itself is reasonably robust and credible. Also, the market's assessment of the degree of credibility in the membership of various currencies in the ERM showed up in an interesting way in the volatility of forwards through time. In addition, the results suggested that the ERM encouraged greater stability in expectations, even though this was not necessarily reflected in greater stability in spot rates until after capital controls were lifted. In this sense, perhaps forward exchange rates might be a better indicator of a change in regime, as they are free of the effects of capital controls.

On a final note, the issue of volatility transfer is not yet a dead one. Volatility transfer might still occur under certain circumstances, and it may occur between exchange rates and variables other than interest rates. Such an analysis is not attempted here, but clearly, given our limited understanding of the behaviour of economic variables under different exchange rate regimes, research might be profitably directed to this area.

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Chapter Four: ERM EXCHANGE RATES AND TARGET ZONES

I. Introduction

The Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) is a de facto target zone. A target zone is a hybrid exchange rate regime, and is otherwise known as an adjustable peg exchange rate regime. In a managed floating exchange rate regime, the monetary authorities can, at their discretion, intervene in the foreign exchange market to influence the exchange rate. In a fixed or pegged exchange rate regime, the monetary authority agrees to fix the rate for buying and selling the domestic currency against another currency or basket of currencies, and undertakes to buy and sell unlimited quantities at the stated fix. A target zone or adjustable peg regime has elements of both managed and fixed exchange rate regimes. The monetary authorities can intervene to maintain the domestic currency within a specified band against another currency or basket of currencies. Realignments (or an adjustment of the peg) occur when monetary authorities are unwilling to intervene to support the domestic currency and incipient market pressures push the exchange rate outside of its target range.

The characterisation of an adjustable peg exchange rate regime as a target zone stems from the seminal paper of Krugman (1991) which was the first attempt to explicitly analyse the effects of a clearly defined zone on exchange rate behaviour.

There is already strong evidence (see Svensson (1992)) that the target zone model fails to explain the behaviour of exchange rates within a target zone such as the ERM of the EMS, and this chapter seeks to explore further whether this characterisation is indeed unsuitable, given the weekly ERM data used.

Section II sets up a theoretical model for the behaviour of exchange rates in a target zone, and section III describes the theoretical implications on the distribution of exchange rates within the target zone and other volatility implications. Section IV then explores the empirically observed distributions and the volatility of ERM exchange rates using weekly data. Section V then uses two relatively simple econometric models to try and characterise the actual movement and volatility of exchange rates in the ERM target zone. Section VI concludes.

II. Target Zones

Much theoretical research has appeared in recent years on the topic of target zones and currency bands. This line of research began most recently in 1987 with the innovative Paul Krugman (1991) model of exchange rate movement within an announced target zone. A brief description of this model is presented below.

Consider an idealised world in which economic fundamentals alone largely determine the exchange rate. In such a world, suppose that at any point in time the logarithm of a country's exchange rate is a linear function of these fundamentals:-

$$e = f + v + \gamma \frac{E[de]}{dt} \qquad (4.1)$$

where e is the log exchange rate, f represents the relevant 'driving' fundamental or composite of fundamentals (for example, f would be money supply in a monetary model of the exchange rate) and v represents other factors that affect the exchange rate besides the fundamental(s) and the expected rate of depreciation/appreciation. Krugman treats f as a policy variable, and v as a shift term subject to random shocks:-

$$dv = \sigma dz \qquad (4.2)$$

where σ is a constant and dz the increment in a standard Wiener process.

Consider first a freely floating exchange rate regime. In this case, the authorities do not influence fundamentals at all, and allow e to go wherever it wishes. Here the exchange rate would simply be (f + v), as the expected rate of depreciation/appreciation would be zero, given that v obeys a random walk and E[df/dt] = 0.

Under a fixed exchange rate regime, the monetary authorities would use f to offset any changes in v, and the expected rate of depreciation/appreciation would be zero, so that the exchange rate could be maintained at its fix.

Under a target zone (or currency band) regime, the monetary authorities would intervene at some minimum exchange rate, e_{min}, and would sell the domestic currency at the other end of the zone, e_{max}. The general solution to the differential equation given in (4.1) is:-

$$e = f + v + A\exp\{\alpha(f + v)\} + B\exp\{-\alpha(f + v)\} \qquad (4.3)$$

Using Ito's lemma a solution can be obtained for $\frac{E[de]}{dt}$:-

$$\frac{E[de]}{dt} = \frac{\alpha^2\sigma^2}{2}\left(A\exp\{\alpha(f + v)\} + B\exp\{-\alpha(f + v)\}\right) \qquad (4.4)$$

which, from equation (4.1) implies that:-

$$\alpha = \sqrt{\frac{2}{\gamma\sigma^2}} \qquad (4.5)$$

Under a free float, A=B=0 in equation 4.3, but in a target zone, if symmetry around the zero is assumed so that $e_{min} = -e_{max}$, then (4.3) simplifies to:-

$$e = f + v + A\left(\exp\{\alpha(f + v)\} - \exp\{-\alpha(f + v)\}\right) \qquad (4.6)$$

If A is negative, equation 4.6 defines a family of S-shaped curves.

But which curve in the family defined by (4.6) is relevant here? Clearly, as long as the exchange rate can move anywhere within the band, the curve that is tangent to the edges of the band. If the curve hit the edges of the band, then by Ito's lemma, this would imply an infinite rate of expected appreciation/depreciation, which would in turn be ruled out by arbitrage. This tangency condition is very similar to the concept of 'high-order contact' or 'smooth pasting' in option-pricing theory, and hence the name 'smooth pasting' has been adopted in the literature on this subject. Figure 4.1 shows examples of the relationship defined in equation 4.6 between fundamentals and the exchange rate (using values of A=-0.3, -0.6 and -0.9). The larger the value of A, the closer is the S-shaped curve to the free-float 45-degree line.

After Krugman's initial paper on this subject, a mass of other papers appeared (notably Miller and Weller (1990), Weber (1992), Flood, Rose and Mathieson (1990), Bertola and Caballero (1992), Svensson (1991a) and Krugman and Miller (1992)) extending and refining the target zone approach, whilst several papers attempted to evaluate the usefulness of the target zone approach (see Svensson (1992) for example).

III. Empirical Implications of the Target Zone Approach

There are three major implications with the target zone approach (see Svensson (1992)): firstly, target zone models predict that there will be a realignment each time the process driving the fundamentals hits the boundaries of the band - in reality, exchange rates in the ERM of the EMS have hit the boundary, and even crossed it, without a realignment occurring. Secondly, target zone models predict that most of the exchange rate variability should be observable in the middle of the band, when in fact in reality this is often not the case. Thirdly, exchange rate distributions inside the band should be bi-modal, with a higher density at the edges of the band - evidence to be presented in this chapter suggests that this is not the case.

There are additional concerns with the target zone approach. Firstly, the target zone is assumed perfectly credible in the Krugman model. The model can be modified, as has been done by Bertola and Caballero (1992), to give policymakers the option of either defending the zone through intervention or initiating a realignment. With this modification, the constants A and B in equation (4.4) above depend, among other things, on the relative probabilities of these two mutually exclusive events. In particular, they show that 'smooth pasting' occurs (that is, $A<0$ and $B>0$), if at the boundary of the band for fundamentals the realignment probability is small (in fact, less than 0.5). If the realignment probability is large (greater than 0.5), speculation is de-stabilising ($A>0$ and $B<0$) and the relationship between the exchange rate and its fundamentals becomes an inverted S-shape curve (what might be called 'hard pasting'!).

Empirically, though, these models all imply that there are non-linearities in the relationship between exchange rates and economic fundamentals. Flood, Rose and Mathieson (1990) use interest rate differentials as a proxy for fundamentals and conclude that there is no compelling evidence for non-linearities, at least not of the sort that would be implied by a target-zone model.

Svensson (1991b, 1991c, 1991d) has explored the implications of a target zone model for interest rates, given that interest rates are taken to be an important economic fundamental for exchange rates. Svensson assumes that interest rates are not a proxy for the exogenous fundamental process, f, but are endogenously determined through discrepancies between the expected maturity exchange rate and the spot exchange rate, which in turn is a theoretical non-linear function of the exogenous fundamentals. Hence the interest rate differential should also be a non-linear function of the fundamental, and so should fluctuate within a defined zone. This target zone for interest rate differentials should become flatter and less non-linear the longer the maturity. Svensson (1991b) reports, using a linearised model version, that the estimated slope coefficients of the relationship between the interest rate differential at various maturities and the exchange rate indeed becomes smaller for longer maturities. Of course, this finding does not justify use of the target zone approach, but it does confirm a likely relationship between interest rate differentials and exchange rates.

Other empirical work with target zones has been done by Smith and Spencer (1992), who use a testing strategy for target zone models based on the method of simulated moments. This approach maps simulated moments (mean, variance, skewness and kurtosis) of exchange rate levels and changes from calibrated standard target zone models with the corresponding moments from real world data by minimising a moment-matching loss function. They find that the target zone model can account for significant predictable conditional heteroskedasticity and fat tails in exchange-rate changes. This is important (not only because of the findings of Chapter two), but also because it implies that the traditional time-homogeneous Wiener processes for fundamentals in target zone models should perhaps be modified to more general continuous-time stochastic processes.

Lindberg and Söderlind (1994) summarise the more important testable implications of the basic Target Zone model as:-

TABLE 4.1

Implications of the Target Zone Model

Exchange rate	Fundamental (interest rates)
i) Non-linearity in univariate forecasting equation.	ii) Negative relation to exchange rate, weaker for longer terms.
iii) U-shaped distribution.	iv) U-shaped distribution. Denser for longer terms.
v) ∩-shaped conditional variance	vi) ∩-shaped conditional variance.

Source: Lindberg and Söderlind (1994), page 1446.

The target zone modelling approach, as Krugman (1992) readily acknowledges, "is ideally suited to the elegant methods of stochastic calculus" but that "candour requires that we acknowledge that this is not an unimportant part of the field's appeal to theorists...". One of the ironies of the burgeoning target zone literature is that it has given the monetary exchange rate model a new lease of life. The approach allows a certain degree of agnosticism in defining what drives the model, and while this is theoretically appealing, in empirical research, this is its main downfall. As Krugman admits: "since attempts of researchers to identify fundamental explanatory factors for exchange rates have been notably unsuccessful, it is a relief for them to work on a subject that sidesteps the whole question".

IV Empirical Evaluation of ERM Exchange Rates in a Target Zone

As stated in section III, there are three major implications of the target zone approach for exchange rates operating in a defined fluctuation band. Firstly, target zone models predict that there will be a realignment each time exchange rates hit the boundaries of the target zone. Is this true in reality, and if so what is it's extent? Figures 4.2 to 4.9 show deviations of the Ffr, UK£, Ilira, Dkr, I£, Hfl, Bfr, Spta within their specified bilateral target zones against the DM, which were +/- 2.25% for all currencies except the Ilira, UK£ and Spta. These three currencies opted for a wider +/-6% fluctuation band, under the premise that this was a temporary situation which would only persist until steps were taken to narrowing the band to the ERM norm. The UK£ was only a member of the ERM from October 8, 1990, but was a member of the EMS throughout the period of the EMS and the Spta was only a member of the ERM and the EMS from June 19, 1989 onwards.

In the first few years after EMS-inception, the figures illustrate that currencies such as the Ffr, Dkr, I£ and Bfr regularly breached their target zone boundaries. When this happens, the figures readily illustrate the form of action taken by the monetary authorities in question. For instance in figure 4.2, the Ffr breached its lower fluctuation limit in early 1981, but interest rates combined with central bank intervention were clearly effective in pushing the exchange rate back to the centre of its target zone, albeit temporarily, until October 1981, when even though there was no incursion of the lower boundary, a realignment occurred, pushing the Ffr up to the top of its target zone again. The figures also clearly illustrate the increasing market confidence in the ERM from around 1983 onwards, as boundary incursions become a much rarer occurrence. In addition, it is also clear that from 1984 onwards, the Italian authorities began to shadow the narrower +/-2.25% fluctuation margin, even though they still maintained the announced +/-6% fluctuation margins.

The second problem with target zone models is that they predict that most of the exchange rate variability should be observable in the middle of the band, if the fundamental really does follow a Wiener process. One way of assessing this is to plot the position of the exchange rate in the target zone (as a % divergence from the central rate versus the DM) against the absolute change in the log exchange rate from this particular location $[\log(e_{t+1}) - \log(e_t)]$. These scatterplots appear as figures 4.10 to 4.17. One observation each side of a realignment (and the realignment itself) has been discarded so that the realignment and any discontinuous jump of the exchange rate can be excluded from consideration.

No discernable pattern emerges from the data, but the pattern is clearly different for a currency like the I£ compared with say the Hfl. The Hfl has had the most credibility in terms of minimising realignments (it has had no realignments against the DM since 1983 and still maintains +/-2.25% margins), so this exchange rate should most closely reflect the theoretical target zone model. It is interesting to note the contrast between figures 4.13 and 4.14 (I£ and the Hfl) - in the case of the I£

the large changes tend to occur at the edges of the target zone, whereas there appears to be a tendency for the larger changes in the Hfl to occur towards the middle of the target zone. Clearly, as the Bertello and Caballero (1990) model predicts, the credibility of the target zone boundaries is also a factor in inducing larger changes in exchange rates.

The third problem with the target zone model is that the model anticipates that exchange rate distributions inside the band should be bi-modal, given a Wiener process for the fundamentals, with a higher exchange-rate density at the edges of the band. Figures 4.18 to 4.25 show normal kernel density estimates of the position of exchange rates within (and slightly out of) the target zone. The figures show a wide variation in the exchange rate distributions, but that modes are not to be found towards the edge of the target zone. Bertola and Caballero (1992) offered an explanation for this observation based on repeated realignments of the exchange rate band, which would automatically render the fundamental mean-reverting (as per its effect on the position of the exchange rate within the band). In addition, they provided empirical evidence of interest rate differentials frequently indicating expectations of future realignments, thereby suggesting that fluctuation margins are non-credible.

Beetsma and van der Ploeg (1994) attempt to evaluate the credibility of the fluctuation margins using the assumption of covered interest parity. They graph daily log deviation in exchange rates from central parities versus daily one-month offshore interest rate differentials, noting that when interest rate differentials imply an expected exchange rate that lies outside the band, this signals a danger of realignment and therefore non-credible fluctuation margins. They calculate interest rate differentials from spot and one-month forward exchange rates, assuming that covered interest parity holds[1].

The graphical analysis of Beetsma and van der Ploeg (1994) is repeated, using weekly changes in log exchange rates versus weekly three-month offshore interest rate differentials. Figures 4.26a to 4.29a show scatterplots of deviation of exchange rates from central parities versus (actual, not imputed) three-month interest rate differentials for the period of the ERM of the EMS to the end of January 1992, for the Ffr, UK£, Lira and Hfl. The area between the diagonal lines is the set of exchange rate and interest rate differential combinations for which the implicit expected exchange rate 3 months lies within the band. As it is widely recognised (see Giavazzi and Spaventa (1990)) that the nature of the EMS changed quite dramatically in the period after March 1983, due to greater credibility inducing a lower frequency of realignments, figures 4.26b to 4.29b and figures 4.26c to 4.29c split the period up into the pre-March 1983 period and the period after this date. The exception here is for the UK£, where the more obvious breakpoint is in October 1990, when sterling

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1 In their paper they state that they are using uncovered interest parity, but this clearly cannot be so.

entered the ERM. Similar qualitative results are obtained to those of Beetsma and van der Ploeg, with the danger of realignment decreasing dramatically after 1983 for all ERM currencies. The results here differ in one respect though. Beetsma and van der Ploeg's graphs for the Ffr show a positive correlation between the position of the nominal exchange rate in the band and the interest rate differential during the earlier ERM period. Figure 4.26b shows no such correlation. This may be due to two possible reasons; firstly Beetsma and van der Ploeg use 1-month exchange rate forwards, a market that is somewhat thinly traded compared to spot rates, and therefore open to wide swings from volume effects on a daily basis (recall that they also use daily data); and secondly, covered interest parity often does not hold exactly, which adds a second source of error. These two reasons probably account for the different results obtained here for the Ffr/DM exchange rate.

The reduced danger of realignment post-1983 would, according to the Bertola and Caballero (1992) modified target zone model, produce a less centralised distribution of unconditional density estimates, as the exchange rate takes full advantage of the permitted range for fluctuation. In statistical terms, this should imply increased density at the edges of the bands. Figures 4.30 to 4.33 show normal kernel estimates for Ffr, Ilira, Bfr and Hfl, both for before 1983 and after 1983. What is particularly striking about these four charts is that there is clearly no definitive answer here for all ERM currencies, with the Ffr (figure 4.30) showing neither greater concentration after 1983, nor greater concentration of density before 1983; the Ilira (figure 4.31) shows slightly more density towards the very edges of the target zone after 1983, and the Bfr (figure 4.32) shows completely the opposite. Only the Hfl (figure 4.33) shows a definite major shift in the density concentration within the target zone between the early EMS period and the later EMS period. But this is significant, as the Hfl has been the ERM's most exemplary currency member and De Nederlandsche Bank has closely tied movements of the Hfl to movements of the DM, both before and after 1983. Therefore, the Bertola and Caballero assertions, in and of themselves, appear to contradict the evidence; if anything, the reduced danger of realignment appears (for the more committed members of the ERM) instead to produce a greater centralised distribution of unconditional density estimates.

As Svensson (1992) points out, the other suggestion for an extension of the target zone model so that it might better fit with reality, is to take into account the possibility of intra-marginal interventions (rather than just marginal interventions that occur at the edge of the bands). The argument here is that the hump-shaped empirical exchange rate distribution is due to the fact that central bank interventions frequently occur in the interior of the exchange rate band (see Lindberg and Söderlind (1992) and Delgado and Dumas (1991) for discussions of its practical and empirical importance), so the monetary authority has an incentive to push the fundamental towards its mid-point for the target zone. These 'leaning against the wind' intra-marginal interventions could be modelled in terms of a drift of the fundamental f such as:-

$$\frac{E[df_t]}{dt} = -\rho f_t \qquad (4.7)$$

Consider a managed floating regime (following Lewis (1990)). With a managed floating regime, there is no specified fluctuation band, and so there are therefore no marginal interventions. If the exchange rate is above its desired level, mean-reverting interventions take place to push the exchange rate towards its implied 'central parity'. The result is a less steep line than with a freely floating exchange rate for a given change in the fundamental (the equation for the line would be $e_t = [f_t/(1+\rho)]$, whereas with a freely floating rate the equation is simply $e_t = f_t$). This implies that a honeymoon effect[2] operates in a managed floating regime even without a pre-announced fluctuation band. If an explicit fluctuation margin is then added to the intra-marginal intervention curve, then there will be an additional honeymoon effect, but with a much less pronounced S-shaped curve and therefore smooth-pasting at the edge of the band. In a target zone with mean-reverting interventions, Lindberg and Söderlind (1992) show that in theory the unconditional

2 'Honeymoon' effect normally refers to the behaviour of exchange rates when in a credible target zone - that is the exchange rate fluctuates less than it would do under a freely floating regime until the credibility of the fluctuation limits of the target zone are tested by the market.

distribution of the fundamental is a hump-shaped truncated normal distribution. If intra-marginal intervention is sufficiently mean-reverting, the exchange rate equation becomes almost linear, which then implies a hump-shaped distribution for the unconditional distribution of the exchange rate, as well.

In an estimation of a target zone model with mean-reverting interventions for the Swedish krona, Lindberg and Söderlind find that this fits the data much better than the original Krugman model does. As Svensson (1992) points out, the Lindberg and Söderlind approach implies that smooth pasting and non-linearities may be relatively unimportant compared with the effects of intra-marginal mean-reverting interventions. Unfortunately, in most cases, intervention data is not readily available from central banks, and in the case of the EMS has, in general, been withheld from researchers as public release of such data was thought to put the monetary authorities in a somewhat compromising position (in terms of future intervention behaviour). Hence, substantiation of the intra-marginal intervention approach has not been attempted in the literature to date for the EMS.

The empirical evidence, then, does not support the simple target zone model, and suggests that the formulation of the model is inappropriate for the phenomena observed in reality. In particular, the graphical analysis presented here suggests that currency-specific and regime-specific factors need to be addressed before any generalisations about the behaviour of exchange rates within a target zone can be made.

V. Econometric Experiments with EMS data

Given the qualitative results of the previous section, econometric analysis is now used to look at various models that could be adopted to conduct simple tests using weekly data from March 1979 to January 1992. Econometric "experiments" are conducted below, using models that have not, to date, been used extensively in the literature.

a) Volatility and Position within the Target Zone.

As was noted in section IV above, target zone models predict that most of the exchange rate variability should be observable in the middle of the band, given that the fundamental really does follow a Wiener process. In figures 4.10 to 4.17 the position of the exchange rate in the target zone (as a % divergence from the central rate versus the DM) was plotted against the absolute change in the log exchange rate from this particular location $[\log(e_{t+1}) - \log(e_t)]$. One observation each side of a realignment was discarded so that the realignment itself or any discontinuous jump of the exchange rate could be excluded from consideration.

As a simple exercise, the log weekly change in exchange rates was regressed on the percentage divergence position in the target zone. Several complications, however, could potentially arise. Firstly, the target zone model predicts that the movement in exchange rates, for a given movement in the fundamental, should be greatest in the centre of the target zone. Further, if the exchange rate is mean reverting, then more often than not, it should be expected to appreciate when situated near to the lower boundary of the target zone, and vice versa when near to the upper boundary. A statistical test can therefore be constructed for mean reversion towards the centre of the target zone. Table 4.2 presents a summary of the findings for each currency of the number of mean reverting movements in exchange rates during the EMS period. Annex 4A presents a sign test of the significance of these results for each of the ERM currencies.

TABLE 4.2

Proportion of Mean-Reverting Currency Movements

Currency	Total observed	Divergence # positive	Reverting Proportion	Divergence # negative	Reverting Proportion
Ffr	666	318	0.557	348	0.497
UK£	67	13	0.539	54	0.463
Lira	663	366	0.547	297	0.495
Dkr	646	267	0.611	379	0.472
I£	665	291	0.378	374	0.465
Hfl	670	336	0.571	334	0.572
Bfr	665	139	0.640	526	0.508
Spta	123	122	0.443	1	1.0

The results from table 4.2 and Annex 4A show that the degree of reversion varies substantially between currencies, and also with respect as to whether the currency is above or below its central parity against the DM. As expected, most of the currencies that have traditionally had rapid inter-realignment depreciation rates have their proportion of mean-reverting currency movements greater than 0.5 when the currency is above central parity, and the proportion less than 0.5 when the currency is below central parity. The table is informative though, in that empirically only the Hfl behaves in a way that might be remotely similar to that predicted by the target zone model. When either above or below the central parity, nearly 60% of the currency movements tend towards the central parity. Hence only in the case of the Hfl might it be claimed that movements are truly mean reverting.

The above analysis just covers numbers of movements towards the central parity, but not the size of any individual exchange rate change. The target zone model predicts that the size of mean-reverting movements in the exchange rate should be greater towards the centre of the band, and because the model is exactly specified, the nature of this non-linear relationship can be derived algebraically (as done in Lindberg and Söderlind (1994)). So there should be a negative relationship between exchange rate volatility and the position in the band (assuming a uniform distribution for the fundamental). A linear model should capture the essence of this relationship, even though in theory (if the Krugman model is followed) the relationship is clearly non-linear. Table 4.3 gives estimates for a simple linear model where the absolute size of the change in log exchange rates is regressed on a constant and the absolute position of the exchange rate within the band.

TABLE 4.3

Linear Model of Exchange Rate Volatility and Band Position

$$|\log(e_{t+1}) - \log(e_t)| = \alpha + \beta|\%d_t| + u_t \qquad (4.8)$$

Currency	$\alpha(x10^{-3})$	t-statistic	$\beta(x10^{-3})$	t-statistic	Uncentered R^2
Ffr	1.639	6.01	0.683	2.87	0.25
UK£	3.323	5.78	0.376	1.08	0.64
Lira	3.120	11.73	0.096	0.70	0.39
Dkr	2.813	12.99	-0.087	0.48	0.45
I£	2.292	12.81	0.520	5.22	0.37
Hfl	1.055	10.93	1.522	9.16	0.44
Bfr	2.647	8.27	0.538	2.15	0.32
Spta	4.609	5.20	-0.147	0.58	0.50

Notes: i) a value of the t-statistic greater than 1.96 is significant at the 5% level;
ii) all exchange rates are against the DM; and
iii) $\%d_t$ = percentage divergence from central parity.

The regressions above show that not only is the sign on the β coefficient wrong whenever it is significant, but also that when it does have the right sign, it is insignificant. Clearly, the hypothesised relationship is not evident in the data. From a theoretical standpoint, this probably stems from the assumption made about the nature of the distribution of the fundamental.

Conceivably, either the relationship might be changing over time, or alternatively, the changes in regimes forced by realignments may be distorting this relationship (- although the result for the Hfl does not suggest this). The exercise was therefore repeated, taking the periods between each realignment separately, by way of introducing inter-realignment dummies. The results for the simple regressions of the absolute change in log exchange rates on the absolute value of the divergence position of the exchange rate in the target zone are presented in Annex 4B. The qualitative results resemble the results in table 4.3 with no changes in variable signs or demonstrable changes in statistical significance. There are, however, indications that the volatility behaviour does vary significantly between inter-realignment periods.

The above results appear to contradict the suggestion that the data consistently exhibits mean reversion and also that volatility is greater towards the centre of the target zone.

b) Using a limited dependent variable model for target zones.

Pesaran and Samiei (1992a and 1992b) have constructed a linear rational expectations model of price developments within a target zone framework. The target zone framework used by Peseran and Samiei differs substantially from the Krugman framework expounded above, in that there is no smooth pasting or honeymoon effect within the target zone. The model is in essence an econometric model, and is developed so that it may be directly tractable as such.

Pesaran and Samiei take a linear rational expectations model, such that:-

$$e_t = \gamma E_{t-1}[e_t] + \beta' x_t + u_t \qquad (4.9)$$

where e_t is the exchange rate and the disturbance term, $u_t \sim N(0,\sigma_u^2)$ and x_t is a vector of exogenous variables.

Suppose that a target zone is announced for the exchange rate such that:-

$$e_t = \begin{cases} \bar{e}_t & \text{if } e^* \geq \bar{e} \\ \gamma E_{t-1}[e_t] + \beta' x_t + u_t & \text{otherwise} \\ -\bar{e}_t & \text{if } e^* \leq -\bar{e} \end{cases} \qquad (4.10)$$

where $\bar{e}_t$ and $-\bar{e}_t$ are the zone limits either side of central parity and e^* is the latent exchange rate. Thus, if e^* (the free-floating exchange rate) lies outside the target zone, announced as $[-\bar{e},\bar{e}]$, then e_t automatically takes on the value of e at the boundary of the target zone, that is, $-\bar{e}$ or $\bar{e}$. The derivation of the solution to the linear rational expectations model used by Pesaran and Samiei and its associated maximum likelihood are given in Annex 4C.

The likelihood function is straightforward to construct:-

$$L = \prod_0 \text{prob}\{e^* < -\bar{e}\} \prod_1 \text{prob}\{e^* | -\bar{e} \leq e^* \leq \bar{e}\}\text{prob}\{-\bar{e} \leq e^* \leq \bar{e}\}$$

$$\prod_2 \text{prob}\{e^* > \bar{e}\} \qquad (4.11)$$

where the subscripts under the products refer to whether the exchange rate is at, or below, the lower limit of the zone (subscript 1), between the two limits (subscript 2) or at or above the upper limit for the zone (subscript 3). Assuming a standard normal density function, equation 4.11 can be written as:-

$$L = \prod_0 \Phi_{tL} \prod_1 [\phi_{tU} - \phi_{tL}] \,\sigma \prod_2 [1-\Phi_{tU}] \qquad (4.12)$$

So the log likelihood function is:-

$$\ln L = \sum_{0} \ln\Phi_{tL} - \frac{n_1}{2}\ln(2\pi\sigma_u^2) - \frac{1}{2\sigma_u^2}\sum_{1}(e_t - \gamma E[e_t] - \beta' x_t)^2 + \sum_{2}\ln[1-\Phi_{tU}] \qquad (4.13)$$

As an empirical application of this model, Pesaran and Samiei (1992b) go on to estimate a simple 2-country monetary model of the exchange rate, using monthly data on the Ffr/DM exchange rate from May 1979 to May 1989, of the following form:-

$$e_t^{\bullet} - e_{t-1} = \gamma(E[e_t] - e_{t-1}) + \beta' x_t + \delta' h_t + u_t \qquad (4.14)$$

where e_t is the log of the exchange rate and is determined by equation 4.13. In this case x_t is a vector of money supply and GNP variables and h_t is a variable representing interest rates. The authors estimate equation 4.14 using the maximum likelihood function defined by equation 4.13. Various complications arise from using the vector of exogenous variables to determine x_t. Equation 4.14 is not a limited-dependent variable model per se, as the dependent variable in the equation above represents the change in the log exchange rate, but the maximum likelihood technique used takes into account the fact that the exchange rate operates in a target zone.

In this study, an equation of the form of 4.14 was estimated, with some important differences. The form of the estimated equation was as follows:-

$$e_t^{\bullet} - e_{t-1} = \alpha + \beta x_t + \gamma({}_tf_{t-3} - e_{t-1}) + u_t \qquad (4.15)$$

where variables are as defined in equation 4.14, with ${}_tf_{t-3}$ equal to the 1 month forward exchange rate of three weeks ago. This should proxy well as the expected current exchange rate. The variable x_t here is the 3-month offshore interest rate differential with Germany, and therefore does not really act as a truly exogenous variable. The 3-month differential was used because the market is is traded fairly extensively for all ERM participant countries, unlike the 1-month offshore interest rate, which can suffer a larger degree of volatility, due to thin trading conditions.

The coefficients of equation 4.15 were estimated by maximum likelihood, using the Berndt, Hall, Hall and Hausman (1974) maximization technique, and are tabulated below in table 4.4.

<u>TABLE 4.4</u>

<u>Limited Dependent Variable Model Estimates</u>

(1979-1992)

Coefficient	Ffr	Lira	Hfl	UK£
$\alpha (x10^{-5})$	9.161 (3.83)	36.473 (1.82)	2.714 (0.27)	-57.509 (0.75)
$\beta (x10^{-4})$	-4.692 (4.69)	1.785 (3.00)	1.944 (0.76)	-92.686 (2.94)
$\gamma (x10^{-2})$	4.72 (4.32)	7.03 (4.58)	16.42 (8.70)	-2.64 (0.39)
$\sigma^2 (x10^{-5})$	1.164 (17.34)	2.659 (54.65)	6.035 (19.10)	5.259 (7.11)
R^2	0.457	0.009	0.123	0.113

Notes: i) N=670 observations, with the exception of the UK£, where there are 107 observations.
ii) As in Pesaran and Samiei (1992), R^2 is calculated as $1 - (\hat{SEE}/Var(\Delta e))$.
iii) In the case of the UK£, the exchange rate is the DM/UK£ rate.
iv) Figures in parenthesis are t-statistics.

As Pesaran and Samiei (1992a) found, the fit for the Ffr/DM rate was good with this specification, but as table 4.4 demonstrates, the other 3 currencies did not yield similar results. Annex 4D gives OLS estimates of the specification in equation 4.15. Figures 4.34 to 4.37 show the actual and fitted log change in the Ffr, Lira, UK£ and Hfl exchange rates.

In relation to table 4.4, firstly, the interest rate coefficient, β, is negative and significant for the Ffr, but is positive and not significant for the Hfl. This suggests that an increase in the interest rate differential is associated with a depreciation of the Ffr and neither a depreciation nor appreciation of the Hfl. It could be that the early years of the ERM are contaminating the sample as frequent attempts were made in France to defend the Ffr, mainly by widening the interest rates differential versus the DM.

To attempt to have, at minimum, uniformity in terms of the coefficient signs, and as an additional exercise to see how well the econometric model deals with the relatively minor exchange rate fluctuations that characterised the latter years of the ERM, the model was re-estimated, but just for the period 1987 to 1992. The results are tabulated in table 4.5.

TABLE 4.5

Limited Dependent Variable Model Estimates

(1987-1992)

Coefficient	Ffr[1]	Lira[2]	Lira[1]	Hfl[1]	Hfl[3]
$\alpha(x10^{-4})$	1.496 (1.14)	3.378 (1.62)	6.565 (4.32)	-1.697 (2.59)	-1.811 (2.79)
$\beta(x10^{-3})$	2.841 (6.77)	1.672 (6.14)	1.491 (12.01)	0.343 (0.94)	0.031 (0.94)
$\gamma(x10^{-2})$	-1.810 (0.04)	-2.905 (0.09)	0.124 (0.91)	34.00 (16.20)	31.31 (7.24)
$\sigma^2(x10^{-6})$	3.556 (11.51)	11.310 (15.95)	10.58 (0.43)	1.117 (12.84)	0.977 (11.55)
R^2	0.170	0.043	0.105	0.174	0.278

Notes: i) N=266 observations.
ii) As in Pesaran and Samiei (1992), R^2 is calculated as $1 - (\hat{SEE}/Var(\Delta e))$.
iii) Superscript 1 = +/-2.25%
Superscript 2 = +/-6.00%
Superscript 3 = +/-1.00%
iv) Figures in parenthesis are t-statistics.

Table 4.5 gives coefficient estimates for the announced target zone widths. The R^2 statistics reported by Pesaran and Samiei (1992) for the Ffr are much higher than those shown in table 4.5, but this is probably due to the fact that they used many more explanatory variables (at least 10) and they also used monthly data (which through temporal aggregation exhibits less volatility). Table 4.5 now gives estimates for both the Lira and the Hfl for a narrower unannounced target zone, which was allegedly operational in both cases to afford tighter discipline than the ERM was able to offer. The reasons, however, for pursuing a tighter exchange rate policy in these two countries were distinctly different. In the case of Italy, the 'shadowing' of the narrower target zone was in preparation for the eventual narrowing of the margin of fluctuation to the "normal" (+/-2.25% margins). For the Netherlands, the narrower target zone was a further voluntary discipline to reflect the desire of de Nederlandsche Bank to be seen as exactly 'shadowing' German monetary policy in the eyes of foreign exchange market participants. Interestingly enough, in both these cases, the model estimates improve when the 'shadow' target zone limits are used rather than the announced limits. (The Ffr with +/-1.00% results are not shown, but give much worse results than those reported, because the Ffr did not 'shadow' a narrower zone). Figures 4.38 to 4.40 give actual and fitted log differenced exchange rates for the Ffr, Lira and Hfl, all assuming a +/-2.25% fluctuation margin.

These results do suggest one generalisation, however, unlike the results in table 4.4. Here, during this period of enhanced credibility for the ERM of the EMS, it appears that either interest rates had a significant impact on maintaining exchange rates within their target zone (the coefficient is always positive, and sometimes significantly so), or expectations appeared to be the prime determinant of exchange rate changes within the band (as with the Hfl). If monetary policy is almost entirely tied to German monetary policy (as it is for the Netherlands), then interest rate differential increases or decreases become a rarity, and only if economic fundamentals dictate that such a move can be justified in the foreign exchange market. This is coupled with the fact that the Hfl target zone against the DM became the most credible currency cross-rate target zone in the ERM, evidenced by the Hfl's continuing maintenance of the 'narrow' fluctuation bands in the ERM even after the other ERM members abandoned these bands in August 1993 in favour of much wider fluctuation bands. Thus, if interest rates are virtually tied to German rates, expectations of future exchange rate moves (in the form of the forward exchange rate) become a much more reliable measure of the direction and extent that exchange rates will move, as domestic interest rate uncertainty is largely removed (- it now depends on German monetary policy). Conversely, if the market knows that monetary policy retains some degree of independence, then changes in interest rate differentials become a much more important source of information about the future movement of exchange rates than the market forecast made three weeks ago (in the form of the one month forward exchange rate).

To extend this interpretation of the above results for the ERM, while placing them in economic terms, the word 'credibility' has two possible meanings here. Firstly, it could apply to "the tying of one's hands" as per the loss of sovereignty in monetary policy, or secondly, it could imply the judicious use of interest rates, in order to make use of the target zone, without breaching the allowed margins or inciting the speculators to mount a speculative attack on the currency. This distinction in defining 'credibility' in an economic context has not been fully explored in the literature, and remains an area where further research might prove fruitful.

VI. Conclusions

The target zone literature has had a profound effect on the theoretical approach to characterising adjustable peg exchange rate regimes. There is, however, less auspicious success in the results of empirical studies on the subject. In this study, the theoretical implications of the target zone model are compared with the actual behaviour of exchange rates over the period 1979-92, and not only is there scant comparability between observed currency behaviours, but there are also some glaring inconsistencies between what the theory implies and what is actually observed.

In particular, the efforts to modify the target zone model to take into account policy tools such as the frequency of realignments and intra-marginal intervention have yielded little, so perhaps the target zone model itself is too rigid to begin with. The results, as shown in section IV, indicate that the distribution of the exchange rate within the band differs significantly from that predicted by the target zone model, and further, that additional explanations such as intra-marginal interventions, do not square with the empirical facts. In the later part of the chapter, some econometric evidence was presented, which confirmed the differing experiences of ERM currencies, and an explanation was offered for the observed currency movements, given the nature of the use of the target zone for policy purposes by the monetary authorities concerned. The implication is that differing interactions of exchange rate policy with monetary policy will lead to different exchange rate behaviours. These policy differences should be explored in more detail, so that a fuller understanding of the effects of monetary policies on the behaviour of exchange rates in an adjustable peg regime might be gained.

There is a lack of secure stylised facts from the ERM data on target zones, and so it may transpire that so specific a model can never entirely capture the experience of every participating currency in an adjustable peg regime like the ERM. Clearly, more research needs to be undertaken in regard to commonalities and differences in experiences with the ERM and other adjustable peg regimes. Most importantly though, the theory provides an adequate launchpad to explore the theoretical behaviour of exchange rates in an adjustable peg regime, but to its detriment, it still offers no adequate explanation as to why such a regime might be desirable.

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Chapter Five: MODELLING VOLATILITY OF EXCHANGE RATES IN THE EXCHANGE RATE MECHANISM

I. Introduction

In chapter two a non-parametric analysis of volatility of exchange rates concluded that the nature of this volatility changed once a currency became a member of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS). Spot exchange rates became less volatile, not only in the tails of their empirical distributions, but also in the central portions of their distributions. This corroborated the statistical evidence that kurtosis increased, but mostly due to increased peakedness, as tail-fatness decreased. In chapter three, a similar analysis was conducted for offshore interest rates and forward exchange rates. The results differed from those of spot exchange rates, in that the results for forward rates showed a decrease in tail-fatness, but less tendency to peakedness in the central portion of the distribution. The results for offshore interest rates were mixed, with no definitive tendency, but rather a dependency on the nature of domestic monetary policy and the existence of capital controls. In chapter four, the movement of exchange rates within the fluctuation margins (or target zone) was analysed, with the main findings being that the movement of exchange rates do not conform to those predicted by the theoretical target zone model (Krugman (1991)). A simple econometric model was constructed, following econometric work of

Pesaran and Samiei (1992), which attemted to take the fluctuation margins into account when modelling exchange rate movements within the band.

In this chapter, the modelling approach to volatility is presented, and various aspects of previous chapters are incorporated to more sensibly interpret the findings of these models. Section II outlines the modelling approach, section III presents several competing models of exchange rate volatility with the introduction of a synthesis of two modelling approaches, and section IV presents a possible interpretation of these models. Section V concludes.

II. The Modelling Approach to Volatility

The modelling approach to characterising volatility stems from research by Bollerslev (1987) which utilised the approach originated by Engle (1982). The Autoregressive Conditional Heteroskedastic (ARCH) model introduced by Engle explicitly recognises the fact that time series of financial data are not typically independent, even though they might be serially uncorrelated. Under an ARCH specification, the conditional error distribution is normal, but with conditional variances linearly dependent on past squared errors. And although the conditional error distribution is normal, the unconditional error distribution is leptokurtic, reflecting the observed tail-fatness in the empirical distributions of financial data.

A simple extension of the ARCH model, known as the

Generalised ARCH (GARCH) model also allows the current conditional variance to be a function of past conditional variances (see Bollerslev (1986)). Other variations on the ARCH model have also been developed such as the ARCH-in-mean (ARCH-M) model (Engle, Lilien and Robins (1987)) and the GARCH-M equivalent, which allow a function of the conditional variance to enter the regression function, representing a 'risk' term. It has also been noted that equity returns exhibit asymmetrical conditional variance behaviour, and this has been modelled by the EGARCH model (Nelson (1991)).

Given a set of normally distributed error terms, e_t, such that:

$$e = Y - f(X,\beta) \tag{5.1}$$

where equation 5.1 is in scalar terms, the modelling approach attempts to fit an equation for h, where h is the conditional variance, for example with an ARCH specification:

$$h_t = \alpha_0 + \Sigma\alpha_i e_{t-i}^2 \tag{5.2}$$

or with a GARCH specification:

$$h_t = \alpha_0 + \Sigma\alpha_{1i} e_{t-i}^2 + \Sigma\alpha_{2j} h_{t-j}. \tag{5.3}$$

The input from entry t into the log likelihood function can be written as:

$$\ln L = -0.5\ln h_t - 0.5e_t^2/h_t \tag{5.4}$$

In estimating equation 5.3, and therefore the likelihood function term for the ARCH model and all its variations, the system has to be estimated recursively.

One obvious problem with this approach is defining the form of the h_t that is most suited to the underlying process generating the disturbances. In particular, it is not clear whether these models sufficiently account for the observed leptokurticity, given their assumption of conditionally normal errors. Empirical studies of exchange rates (see Milhøj (1987) for example) have found that the ARCH and GARCH models with conditional normal errors do not fully account for the leptokurtosis in exchange rates.

With this in mind, Bollerslev (1987) extends the ARCH and GARCH models by allowing for conditionally Student-t distributed errors. An alternative to assuming a Student-t distribution is to use a (robust) estimate of the covariance of the parameter estimates using the matrix of second derivatives and the average of the period by period outer products of the gradient. Under fairly weak conditions, the resulting estimates are consistent even when the conditional distribution of the residuals is non-normal (see Bollerslev and Wooldridge (1992)).

III. ARCH Model Estimation

It is of some interest to test for a shift in the conditional variance of interest rate and spot and forward exchange rate changes post-March 1979, given that from chapters two and three, an unconditional change in the variance of most exchange rates and interest rates occurred. If autoregressive conditional heteroskedasticity in exchange rate and interest rate innovations has explanatory power, then the ARCH technique might be used to estimate whether a shift in the conditional variance has occurred post-1979. As log exchange rate and interest rates are known to be highly autoregressive in nature (- Mussa (1984) found that the exchange rate appears to approximate to a random walk), a tractable way of estimating the conditional variance would be to model the evolution of interest rates and exchange rates as a random walk process with an ARCH disturbance. This is recognised as being the simplest possible parameterisation and reflects the failure of models of exchange rate determination to out-perform a random walk (see Meese and Rogoff (1983)).

Accordingly, an ARCH model was estimated of the form:-

$$e_t = e_{t-1} + u_t \tag{5.5}$$

$$h_t = E(u_t^2 | I_{t-1}) = \alpha_0 + \alpha_1 u_{t-1}^2 \tag{5.6}$$

where e_t is either the interest rate or the log exchange rate and I_{t-1} is the information set at time t-1. Equation 5.5 describes a random walk for the exchange rate, while equation 5.6 describes the parameterisation for the conditional variance. The system described by equations 5.5 and 5.6 was estimated by maximum likelihood methods, using the Berndt-Hall-Hausman technique (see Berndt, Hall, Hall and Hausman (1974)). In each case, the ARCH parameterisation was estimated for the pre- and post-EMS periods separately. The results appear below in tables 5.1 to 5.3. In order to test for a change in the ARCH parameterisation coefficients, a likelihood ratio test (with null hypothesis of no difference in coefficient values in the two sub-samples) was also constructed and is presented in the tables.

Table 5.1

Maximum Likelihood ARCH Estimates
Spot Exchange Rates

	Pre-EMS			Post-EMS			
Exchange Rate	α_0	α_1	$\mu(h_t)^{1/2}$	α_0	α_1	$\mu(h_t)^{1/2}$	LR Test
Ffr	7.17e-5 (24.41)	0.445 (8.11)	0.011	2.17e-5 (94.71)	0.003 (0.45)	0.005	143.78 (0.00)
UK£	10.6e-5 (24.25)	0.311 (5.40)	0.051	10.4e-5 (21.56)	0.209 (4.02)	0.011	7.51 (0.02)
Ilira	12.5e-5 (32.12)	0.517 (5.42)	0.172	1.69e-5 (31.06)	0.576 (15.56)	0.006	290.93 (0.00)
Dkr	5.45e-5 (34.91)	0.169 (3.13)	0.011	1.22e-5 (24.82)	0.384 (12.26)	0.004	229.42 (0.00)
I£	10.7e-5 (24.27)	0.311 (5.40)	0.051	1.15e-5(*) (39.03)	0.710(*) (28.36)	0.005	361.92 (0.00)
Hfl	2.18e-5 (25.67)	0.341 (4.30)	0.014	0.30e-5 (30.10)	0.664 (13.57)	0.003	248.58 (0.00)
Bfr	2.45e-5 (16.08)	0.394 (3.53)	0.070	1.02e-5 (24.44)	1.032 (31.14)	0.007	29.33 (0.02)
Spta	5.60e-5 (20.25)	1.468 (44.11)	0.156	0.050(*) (134.34)	0.479(*) (1.75)	0.312	1791.93 (0.00)
DM/US$	10.7e-5 (19.81)	0.410 (5.67)	0.031	22.8e-5 (16.94)	0.171 (3.32)	0.017	31.95 (0.00)

Notes: i) e-5 indicates that the coefficient value is 10^{-5}.
ii) Figures in parentheses below coefficient estimates are t-statistics; and
iii) The figures below likelihood test statistics are marginal significance levels. The likelihood ratio statistic tests for a shift in the coefficients post-March 1979.
iv) A (*) indicates that convergence was not achieved.

Table 5.2

Maximum Likelihood ARCH Estimates
3-month Euro-interest Rates

	Pre-EMS			Post-EMS			
Interest Rate	α_0	α_1	$\mu(h_t)^{1/2}$	α_0	α_1	$\mu(h_t)^{1/2}$	LR Test
Ffr	0.656 (17.86)	0.021 (0.36)	0.819	0.449 (69.66)	2.207 (91.34)	2.448	110.92 (0.00)
UK£	0.353 (8.75)	0.367 (4.17)	0.768	0.116 (61.15)	0.024 (20.73)	0.344	333.21 (0.00)
Ilira	0.931 (83.95)	-0.004 (0.33)	0.963	0.694 (111.70)	0.705 (14.44)	1.225	196.37 (0.00)
Hfl	0.221 (14.84)	0.882 (8.11)	0.883	0.060 (63.04)	0.828 (16.28)	0.354	38.74 (0.00)
DM	0.013 (10.71)	0.763 (7.52)	0.196	0.015 (37.54)	0.733 (18.58)	0.212	602.54 (0.00)
US$	0.028 (8.50)	0.538 (3.86)	0.244	0.033 (24.92)	1.679 (28.00)	0.563	451.64 (0.00)

Notes: i) Figures in parentheses below coefficient estimates are t-statistics; and
ii) The figures below likelihood test statistics are marginal significance levels. The likelihood ratio statistic tests for a shift in the coefficients post-March 1979.

Table 5.3

Maximum Likelihood ARCH Estimates
3-month Euro-interest Rate Differentials

	Pre-EMS			Post-EMS			
Interest Rate	α_0	α_1	$\mu(h_t)^{1/2}$	α_0	α_1	$\mu(h_t)^{1/2}$	LR Test
Ffr	0.681 (17.11	0.032 (0.51)	0.839	0.293(*) (59.85)	2.956(*) (89.32)	2.800	76.44 (0.00)
UK£	0.343 (7.77)	0.434 (4.10)	0.794	0.112 (24.35)	0.334 (7.16)	0.403	77.28 (0.00)
Ilira	0.950 (82.26)	-0.005 (0.41)	0.972	0.221 (17.72)	1.354 (17.57)	1.331	168.07 (0.00)
Hfl	0.235 (13.91)	0.870 (8.07)	0.897	0.057 (25.13)	0.646 (13.64)	0.354	118.15 (0.00)
US$	0.051 (8.09)	0.378 (2.77)	0.282	0.118 (34.38)	0.510 (7.96)	0.464	34.62 (0.00)

Notes: see table 5.2 and table 5.1 note iv).

Consider first the ARCH estimates for spot exchange rates (table 5.1). Convergence was not achieved after 50 iterations in two cases (these cases are starred). With the exception of the Bfr and Spta, the value of α_1 was consistently below 1.0. Values of α_1 in excess of 1.0 imply an explosive process, indicating that the process may not have a unit root, or it may imply that a higher order process would be more appropriate. If it is the former (lack of unit root) then this implies non-stationarity (see Cuthbertson, Hall and Taylor (1992)). In the case of an explosive process, it is a possibility that ARCH is an inappropriate parameterisation for modelling volatility of financial varibles, so the Engle (1982) test was used to attempt to detect whether there is indeed the presence of first-order ARCH effects in the random walk innovations (reported in Annex 5A). In all cases the test detected the presence of first-order ARCH effects.

With the exception of the Spta, there was a significant drop in the average conditional variance post-1979, and all the LR statistics indicate there was a significant change in coefficient estimates between the two sub-samples. The coefficient estimates (with the exception of the Ffr) on α_1 appear to be better post-1979 for the ERM currencies, but quite the opposite appears to be true for the non-ERM currencies (the UK£ and Spta are included here).

But how well does the model fit the observed volatility? A rough assessment can be gleaned from the scaled residuals, that is:

$$u_t^* = \frac{u_t}{(h_t)^{0.5}} \tag{5.7}$$

The scaled residuals, if the ARCH model is a satisfactory model of volatility, should be normally distributed and should exhibit no serial correlation. The scaled residuals, as Annex 5A shows, are not normally distributed, but exhibit serial correlation (using an LM test) and kurtosis that is significantly different from a normal distribution. This suggests that the conditional normal distribution is not appropriate in this instance.

Consider next the ARCH estimates for interest rates and interest rate differentials (tables 5.2 and 5.3). Even though convergence was achieved in all cases, estimates again appear to be much more satisfactory post-EMS inception. Note also that (with the exception of certain French, US and Italian interest rates) the α_1 coefficients are considerably below one. The Engle test (for the existence of ARCH effects) suggests that ARCH effects are present in all cases except for the French interest rates. Perhaps because weekly data is being used here, although ARCH effects might be present, normal likelihoods are also inappropriate because of fat tails in the empirical distributions. These specification problems, though, could explain why the results for the mean conditional standard deviation of interest rate changes ($h_t^{1/2}$) are puzzling. Only the UK£ and Hfl interest rate changes show a lower mean conditional standard deviation. These results do not qualitatively differ for Eurointerest rate differentials. In all cases, there is a significant shift in the ARCH coefficients for the interest rates and interest rate differentials post-March 1979.

The results above are similar to the findings of Fujihara and Park (1990), who use an ARCH model with the US$-UK£ and US$-DM futures prices.

Given the findings reported in Annex 5A of residual kurtosis, and other research that suggests that exchange rates are integrated of order one, an approach similar to that of Pesaran and Robinson (1993) was adopted. An ARCH model was estimated of the form:-

$$\Delta e_t = \beta_0 + \beta_1 \Delta e_{t-1} + u_t \tag{5.8}$$

$$h_t = E(u_t^2 | I_{t-1}) = \alpha_0 + \alpha_1 u_{t-1}^2 \tag{5.9}$$

where Δe_t is the change in the log exchange rate or interest rate. The results for equation 5.9 are presented in tables 5.4 to 5.6 below and the values for the estimated parameters on equation 5.8 and test statistics are given in Annex 5B.

Table 5.4

Maximum Likelihood ARCH Estimates
Log Change in Spot Exchange Rates

	Pre-EMS			Post-EMS			
Exchange Rate	α_0	α_1	$\mu(h_t)^{1/2}$	α_0	α_1	$\mu(h_t)^{1/2}$	LR Test
Ffr	6.21e-5	0.642	0.012	0.96e-5(*)	1.684(*)	0.007	148.24
	(21.34)	(5.20)		(24.83)	(19.0)		(0.00)
UK£	9.87e-5	0.346	0.012	10.41e-5	0.198	0.011	2.20
	(17.89)	(5.20)		(20.52)	(3.79)		(0.33)
Ilira	13.4e-5	0.290	0.014	1.64e-5(*)	0.646(*)	0.006	237.35
	(27.50)	(4.29)		(24.07)	(13.04)		(0.00)
Dkr	5.83e-5	0.113	0.008	1.31e-5(*)	0.368(*)	0.004	234.09
	(28.47)	(2.14)		(22.32)	(11.95)		(0.0)
I£	9.92e-5	0.344	0.012	0.95e-5	1.088	0.006	384.63
	(17.98)	(5.21)		(14.99)	(21.54)		(0.00)
Hfl	2.07e-5	0.376	0.006	0.32e-5	0.563	0.003	238.03
	(19.16)	(4.12)		(31.20)	(13.37)		(0.00)
Bfr	2.36e-5	0.372	0.006	0.96e-5(*)	0.926(*)	0.006	40.90
	(17.85)	(3.32)		(23.31)	(23.42)		(0.00)
Spta	3.83e-5	2.597	0.028	0.052	0.309	0.280	1819.7
	(11.87)	(22.84)		(10.14)	(1.32)		(0.00)
DM/US$	10.1e-5	0.450	0.014	22.6e-5	0.176	0.017	36.59
	(19.52)	(5.88)		(16.72)	(3.30)		(0.00)

Notes:
i) e-5 indicates that the coefficient value is 10^{-5}.
ii) Figures in parentheses below coefficient estimates are t-statistics; and
iii) The figures below likelihood test statistics are marginal significance levels. The likelihood ratio statistic tests for a shift in the coefficients post-March 1979.
iv) A (*) indicates that convergence was not achieved.

Table 5.5

Maximum Likelihood ARCH Estimates
Change in 3-month Euro-interest Rates

Interest Rate	Pre-EMS α_0	α_1	$\mu(h_t)^{1/2}$	Post-EMS α_0	α_1	$\mu(h_t)^{1/2}$	LR Test
Ffr	0.672	-0.017	0.812	0.087	5.003	3.733	127.20
	(21.84)	(0.94)		(17.84)	(33.29)		(0.00)
UK£	0.346	0.351	0.758	0.105	0.048	0.332	137.22
	(8.01)	(3.39)		(33.61)	(1.69)		(0.00)
Ilira	0.929	0.041	0.984	0.246	1.315	1.330	115.98
	(31.46)	(0.14)		(18.65)	(14.85)		(0.00)
Hfl	0.216	0.891	0.903	0.047	0.448	0.287	170.87
	(12.78)	(7.97)		(35.99)	(8.58)		(0.00)
DM	0.012	0.788	0.192	0.016	0.602	0.199	-0.853
	(10.49)	(7.35)		(25.78)	(15.87)		(NA)
US$	0.029	0.491	0.234	0.047	1.349	0.503	16.89
	(8.53)	(3.47)		(26.20)	(21.57)		(0.00)

Notes: i) Figures in parentheses below coefficient estimates are t-statistics; and
ii) The figures below likelihood test statistics are marginal significance levels. The likelihood ratio statistic tests for a shift in the coefficients post-March 1979.

Table 5.6

Maximum Likelihood ARCH Estimates
Change in 3-month Euro-interest Rate Differentials

Interest Rate	Pre-EMS α_0	α_1	$\mu(h_t)^{1/2}$	Post-EMS α_0	α_1	$\mu(h_t)^{1/2}$	LR Test
Ffr	0.690	0.001	0.831	0.195	3.721	3.135	64.32
	(19.45)	(0.03)		(28.79)	(26.61)		(0.00)
UK£	0.329	0.411	0.794	0.104	0.448	0.416	78.00
	(7.06)	(3.50)		(23.16)	(7.36)		(0.00)
Ilira	0.921	0.035	0.977	0.196	1.516	1.400	155.07
	(34.58)	(0.26)		(13.90)	(17.00)		(0.00)
Hfl	0.197	1.081	0.979	0.055	0.669	0.356	110.57
	(8.90)	(7.21)		(25.82)	(11.96)		(0.00)
US$	0.050	0.257	0.261	0.056	1.330	0.549	33.44
	(9.66)	(2.31)		(19.10)	(15.71)		(0.00)

Notes: see Table 5.5

Firstly, comparing tables 5.1 and 5.4 for spot exchange rates, it is noteworthy that the coefficients on the error process are generally similar between the two models (equation 5.6 and equations 5.9). Only in the case of the Ffr are the estimates (post-1979) completely dissimilar. Table 5.4 also shows that there are increased problems with convergence post-EMS-inception, and particularly for the ERM currencies, with the exception of the Hfl. As for the results for the conditional standard deviation, the results now show that all the ERM currencies (with the exception of the Bfr) experienced a substantial (at least fifty percent) reduction, but the conditional standard deviation of the freely-floating currencies either increased substantially or was roughly equal between the two periods. The LR test shows that there was a significant difference in parameters between the two subperiods, except for the UK£. As Annex 5B shows, the estimated coefficients on β_0 and β_1 were mostly significant and between zero and one. Further, for all currencies, excess kurtosis was reported for the scaled residuals, and the evidence on serial correlation of the scaled residuals was mixed.

The results for the change in interest rates (tables 5.5) are also little different from those of the random walk model (table 5.2). In this case (as Annex 5B shows), excess kurtosis in the scaled residuals remained a problem, but serial correlation of the scaled residuals was eliminated. The conditional variance measure increased for the Ffr, Ilira and the

US$ Eurorates, but fell for the UK£ and Hfl rates, and was roughly equal for the DM rate. This tends to confirm the suggestion made in chapter three that the use of capital controls might distort the results, in that both Italy and France used capital controls in the early 1980s, thereby tending to increase volatility of offshore rates, but perhaps leading to less volatile onshore rates.

The results for the change in interest rate differentials (table 5.3) are also similar to those of interest rates. In this case though (as Annex 5B shows), kurtosis in the scaled residuals is virtually eliminated for floating rate currencies (but still remains for ERM currencies) and in general, for all currencies, serial correlation of the residuals does not appear to be of great concern.

The implication of the results for the two ARCH models estimated above, is that the model formulation does not adequately account for the kurtosis of exchange rates. Further, the model appears to be a better fit for interest rates than exchange rates.

IV. Accounting for Fat-tails

So as to take into account the fat-tailed nature of empirical distributions of financial variables, an approach was used similar to that of Bollerslev (1987). Bollerslev uses a GARCH(1,1) model for a variety of financial variables, but extends it by allowing for conditionally Student-t distributed errors. Bollerslev calls this model the GARCH-t model, noting in fact that the estimated model "seems to provide a simple and parsimonious description of the time series properties" (p545) for both the UK£ and the DM. The Student-t distribution is symmetric around zero, and its variance and its kurtosis analogue are equal to:

$$E(u_t^2 | I_{t-1}) = h_{t|t-1} \tag{5.10}$$

$$E(u_t^4 | I_{t-1}) = 3(\nu - 2)(\nu - 4)^{-1} h_{t|t-1}^2 \quad ; \nu>4 \tag{5.11}$$

where ν is the degrees of freedom parameter and $h_{t|t-1}$ is given by:-

$$h_t = h_{t|t-1} + \varepsilon_t \tag{5.12}$$

The problem arises in estimating h_t in this instance, as it is generally unobservable. By specifying the conditional distribution of ε_t as an inverted gamma distribution (see Raiffa and Schlaifer (1961)), estimation becomes possible.

To this end, two models were estimated, and both only for exchange rates, given that interest rates were better characterised by an ARCH model than were exchange rates. The first model to be estimated was a GARCH(1,1) model, as described by equation (5.8) with the conditional variance process as:-

$$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 h_{t-1} \tag{5.13}$$

but with conditionally normal errors, and a GARCH-t(1,1) model with conditionally Student-t errors. The results appear in tables 5.7 to 5.10.

TABLE 5.7

GARCH Estimates for the Log Change in Exchange Rates

(1971-79)

	Ffr	UK£	Ilira	Dkr(*)	I£	Hfl	Bfr	DM
β_0(e-4)	9.728	-13.90	10.554	7.947	-1.369	-0.621	2.078	-15.70
	(2.51)	(2.29)	(1.36)	(1.62)	(2.27)	(0.33)	(0.88)	(2.38)
β_1	0.133	0.041	0.127	-0.172	0.041	-0.190	-0.245	0.024
	(2.17)	(0.59)	(1.81)	(2.99)	(0.59)	(4.10)	(5.00)	(0.38)
α_0(e-5)	7.63	4.03	2.57	6.74	3.96	0.18	0.54	7.34
	(18.9)	(7.68)	(6.03)	(2.81)	(7.63)	(5.20)	(5.08)	(5.78)
α_1	-0.06	0.45	0.680	-0.121	0.453	0.732	0.621	0.201
	(1.95)	(7.27)	(13.44)	(0.31)	(7.40)	(34.63)	(9.99)	(1.75)
α_2	0.460	0.277	0.188	0.112	0.279	0.252	0.222	0.377
	(7.81)	(5.00)	(3.98)	(2.18)	(5.00)	(8.26)	(3.86)	(5.36)
$\mu(h)^{0.5}$	0.011	0.013	0.014	0.009	0.013	0.006	0.007	0.013
K	10.10	4.90	35.23	29.95	17.28	17.98	33.26	2.28
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
χ^2	11.98	16.07	18.27	23.80	14.91	9.00	9.30	11.29
	(0.06)	(0.01)	(0.01)	(0.0)	(0.02)	(0.17)	(0.16)	(0.08)

Notes: i) (e-4), for example, indicates that the coefficient value is 10^{-4} in order of magnitude.

i) K = kurtosis measure for the scaled residuals.

ii) χ^2 statistic is a test of serial correlation in the scaled residuals up to order 6.

iii) a (*) refers to non-convergence in estimating the likelihood function.

TABLE 5.8

GARCH Estimates for the Log Change in Exchange Rates

(1979-92)

	Ffr	UK£	Ilira	Dkr	I£(*)	Hfl	Bfr(*)	DM
β_0(e-4)	6.666	-3.578	0.724	2.618	-3.048	0.086	1.488	-2.738
	(10.50)	(0.88)	(0.52)	(2.07)	(2.59)	(0.16)	(1.50)	(0.441)
β_1	0.247	0.090	-0.131	-0.088	-0.183	-0.337	-0.332	0.019
	(7.61)	(2.40)	(3.72)	(1.63)	(7.17)	(14.13)	(7.67)	(0.44)
α_0(e-5)	0.885	0.417	1.114	0.548	0.363	0.00	0.525	8.988
	(20.58)	(3.54)	(16.15)	(8.20)	(7.14)	(0.11)	(11.92)	(2.54)
α_1	0.014	0.884	0.136	0.354	0.344	0.967	0.201	0.518
	(0.72)	(38.72)	(4.24)	(7.93)	(8.72)	(266.3)	(9.09)	(3.39)
α_2	1.803	0.084	0.775	0.382	0.866	0.032	1.006	0.155
	(17.44)	(4.98)	(14.23)	(12.27)	(15.29)	(7.36)	(26.0)	(3.15)
$\mu(h)^{0.5}$	0.006	0.011	0.006	0.004	0.006	0.003	0.006	0.017
K	25.84	5.32	22.69	28.20	15.65	17.35	21.39	2.19
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
χ^2	95.49	14.10	95.23	48.49	51.99	40.30	16.41	13.82
	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.03)

Notes: see table 5.7

TABLE 5.9

GARCH-t Estimates for the Log Change in Exchange Rates

(1971-79)

	Ffr	UK£	Ilira	Dkr	I£	Hfl	Bfr	DM
β_0(e-4)	3.560	-4.131	3.972	4.769	-4.094	9.481	2.990	-9.809
	(1.37)	(1.09)	(1.34)	(1.82)	(1.08)	(0.66)	(1.53)	(2.21)
β_1	-0.027	0.006	0.093	-0.172	0.006	-0.139	-0.251	0.034
	(0.78)	(0.12)	(1.99)	(2.99)	(0.11)	(2.65)	(4.76)	(0.62)
α_0(e-5)	97.85	4.500	0.844	6.394	4.54	1.569	0.690	3.055
	(0.05)	(1.48)	(1.65)	(1.92)	(1.43)	(1.14)	(2.94)	(2.49)
α_1	0.494	0.432	0.746	-0.017	0.437	0.259	0.427	0.465
	(2.06)	(3.77)	(13.16)	(0.22)	(3.85)	(2.31)	(4.49)	(4.51)
α_2	3.315	0.828	0.443	0.726	0.839	1.468	0.536	0.620
	(0.05)	(1.40)	(1.67)	(1.35)	(1.36)	(1.08)	(2.75)	(2.36)
ν	2.013	2.52	2.46	2.53	2.51	2.33	3.57	3.09
	(7.38)	(5.51)	(7.25)	(6.18)	(5.49)	(6.68)	(5.00)	(5.09)
$\mu(h)^{0.5}$	0.011	0.015	0.016	0.010	0.015	0.007	0.007	0.015
K	10.09	5.17	87.34	35.25	23.01	26.81	35.05	2.99
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
χ^2	11.98	20.19	9.76	14.42	10.22	8.79	9.17	9.66
	(0.06)	(0.00)	(0.14)	(0.03)	(0.12)	(0.19)	(0.16)	(0.14)

Notes: see table 5.7

TABLE 5.10

GARCH-t Estimates for the Log Change in Exchange Rates

(1979-92)

	Ffr	UK£	Ilira	Dkr	I£	Hfl	Bfr	DM
β_0(e-4)	0.885	1.800	1.568	2.622	-1.294	-0.276	1.345	0.517
	(1.15)	(0.59)	(1.26)	(2.27)	(1.24)	(0.61)	(1.29)	(0.09)
β_1	-0.086	0.062	-0.112	-0.144	-0.235	-0.326	-0.346	0.026
	(2.48)	(1.70)	(2.89)	(3.71)	(5.89)	(10.56)	(9.34)	(0.61)
α_0(e-5)	1.755	0.206	0.950	0.625	0.800	0.004	0.469	8.736
	(1.66)	(1.53)	(2.54)	(2.46)	(3.65)	(1.71)	(3.39)	(2.08)
α_1	-0.014	0.859	0.452	0.465	0.194	0.919	0.359	0.527
	(0.94)	(27.82)	(3.64)	(2.70)	(2.01)	(52.69)	(4.36)	(2.85)
α_2	0.930	0.164	0.397	0.190	0.583	0.084	0.714	0.162
	(1.47)	(3.15)	(2.41)	(2.41)	(3.26)	(3.01)	(3.54)	(2.57
ν	2.29	3.47	2.71	3.38	3.04	3.20	3.08	8.72
	(10.85)	(6.17)	(8.27)	(6.66)	(8.35)	(7.33)	(7.81)	(2.68)
$\mu(h)^{0.5}$	0.006	0.012	0.006	0.004	0.005	0.003	0.006	0.017
K	27.20	8.63	24.21	29.53	16.01	18.30	24.76	2.21
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
χ^2	20.22	15.29	91.15	34.91	71.10	37.59	16.39	14.13
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.03)

Notes: see table 5.7

Comparing tables 5.7 and 5.8, it is apparent that the mean conditional standard deviation drops on entering the ERM of the EMS, and further that the coefficients differ substantially between the two periods. A likelihood ratio test (not reported here) showed that the coefficients were significantly different between the two periods. With the exception of the Ffr, all currencies appeared to exhibit marginally less scaled residual kurtosis after 1979, but substantially more serial correlation. The DM/$ rate also showed similar results, but the UK£ scaled residuals showed diametrically opposite results. Also of note, are the remarkably similar coefficients for the UK£ and I£ before

1979, but the change in the sign and magnitude of the estimated β coefficients after 1979. The limited success of the 'snake' might be one interpretation of the negative coefficients on β_1 before 1979, as after EMS inception, all ERM participating currencies have (mostly significant) negative β_1 coefficients (again, with the exception of the Ffr). The results for the Ffr are puzzling, particularly in terms of the kurtosis for the scaled residuals and the significantly positive coefficient on β_1. Perhaps the turbulence of the early years of membership of the Ffr in the ERM are affecting the post-1979 results, but more generally, the results underline the difficulties in making generalizations about experiences of currencies in the ERM.

The results of tables 5.9 and 5.10 above might be expected to confirm that the GARCH-t specification gives a better fit, principally because it better takes into account the kurtosis in the empirical distribution. Thus kurtosis in the scaled residuals should be expected to fall if the specification yielded an improvement over the basic GARCH model. Prior to 1979, this was certainly not the case, implying that the GARCH-t may not be a superior specification over the GARCH model for these years. Serial correlation of the scaled residuals did fall though, for the ERM currencies, when using the GARCH-t specification. In terms of the coefficients in table 5.9, the β_1 coefficient becomes negative, but not significantly so. After 1979, similar results are obtained for the kurtosis of the scaled residuals, but serial correlation substantially increases. The β_1

coefficient for the Ffr becomes significantly positive, with all other ERM currencies retaining the same-signed β_1 coefficients. In all cases the degrees of freedom coefficient, ν, increased post-1979, and in the case of the DM, by a substantial amount. These results (comparing between an ARCH-type specification with normal errors, and one with student-t distributed errors) are not disimilar to those obtained by Pesaran and Robinson (1993). There is one notable exception, however. Pesaran and Robinson obtained estimates for ν that were greater than 4.0, which implies that the fourth moment of the t-distribution exists. With the exception of the DM post-1979 (for which a conditional kurtosis measure of 2.098 is obtained), this result was not obtained here.

How are these results to be interpreted? Firstly, it appears that the coefficients are substantially different between the GARCH and GARCH-t models, which suggests that accounting for fatness of tails might enhance the model. Secondly, and perhaps most importantly, it appears that a significantly negative β_1 coefficient has been a hallmark of the effects of the ERM of the EMS. This reflects a gradual increase in credibility of the system, so that in general, changes in log exchange rates decreased over time. Thirdly, the Pesaran and Robinson results were obtained using daily data, which better accounts for 'news' effects - by using weekly data here, intra-week volatility is not accounted for so sudden changes in volatility either be missing from the data completely, or if only short term, may show up as only one or two observations.

V. Accounting for a Target Zone with GARCH models

The analysis of chapter four found that consideration of the fluctuation bands that constitute an integral part of the ERM improves the fit of the model. Within a GARCH framework, this can also be accounted for, by including terms in the likelihood function that specify, akin to the tobit model, the limits of fluctuation that are permitted for currencies in the ERM.

The GARCH specification of equations (5.8) and (5.13) are combined with a limited dependent variable specification:-

$$e_t = \begin{cases} \bar{e}_t & \text{if } e^* \geq \bar{e} \\ \beta_0 + e_{t-1} + \beta_1 \Delta e_{t-1} + u_t & \text{otherwise} \\ -\bar{e}_t & \text{if } e^* \leq -\bar{e} \end{cases} \tag{5.14}$$

$$\text{and} \qquad h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 h_{t-1} \tag{5.15}$$

where the actual equation estimated is the Δe_t form of (5.14). As above, two distributional assumptions are made for the errors: firstly that they are conditionally normal and secondly that they are conditionally Student-t distributed. The model will be called the LDGARCH (limited-dependent-variable-GARCH) model and its Student-t variant, the LDGARCH-t model.

The results of estimating the specification in equations 5.14 and 5.15 are presented below in tables 5.11 and 5.12 for the EMS period (1979-1992), for the Ffr, Ilira, Dkr, Hfl and Bfr.

TABLE 5.11

LDGARCH Estimates for the Log Change Exchange Rates

(1979-92)

	Ffr	Ilira	Dkr	Hfl	Bfr
β_0(e-4)	1.637	0.759	3.050	0.998	1.900
	(1.35)	(0.55)	(1.50)	(0.19)	(0.06)
β_1	0.075	-0.130	-0.134	-0.304	-0.308
	(1.80)	(3.68)	(2.16)	(12.02)	(8.54)
α_0(e-5)	0.291	1.118	1.974	0.00	4.040
	(7.29)	(16.15)	(66.85)	(1.22)	(32.94)
α_1	0.384	0.137	-0.103	0.965	-0.210
	(8.99)	(4.23)	(8.63)	(257.4)	(5.55)
α_2	0.634	0.769	0.129	0.029	0.179
	(8.64)	(14.20)	(8.46)	(7.39)	(14.49)
$\mu(h)^{0.5}$	0.0049	0.0057	0.0043	0.0025	0.0059
K	38.93	9.85	8.85	6.52	48.12
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
χ^2	2.55	4.85	11.41	25.90	16.39
	(0.86)	(0.56)	(0.07)	(0.00)	(0.01)

Notes: i) K = kurtosis measure for the scaled residuals.

ii) χ^2 statistic is a test of serial correlation in the scaled residuals up to order 6.

TABLE 5.12

LDGARCH-t Estimates for the Log Change in Exchange Rates (1979-92)

	Ffr	Ilira	Dkr	Hfl	Bfr(*)
β_0(e-4)	1.123	1.570	1.844	-0.268	0.257
	(1.40)	(1.26)	(1.63)	(0.59)	(0.28)
β_1	-0.122	-0.112	-0.161	-0.324	-0.352
	(3.34)	(2.90)	(4.03)	(10.51)	(9.84)
α_0(e-5)	0.257	0.952	0.656	0.004	30.50
	(3.64)	(2.54)	(2.41)	(1.79)	(1.41)
α_1	0.497	0.452	0.486	0.917	0.333
	(4.77)	(3.62)	(3.33)	(52.06)	(3.98)
α_2	0.185	0.397	0.332	0.078	69.86
	(2.74)	(2.41)	(3.88)	(3.03)	(1.48)
ν	3.39	2.71	2.89	3.39	2.01
	(8.96)	(8.27)	(8.25)	(6.58)	(452.70)
$\mu(h)^{0.5}$	0.0041	0.0057	0.0045	0.0025	0.0462
K	44.81	13.30	5.65	8.28	17.83
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
χ^2	1.16	4.00	7.40	26.17	9.74
	(0.98)	(0.68)	(0.29)	(0.00)	(0.14)

Notes: i) K = kurtosis measure for the scaled residuals.
ii) χ^2 statistic is a test of serial correlation in the scaled residuals up to order 6.
iii) a (*) refers to non-convergence in estimating the likelihood function.

The results of tables 5.11 and 5.12 appear, in general, to be a distinct improvement over the standard GARCH and GARCH-t models. Comparing tables 5.8 and 5.11, the estimated coefficients for most of the currencies in table 5.11 appear similar to those of table 5.8, with the coefficients for a currency like the Ilira (with its wide +/-6% band) almost identical. For the Ffr, the β_1 coefficient is still positive, but now insignificantly so. The only other notable change in sign occurs for the α_1 coefficient with the Dkr and the Bfr.

Apart from these currency-specific changes, the general trend is for a fall in serial correlation in the scaled residuals, and with the exception of the Bfr and Ffr, a reduction in the scaled residual kurtosis as well. The mean conditional standard deviation is almost identical to the estimates obtained for the GARCH model.

Now, comparing the LDGARCH-t model (table 5.12) with the GARCH-t model (table 5.10), the reduction in serial correlation of the scaled residuals is even more marked, with all currencies (excepting the Hfl) showing no residual serial correlation. Kurtosis falls (with the exception of the Ffr) and mean conditional standard deviations are almost identical. A further comment about the degrees of freedom estimate, ν, is appropriate here. The estimated coefficient increases for the Ffr and the Hfl, but falls for the Dkr and Bfr. As expected (because the Ilira rarely approached its fluctuation margins without pre-emptive action being taken), the Ilira has exactly the same estimated coefficient. Evaluating the increase in the degrees of freedom coefficient together with the residual kurtosis is perhaps a fruitful avenue for future research.

Lastly, comparing tables 5.11 and 5.12, in terms of fit, there is little evidence to indicate that the conditional Student-t distributional assumption yields superior results to the conditional normal assumption for the errors. The only notable observation is that with the exception of the Ilira, the Student-t assumption produces slightly larger β_1 coefficient estimates, indicating a greater reduction in volatility over time. As the Student-t distribution takes into account tail-fatness and more peakedness than the normal, this result confirms the results of chapter two in relation to the use of the Mood test, but here in a time-series context. Further, it should again be noted that all the estimates for ν are less than 4.0.

VI. Conclusions

The development of ARCH models has allowed econometricians to explore the time-series properties of financial variables, without having to appeal to the usual assumptions of normally distributed error processes. Although much has been done in this area, very little empirical work has focused on the ERM of the EMS. In this chapter, the implications of the non-parametric results of chapters two and three were combined with the econometric target zone approach explored in chapter four, to create a new class of ARCH models to take into account both tail-fatness and the limited fluctuation bands for ERM currencies.

The main result found was that all ERM currencies experienced a trend reduction in exchange rate volatility from 1979 to 1992, when factors such as the nature of kurtosis and fluctuation band width are properly taken into account. Further, when allowance is made for these factors, the fit of the model improves, indicating that the increase in kurtosis as a result of the regime-specific characteristics, post-1979, is an appropriate innovation in the modelling approach. The corrollory for future research is that advances in econometric modelling techniques should focus not only on mimicking actual time series behaviour, but also on institutional constraints, where relevant, that financial variables operate under.

Further research is certainly needed, particularly in relation to how temporal aggregation affects distributional assumptions, and how the time series properties vary before, and in the aftermath of, a speculative attack. There is also still much work to be done on explaining the different time-series behaviours of the different currencies when ostensibly operating under an identical exchange rate regime. Lastly, although this chapter did begin to look at the time series properties of offshore interest rates, there is plenty of scope to extend and improve this analysis.

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Chapter Six: EMU AND THE ROLE OF THE EMS IN THE INTEGRATION PROCESS

I. Introduction

The historical origins of European Monetary Union (EMU) are rooted in political concerns arising in the aftermath of the Second World War. The idea of some form of future political union was embedded in the Treaty of Rome (1958), but in its early years the European 'common market' (as the then European Economic Community or EEC was called) developed almost exclusively along economic lines, mostly in the areas of constructing and then maintaining a customs union, and operating a pan-European agricultural policy between its members. The Common Agricultural Policy (CAP) required fairly stable intra-EEC exchange rates to be effective, so member countries adopted narrower fluctuation bands than were required by Bretton Woods. In this period, there was no political consensus on how or whether member countries should seek to develop the customs union into something more substantive. In the early 1970s, as it became clear that the Bretton Woods system was crumbling, attempts were made to encourage new political initiatives aimed at engendering an integration dynamic as part of the *acquis* of the community.

The Werner Report (1971) [which was the product of the Werner Group set up in 1969], was the earliest attempt to specify a more concrete plan to achieve greater monetary and economic integration between member countries. During the Werner Group negotiations, it became clear [see Tsoulkalis (1977) and De

Grauwe (1990)] that two opposing groups had formed with views on strategies to attain EMU. These groups were labelled the 'monetarists' and the 'economists', the former holding to the view that early progress in the monetary field would force an effective coordination of economic policies and the latter believed that harmonisation of economic policies should take priority before any coordination of Community monetary policy were embedded in the system. These two groups have characterised much of the debate surrounding integration in more recent discussions surrounding Maastricht (see Annex 6A for a more detailed description of the history of the politics surrounding EMU).

The stability of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) post-1985 inspired confidence among a new generation of European technocrats, and encouraged new plans for European integration. The issuance of the Delors Report in 1989 provided new impetus towards monetary unification in Europe and laid out the basis for the eventual treaty for unification, signed in Maastricht, the Netherlands, in December 1991. The Delors Report was, in essence, a blueprint for a 'monetarist' approach (of a gradualist kind) to EMU. The plan for EMU was in three stages, and at each stage the degree of convergence and co-operation was to be increased. In the final stage only the European currency unit (Ecu) would circulate.

There were two dissenting voices against the means of achieving monetary union, the UK government and the German government (as well as the Bundesbank). The UK government objected to the report on the basis that it ceded monetary sovereignty to a European monetary institution and that it implicitly sought the abolition of national currencies. The UK government issued two documents (HM Treasury (1989) and (1990)) as alternatives to the Delors plan which embodied the Hayekian parallel-currency principle. This approach came to be known as the "Hard Ecu" plan. The Bundesbank's objections were of an 'economist' nature. The Bundesbank wanted strict criteria to be incorporated into the plan before countries could proceed towards monetary union and the German government also sought greater European political integration so that the European Central Bank could be answerable to a European Parliament that possessed real powers. It became clear that the "Hard Ecu" proposal, whilst it obtained a polite reception, was unacceptable to most of the UK's European partners. At the Inter-Governmental Conference in Maastricht in December of 1991, agreement was reached on a compromise that satisfied the Germans. This consisted of four convergence criteria to be attained before countries could proceed to monetary union. The UK, still dissatisfied, along with Denmark, which foresaw political problems in making the Treaty palatable to its citizens, negotiated opt-out clauses.

This chapter evaluates the different approaches to EMU and looks at the role of the EMS in the process of integration. Section II looks at the whole process of moving towards EMU and the Maastricht approach. Section III focuses on the institutional arrangements for monetary policy that have been agreed upon in the Maastricht Treaty and compares them with other central bank arrangements in other federalist structures, whilst section IV turns to the fiscal policy implications. Section V takes a critical look at the Maastricht convergence criteria and Section VI presents an assessment of the Maastricht approach and evaluates alternatives to Maastricht.

II. The Road to EMU

All 12 States have now successfully ratified the Maastricht Treaty. The process of EMU began with Stage 2 of the Treaty provisions on January 1, 1994, with the establishment of the European Monetary Institute (EMI).

a) Generic Approaches

There are many possible paths to attaining EMU. Below several alternative blueprints for a path to EMU are explored:

i) 'Maastricht' approach [Time-specified/Gradualist];

ii) Hayekian "Hard Ecu" approach [Competition/Gradualist]; and

iii) 'Hawaiian' approach [Shock].

The paths can vary according to both speed of transition and route taken to the final objective, however the two are not mutually independent. There are two basic approaches concerning the speed at which a monetary union is adopted, the gradualist approach (which is essentially an approach that has a specified timetable, or agreed upon criteria before the next stage can begin) and the "shock-therapy" or 'Hawaiian' approach to achieving monetary union. The "Hard Ecu" approach is based on contemporaneous currency circulation, and therefore might be considered gradualist, but there is no certainty as to whether the process will actually yield EMU, as the process could conceivably reverse at any point in time. Next, the three approaches are described in more detail.

i) The 'Maastricht' approach

The Maastricht Treaty envisioned one particular route to EMU, which consists of three stages, as follows:

> Stage 1 (July 1, 1990 to December 31, 1993) - in this stage, the EMS abolished all remaining capital controls, monetary co-operation between the EC central banks was strengthened and realignments of the ERM were possible;
>
> Stage 2 (January 1, 1994 to between January 1997 and January 1999) - in this stage, the EMI is established as a temporary institution to oversee transition to stage 3, all Member States will start the process leading to the independence of their central banks, the Commission and the EMI will establish whether the Member States achieve or are moving towards achieving certain criteria as specified in the Treaty and ERM realignments will be vigorously resisted; and
>
> Stage 3 (from between January 1997 and January 1999

onwards) - in this stage, the exchange rates between the national currencies will be irrevocably fixed, the European Central Bank (ECB) will start its operations, the ECU will become a currency in its own right and will circulate as the only currency in EU member states that have proceeded to the third stage[1] (Denmark and the UK have opt-out clauses from this stage).

The Maastricht approach was to set entry conditions, the convergence criteria, and to use the ERM of the EMS as the stepping stone from which to launch the gradual reduction of volatility until exchange rates can be fixed, after which a single currency can be substituted for all national currencies.

ii) The Hayekian "Hard Ecu" approach.

The "Hard Ecu" approach is another possible route to EMU. In this Hayekian approach, the ECU is always devalued or revalued in line with the strongest currency in the EMS. This is basically the "Hard Ecu" approach put forward by the UK. Economic behaviour then determines the speed at which individuals give up their national currencies for the Ecu, and in the meantime, the two currencies circulate alongside each other. Hayek (1976a,b; 1984) argued that national monopolies in money supply should not be supplanted by control of Ecus by a new supra-national monetary institution. The concurrent circulation of currencies, Hayek argued, would produce greater stability and restrain the abilities of individual national monetary authorities to unduly increase their own money supplies. The drawback here is that if national monetary authorities restrain monetary creation, then this evolutionary-competition approach might not lead to the outcome of all national currencies being replaced by the Ecu, so that the "means" might not achieve the "end" as envisaged in the Maastricht Treaty. One of the advantages of this approach, however, would be that criteria for entry into EMU would be unnecessary, so 'economist' concerns would be placated.

iii) The 'Hawaiian' approach

The 'Hawaiian' approach is one of moving directly to EMU in contrast to the gradualist approach. (The Hawaiian secession into the United States occurred in a single step, with appropriate legislation being adopted simultaneously with adoption of the U.S. dollar). Prior to the signing of the Maastricht Treaty, the Hawaiian approach was favoured by several leading European economists (see Giovannini (1990), for example). It is highly unlikely to be feasible in a European context, as the political pre-requisites for this approach, as illustrated in Germany in the case of German Economic, Monetary, and Social Union (GEMSU), are draconian. It would therefore be unacceptable to most Member States, and furthermore, it would likely not be feasible, as the European institutions to oversee such a transition are insufficiently developed.

The transition to monetary union, as Fratianni, Von Hagen and Waller (1992) point out, could potentially involve 'end games', in that "participants know that a particular arrangement will stop at a certain time and that they can influence their relative wealth or income positions in the subsequent arrangement by taking certain actions under the current one". An example would be seigniorage distribution - if this distribution in the new regime depended on the relative size of national monetary bases, each government would have an incentive to increase money growth to secure a higher seigniorage share. End games can be discouraged by either keeping the timing of the final transition unspecified or by setting entry conditions. This likely explains why, in practice, the 'Hawaiian' approach has tended to incorporate an element of surprise, as a specified transition date could encourage fiscal profligacy and a distortion of economic behaviour in the period before the currency conversion occurs.

b) <u>The Transition Process</u>

Whatever approach is chosen to get to EMU, there are various questions as to the component parts of the transition process. In this instance, there are five issues that need to be addressed:

i) Should EMU be accompanied by economic convergence?;

ii) Should EMU be accompanied by national currency stability?;

iii) Should the EMU process incorporate a role for national central banks, and if so, what should it be?;

iv) Should some form of fiscal federalism be developed in the transition to help Europe's periphery shoulder regional shocks?; and

v) Should EU monetary institutions be developed before EMU eventually occurs, and if so how?

Each of the generic approaches described in the previous section has different responses to these questions, and these are summarised in table 6.1.

TABLE 6.1
The Transition Process to EMU

	Maastricht	Hard Ecu	Hawaiian
i) Economic convergence?	Yes	No	No
ii) Currency stability?	Yes	No	No
iii) National bank role?	Independent	Yes	None
iv) Fiscal federalism?	Minimal	Yes	(Yes)
v) EU monetary authorities?	EMI	Yes	Yes

In table 6.1, three specific examples of the three possible approaches to EMU have been given. Maastricht's answer to the role of National central banks is unclear, but central bank independence is a priority and with the degree of fiscal federalism there is a limit of 1.27% of EU GDP in the stipulated projections for the EU budget (see Annex 6B). The 'Hawaiian' approach does not need any convergence, but requires complete cooperation on the part of the National central banks and also may require some resource transfer depending upon the rate at which the conversion is made. The "Hard Ecu" approach requires no economic convergence or currency stability but for National central banks to play a role in determining the speed at which the transition occurs, and indeed, whether it occurs at all. Some fiscal redistribution may be required for the "Hard Ecu" approach, as regional shocks may endanger the efficacy of national fiscal policies due to the legal ability to substitute national currency for Ecus.

The irony is that to date, the convergence criteria specified in Maastricht will probably not be met by any of the Member States excepting Luxembourg (see De Grauwe and Gros (1991) and Financial Times (1993a)), and most member states are operating, if at all, under exceptionally wide fluctuation bands in the ERM [this is unlikely to change given recent evidence EMI President Mr. Lamfalussy gave to the European Parliament (see Financial Times (1994b))]. The role of National central banks is a moot point with many European governments (notably the UK and France) and the degree of fiscal federalism as envisaged under the Edinburgh plan has been attacked as woefully inadequate (see Sala-i-Martin and Sachs (1991)). Only the development of EU monetary authorities appears to be on track, with the EMI firmly established as a pre-cursor of the ECB in an embryonic form.

b) <u>Currency Stabilisation and the Role of the EMS</u>

The Maastricht Treaty (1992) specifically states that Member States should observe:

> "the normal fluctuation margins provided for by the exchange-rate mechanism of the European Monetary System, for at least two years, without devaluing against the currency of any other Member State" (Article 109j, indent 3).

By 'normal', the Treaty implies the +/-2.25% margins in operation at the time that the Treaty was signed (exceptions were made for Italy and for any new participants in the ERM). Although the 'no devaluation over a certain time period' clause is clearly arbitrary, it actually serves little real purpose. The real objective should be to ensure that when the Member State joins

EMU, it does so such that its currency is at a sustainable level for the longer term. When Ecus replace national currencies they might do so at a rate consistent with the relative wealth of the Member State in question. Otherwise, this might imply a highly conservative monetary policy stance in higher-inflation Member States in the run up to EMU, which would immediately be relaxed once EMU occurs (see Giovannini (1991) for a review of the difficulties in choosing conversion rates to Ecus). If exchange rate stability (that is, reduced volatility) is the only pertinent issue, then if speculative attacks are commonplace, short-term capital controls might need to be introduced to offset undesirable speculative flows (see Financial Times (1993c)). Note that this does not necessarily imply fixed margins of fluctuations, but rather a sustained reduction in short term volatility.

The Maastricht formula of enforcing fiscal, monetary and exchange rate criteria may, in certain circumstances, not be entirely compatible, or indeed, consistent with the overall objectives of EMU. For example, consider an economy where the economic variables for the convergence criteria are approaching their appropriate levels. If a transitory shock hits the economy, which in turn causes a lengthening of the expected period of time before entry into stage 3 of EMU was anticipated, this might lead to some turbulence in the foreign exchange markets. Central bank action to offset such turbulence (by increasing interest rates, for example), might only exacerbate the situation in terms of the economic criteria, further altering expectations. Hence, because of limited room for manoeuvre in the foreign exchange market, transitory shocks can permanently affect expectations, even when it is known *ex-post* that they are transitory. As the ERM of the EMS operates around the Ecu, which is itself a weighted basket of the EMS currencies, the room for manoeuvre with a given transitory shock must be proportionate to the weight the currency has in the Ecu basket.

In a more general sense, then, the use of the ERM of the EMS to achieve EMU is confusing an adjustable-peg exchange rate regime which is very effective when used as an independent volatility-reducing mechanism, with a criteria-dependent dynamic process to move the EC towards a monetary union. The two are mutually incompatible on many levels.

The potential incompatibility of the ERM objective with the convergence criteria has not been observed in practice to date (partly because the margins of fluctuation are now extremely wide at +/-15%), but a similar event in the recent history of the ERM of the EMS serves to illustrate the point. In the summer of 1992, first Denmark surprisingly voted not to ratify the Maastricht Treaty (announced on June 3), and then it appeared that France, in particular, would not ratify the Maastricht Treaty in a country-wide referendum. These setbacks, especially if repeated elsewhere, would not render the Maastricht Treaty timetable completely unworkable (although some doubts were expressed by legal experts at the time), but it was widely perceived that this could cause a delay in the EMU process, if not a partial renegotiation of various sections of the Treaty protocols, or at worse a two-speed EMU process. Here, speculative attacks on various currencies occurred (including the French franc), due to increased uncertainty over the French and other referendum outcomes. This probably acted as a transitory shock would have, creating turbulence in the foreign exchange market and large-scale short-term capital flows. These events and proposed explanations for them are chronicled in detail by Eichengreen and Wyplosz (1993).

III. The Development of Monetary Institutions in the Maastricht Approach

The Maastricht approach to EMU consists of three institutions: in stage two, the European Monetary Institute (EMI) is established and in stage three, the European Central Bank (ECB) takes over from the EMI (which is then dissolved) and forms the centre of a European System of Central Banks (ESCB).

a) The EMI

The EMI is the monetary institution that is envisaged in the Maastricht approach as being pivotal to the transition process to a monetary union over the most decisive period, that is, stage 2. As Fratianni, von Hagen and Waller (1992a) point out, the structure of the EMI is in fact more "federal" than the ECB of stage 3, since the decision-making rules give more weight to the national central banks than the decision-making rules for the eventual ECB do. It is, however, clear in the Treaty that the EMI does not have absolute control over national monetary policies - Article 5, 5.2 (Advisory functions) of the Protocol concerning the EMI states that the EMI can only make recommendations to national monetary authorities concerning the conduct of monetary policy.

The EMI has several explicitly defined functions in stage 2. The first is that it will inherit the EMS and the operation of the ERM (Article 109f(2)). The second is that it will take over the tasks of the European Monetary Cooperation Fund and the third is that it will "strengthen the coordination of the monetary policies of the Member States, with the aim of ensuring price stability". Finally, it will "hold consultations concerning issues falling within the competence of the national central banks and affecting the stability of financial institutions and markets" and it will oversee the Ecu clearing system and encourage the use of the Ecu.

In terms of the preparation for stage 3, the EMI has been given the following tasks (Article 109f(3)): preparation of the instruments and procedures for carrying out a single monetary policy in stage 3; preparing the rules for operations to be undertaken by the national central banks with the framework of the ESCB; and dealing with practical aspects such as preparing Ecu banknotes, harmonising monetary statistics collection etc.

A couple of problems should be recognised here. Firstly, there is an implicit assumption in the design of the responsibilities and work of the EMI that monetary union is a desired objective in and of itself, but there is, unofficially, no unanimous agreement on this point among Member States. To this end, the publication of EMI recommendations concerning a Member State's monetary policy (when corrective action is deemed necessary) may have little or no effect, particularly where national central banks are not currently fully independent and national governments are less than enthusiastic about losing monetary sovereignty. Secondly, the fiscal convergence criteria, which are overseen by the Council of Ministers, have let-out clauses, which were included in the Protocol on the Excessive Deficit Procedure as part of the Maastricht Treaty on the insistence of the Italian delegation at Maastricht (- the convergence criteria and the let-out clauses are reviewed in section V of this chapter). The let-out clauses are dynamic in nature and refer to changes in the variables designated in the criteria: if these fiscal criteria are moving towards the entry conditions, then this may suffice for entry into stage 3 (see Article 104c(2)). The more fiscally profligate Member States could then continue current policies until just before stage 3 is about to begin, and then abruptly reverse policies in order to satisfy the dynamic interpretation of the fiscal criteria. This scenario appears to contradict the whole notion of long-term convergence, and recognises that externalities to national fiscal policies are clearly not an important factor here. This argument further begs the question, to be discussed in section V, as to why fiscal convergence is necessary for monetary union. Thirdly, on an institutional level, fiscal policy is inevitably linked to monetary policy, and yet the EMI oversees only the latter, so there is unlikely to be consistent application of the criteria.

b) The ECB

As soon as stage 3 of the process of monetary union begins, the EMI will be dissolved, and the ESCB will take its place, with the ECB at the centre of the system. Its objectives are simply to maintain price stability. The tasks which it is to carry out are as follows: first and foremost the definition and implementation of the monetary policy of the EU, second, foreign exchange operations, third, the holding and managing of the foreign reserves of Member States, and last, ensuring the smooth running of the payment systems.

Extensive and detailed work has been done on the Statutes of the ECB, in particular, with reference to the institutional provisions of the Bundesbank Act (see Fratianni, von Hagen and Waller (1992a)). In contrast to the Bank of Canada, but in common with the US Federal Reserve and the German Bundesbank, the Governing Council of the ECB will include regional representatives, but in proportion to total overall seats, less than that allocated to the Executive members of the Bank (Article 10). Article 2 of the ECB statute requires the Bank to support the "general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community". The ECB Statute (Article 7) attempts to define independence by addressing specific sources of interference ("neither the ECB, nor a national central bank, nor any member of their decision-making bodies shall seek or take instructions from Community institutions or bodies, from any government of a Member State or from any other body") instead of simply establishing a status (as the Bundesbank Act does). The Treaty gives a strong role to the ECB in determining the exchange rate regime, but the Council of Ministers have power over the common external exchange rate - there appears to be a direct contradiction here. Perhaps the intention here was to mirror the Bundesbank's situation in regard to the German federal government, but the Bundesbank has a very weak role in this regard in determining the regime (for example, it was opposed to the inclusion of the DM in the ERM on its inception in 1979), but does have a strong role in day-to-day operation of the exchange rate policy. Clearly the Maastricht Treaty gives a notionally different form of independence to the ECB than the Bundesbank, in that independence is defined by exclusion rather than a specific institutional status, and exchange rate responsibilities are somewhat different to that of the Bundesbank.

There are other issues concerning the role of the monetary institutions in the process of EMU. Firstly, given the fiscal criteria already adumbrated, Article 104c(1) explicitly states that "Member States shall avoid excessive government deficits". Article 104c goes on to outline mechanisms (and penalties) for ensuring compliance with the Protocol on the Excessive Deficit Procedure. But this Protocol is not only relevant to Stage 2, and therefore is an entry condition, but implicitly remains in force after Stage 3 occurs (see Corsetti and Roubini (1993) for a more technical approach to defining optimal fiscal rules in EMU). The monetary convergence criteria will of course be irrelevant on entering Stage 3, as the ECB will have these variables under its purview. From a political economy perspective, this not only removes monetary policy sovereignty, but also could limit national fiscal policy initiatives. But, as Buiter, Corsetti and Roubini (1993) point out, "the sanction of exclusion from EMU seems a stronger incentive for fiscal discipline than the rather insipid sanctions proposed once EMU is a fact" (page 86). This also has to be placed in the context of the extremely low fiscal expenditures enjoyed by the Community institutions, which would be inadequate for interregional income redistribution and regional stabilisation in other federalist structures such as Canada or the US.

Secondly, the ECB's objectives and the process to ensure its democratic accountability are not well defined. Its primary objective is simply price stability, coupled with a rather vague mandate to support the general economic policies of the union. Price stability after entry into stage 3 is not defined in the Treaty (it is, prior to stage 3, but then only in relative terms), and so it could easily be interpreted in many different ways. In a national context, however, it is usually the responsibility of parliament to monitor and question the implementation of monetary policy. Given that the institutional arrangements are much weaker in the European context than in the Canadian or US context, due to the limited powers of the European Parliament and the limited fiscal responsibilities of the European Council, this does not permit proper accountability to a political institution (let alone one that is politically representative) and one that can legitimately undertake offsetting measures. In the case of the Bundesbank, the mandate is more loosely defined as one of "stability of the currency". Moreover, it has frequently been asked to support specific policies to avert any undermining of the government's fiscal stance, as long as this does not imperil monetary objectives. In this sense the ECB suffers from a lack of democratic accountability and has as its primary objective an economic concept that is open to significant misinterpretation.

c) The National Central Banks and the ESCB

The Maastricht Treaty is very unclear about the institutional status of the national central banks. Semantics aside, Article 14 of the ESCB statute still refers to these institutions as national banks, rather than part of a system of regional banks (following the Federal Reserve model). Although Article 14.3 of the ESCB statute states explicitly that "The national central banks are an integral part of the ESCB and shall act in accordance with the guidelines and instructions of the ECB", there is no unifying organisational structure, so that no provisions have been made for, for example, unilateral action by a national central bank that is in direct contravention of instructions issued by the ECB. By not specifying a proper federalist structure for a unified central banking system in advance, the current arrangements risk putting the national central banks in a dual responsibility role - to their governments and to the ECB.

The lack of any distinct organisational structure should be resolved by 31 December 1996, when the Council of the EMI (see Article 4.2 of the EMI Protocol) has to specify the framework necessary "for the ESCB to perform its tasks in the third stage". Nevertheless, it appears that either lack of agreement on this issue at Maastricht, or a desire to increase the responsibilities of the EMI to encourage participation are behind this approach. This leaves the national central banks in an interesting position, as Article 10.4 of the EMI Protocol states that the Council "shall require unanimity of the members of the Council of the EMI". Nowhere in the Protocol is there any procedure if, for whatever reason, representatives are unable to unanimously select one particular organisational and logistical framework for the ESCB.

The issue of central bank independence is also of significant importance. The architects of Maastricht perhaps foresaw the potential of dual responsibility outlined in the paragraph above and therefore included independence as a criterion for EMU, not entirely because of its usual association with price stability, but perhaps to also minimise any political influence from national governments. But if this is so, the nature of independence for National central banks should have been well specified in the Treaty, as there is some subjectivity in assessing independence both from economic and institutional standpoints. Indeed, independence is not an absolute concept: for instance Grilli, Masciandaro and Tabellini (1991), amongst others, constructed an index of central bank independence suggesting that various qualitative and institutional factors combine to ensure independence. Akin to price stability, the term 'independence' requires definition.

IV. Fiscal Federalism

Fiscal federalism is discussed in a branch of the public finance literature which deals with the assigning of different expenditure and tax/transfer competences to different levels of government (see Oates (1972)). Much of this literature assumes a static economy, so in a sense it is not applicable to EMU. Further, it says little about interregional income redistribution and regional stabilisation, so lacks the ability to deal with the dynamic issue of whether such disparities and asymmetries should be addressed as Member States move towards a more federalist structure. It does, however, have one important implication for

EMU, which has been enshrined in Article 3b of the Maastricht Treaty (1991), the principle of subsidiarity.

a) The Subsidiarity Principle

Subsidiarity stipulates that a higher level of government should only assume responsibilities that cannot be taken care of effectively by a lower level of government. Implicit in this principle is a preference for national autonomy in regulation, so coordination, in terms of for example the formation of committees is assumed preferable to harmonisation or centralisation (see Centre for Economic Policy (1991)). Harmonisation is seen as a last resort, once attempts to coordinate policies between Member States has failed. In all federalist structures there is always a tension between subsidiarity and harmonisation. In theoretical economic terms these competences are normally well specified, but in practical terms the line is very grey indeed.

Several questions arise here, notably: what are the reasons for attempting to implement the subsidiarity principle in practice, and to what extent might the principle of subsidiarity confound the attainment and the effects of EMU?

In answer to the question of why the subsidiarity principle should be used as a competence assignment criterion, Courchene et al. (1993) provide three arguments as follows:

i) national differences in needs and tastes;

ii) better democratic control of public services at a national level; and

iii) decentralised supply of public goods and services encourages competition and innovation between national authorities.

The first of these arguments, in the EU context, is certainly not in dispute: it is the European reality. The second reason reflects the notion that decentralised decision-making brings government 'closer to the people' (see Trech (1981)). The third argument is somewhat controversial, however, as it assumes that a sufficient degree of labour and capital (or corporate) mobility exists between Member States. Certainly, since 1993, the free movement of labour and capital following the implementation of the single market is possible, but cultural and linguistic differences inevitably inhibit labour mobility and other factors such as natural resource availability constrain the movement of firms between Member States.

Even if the third reason cited above (increased competition between national authorities) for the subsidiarity principle is set aside, the principle could be justified on the basis of the first two reasons. But in what circumstances should competences either be coordinated or passed to a supranational level of government, according to the principle of subsidiarity? In 1977, the MacDougall Report was published (Commission of the European Community (1977)) which "examined the criteria for assigning functions to the different levels of a multi-tier government" (Plender (1991)). The report identified 4 rationales for assigning competences, in addition to that of the principle of subsidiarity. These are:

i) cross-border spill-over effects of national policies that give rise to externalities;

ii) economies of scale and/or indivisibilities in national policies; and

iii) the pursuit of homogeneity and/or fairness.

With spill-over effects, the more integrated economies grow, the greater these spill-over effects are likely to be. For economies of scale and/or indivisibilities, efficiency gains are cited as the benefit. The pursuit of homogeneity and/or fairness (labelled as "national standards" in Canada), however, is the most controversial. In terms of the homogeneity argument, this justification has been already caused much debate within Europe following claims that the European Commission has not been following the subsidiarity principle and has initiated directives in areas where it has no competence (for example, sausages, garden implements and beer!).

In terms of the notion of fairness, this brings into play the whole issue of regional disparities, and the fiscal competences of the EU. This issue is crucial, as it is in this realm that the principle of subsidiarity could conceivably confound EMU.

b) <u>Regional Disparities</u>

The political tension between those gaining and losing in a federalist structure is normally justified by the economic principles of fiscal federalism. The principle here is often called the 'resource flow' principle - that is, the flow of resources should flow from richer to poorer Member States. Hence regional disparities might be expected to diminish in a federalist structure. But the degree of political homogeneity is clearly a factor in the perceived desirability for the extent of 'resource flow', even if such economic benefits in terms of overall welfare improvement could be convincingly demonstrated. The experience of federations such as the USA, Australia and Canada is that language and cultural similarities and factor mobility engender a much greater level of acceptance for 'resource flow' in general and more specifically regional income redistribution. Table 6.2 details recent estimates regarding inter-regional income redistribution in the US, Canada and Australia.

TABLE 6.2

Estimates of Competence Specialisation in Selected Federal Countries through a Centralised Budget

Country	Expenditure Centralisation	Revenue Centralisation
USA	76.5%	68.0%
Canada	50.6%	50.3%
Australia	80.4%	74.4%
Switzerland	61.9%	55.6%
Belgium	93.5%	93.1%
Germany	70.0%	61.9%

Notes: i) All figures are for 1988, with the exception of Switzerland, 1984.

ii) 'Expenditure Centralisation' is consolidated central government expenditure as a proportion of consolidated central government plus other state spending: IMF Government Statistics.

iii) 'Revenue Centralisation' is tax revenue and social security contributions to consolidated central government relative to total tax and social security revenue of consolidated governments: IMF Government Statistics.

In the above table, all mature federations are shown to have a substantial degree of expenditure and revenue centralisation. Most of these countries are unilingual, bilingual, or trilingual at most, which suggests that linguistic and cultural differences might be a major impetus for the acceptability of resource flows, as compared with the EU.

d) Budgetary Fairness and Convergence under Maastricht

As Courchene et al (1993) point out, "there is an inverse relationship between State public finance autonomy and interregional redistribution". This claim directly follows from the fact that the capacity for interregional redistribution depends *ceteris paribus* on the size of the federal budget relative to the budgets of the Member States. There are, therefore, in any federation, winners (the poorer Member States) and losers (the richer ones) - this is usually referred to in political terms as "fairness in the supra-national budgetary process". In fact, the acrimonious *juste retour* debate in Europe was triggered by this specific issue in relation to the UK, and although it was corrected with the 'UK abatement declaration' at the Fontainebleau Summit (1984), the issue of "fairness" in terms of net contribution to the EU is still a major issue in many Member States. In most mature federations "fairness" is also an elusive concept in budgetary politics, as certain expenditures cannot generally be apportioned on a regional basis.[2]

This naturally leads to a discussion of the nature of convergence within a more federal EU structure. Given no inter-regional income distribution, there are two views here on whether convergence will occur in an economic union - the most well known often being labelled the 'convergence hypothesis'. The convergence hypothesis states that spatial disparities will tend to disappear under an economic union due to international trade, capital flows and labour mobility. The opposing view stresses the existence of imperfect competition, economies of scale and externalities and so asserts that convergence in an economic union will be deflected due to 'cumulative causation' processes (see Prud'homme (1993)). Clearly, even if international trade has no additional effects in the EU, inter-regional income redistributions must be sufficiently large enough to offset any 'cumulative causation' processes for economic convergence to occur.

The whole notion of budgetary fairness is therefore congruent to that of economic convergence. But economic convergence in reality under Maastricht is a moot issue, as the loss of two economic policy levers (monetary and exchange rate policies) leaves only two other levers (national fiscal policies and the EU budget itself). This could limit national governments when responding to asymmetric shocks and could potentially discourage convergence. The outcome logically depends upon the relative phasing of business cycles between each Member State and the ability of national governments and the European Commission through the EU budget, to respond through fiscal means.

Concerning the role of the EU budget, the medium term evolution of the EU budget was decided by EU leaders at the Edinburgh Summit in 1992. The budget will grow from just under 1.2% of EU GDP to a limit of 1.7% of EU GDP by 1999, coincidental with the last date that stage 3 of EMU can begin. Furthermore, it was decided that the Commission would be denied fiscal sovereignty (the ability to raise taxes independently of national governments) and would continue to raise most of its resources by a 'surcharge' on indirect taxes (VAT) collected by Member States. This is in addition to the legal prohibition from running a deficit and the highly discretionary nature of outlays, with more than 80% being directed to the Common Agricultural Policy or regional development.[3] The inability to raise 'own resources' and to operate inter-personal income transfers, when compared to other more fiscally-sovereign federalist structures, is unique to Europe. This suggests that the reason that the EC budget is so minuscule in comparison with other more mature federations might be because of the political unacceptability of regional income redistribution and the associated addition of tax competences to a centralised federal administration.

The fact that there will be little interregional income redistribution in the EC suggests that the ties binding the Member States together will be far less substantial and resilient than for countries in table 6.2. The reality of this fact spawns a whole series of corollaries, but most poignantly that the Member States will need a great deal of fiscal latitude to deal with regional- or industry-specific disturbances and shocks, given that both monetary sovereignty and the exchange rate instrument will no longer be available to Member States.

It should be noted that one other economic valve for responding to asymmetric shocks, *ex post*, is through labour migration. As has already been noted, cultural and linguistic differences (as well as inter-regional transfers themselves) tend to inhibit the rate of migration to high growth regions, as has been observed in Canada and Switzerland.

As the EU budget cannot support compensatory redistributive initiatives to alleviate the effects of asymmetric shocks, this leaves, *in extremis*, national fiscal policies as the only policy lever available.

V. The Maastricht Convergence Criteria

The Maastricht convergence criteria have a dual purpose. As stage 3 of EMU approaches, economies should maintain a convergent path, not only in a monetary sphere, but also with respect to fiscal policies. Convergence criteria also deflect any concerns that national governments might participate in 'end games' (as explained in section II.a).iii) above). Convergence criteria, then, are a useful way of facilitating a smooth transition period to EMU, with explicit objectives, as well as a complementing the increased fixity of exchange rates envisaged for the EMS. The pertinent question is not the desirability of convergence criteria *per se*, but rather which criteria are relevant, practicable and suitable to reflect convergence of the economic variables that will best ensure the least onerous path to EMU. Any critical assessment of the criteria should pursue this line of inquiry, given that the criteria have already been selected and defined by the Maastricht Treaty.

a) The Criteria

Economic convergence criteria are laid down in the Maastricht Treaty. This is unique to Europe, and is politically a recognition of the 'economists' approach to monetary union. The criteria are as follows (Article 109j):

i) Price Stability - an annual average rate of inflation that does not exceed by more than 1.5% that of, at most, the three best performing Member States;

ii) Interest Rates - observed over a period of one year, a Member State has had an average nominal long-term interest rate on government bonds that does not exceed by more than 2% that of, at most, the three best performing Member States in terms of price stability;

iii) Government Deficits - the deficit should not exceed 3% for the ratio of the planned or actual government deficit to gross domestic product at market prices;

iv) Government Debt - the debt should not exceed 60% for the ratio of government debt to gross domestic product at market prices; and

v) ERM - a Member State has respected the "normal" fluctuation margins provided for by the exchange rate mechanism of the EMS without severe tensions for at least the last 2 years before the examination; it should not have devalued its currency within the mechanism during this period.

Due to the extraordinary events of 1992, criteria v) has essentially been dropped by the EMI (- or, less judgementally, it has been "re-interpreted"). Much has been written on these criteria, and in particular, the fiscal criteria iii) and iv) have been the focus of much attention (see Goodhart (1991), Buiter, Corsetti and Roubini (1993), Langfeldt (1992), Papadia and Schioppa (1993) and Centre for Economic Policy Research (1991), among others).

The first two criteria are very well specified (apart from the maturity of the long-term government bond to be chosen, as liquidity can vary significantly along the yield curve), and make economic sense in the context of the economic circumstances prevailing when the Maastricht Treaty was signed. If stable exchange rates are to be achieved, then inflation convergence in terms of tradable goods would be advantageous. In terms of criteria ii) (long-term interest rates), high intra-EC capital mobility combined with criteria v) (the ERM) would imply that long-term interest rate differentials would only occur with differential default risk. Eliminating such differential risk may be the motivation behind criteria iii) (government deficits) and iv) (government debt). As criteria i) (inflation rates) and ii) (long-term interest rates) are only entry conditions they appear to be sensible, not only because they are defined in relative terms, but also because they closely link the entry conditions so as to be dynamically consistent with the final objective.

Criteria iii) and iv) (government deficits and debt, respectively), in contrast, are absolute objectives that, *inter alia*, bear little relation to the eventual objective. They are, however, linked with the section in the treaty dealing with the co-ordination of national policies (Articles 102a and 103). Table 6.3 summarises the Maastricht criteria.

TABLE 6.3

The Maastricht Convergence Criteria

Criteria	Nature	Entry Condition?
i) Inflation rate	Relative	Entry
ii) Interest rate	Relative	Entry
iii) Govt. deficit	Static	Continuing
iv) Govt. debt	Static	Continuing
v) ERM	Relative	Entry

It should be noted that the ERM conditions are really a 'relative' criteria because the Ecu itself is a basket of all EMS currencies, and further, although the ERM may continue after stage 3 of EMU begins, as soon as all Member States adopt the Ecu, the ERM will cease to exist. Also, and most importantly here, the fiscal criteria would not be relaxed (post-stage 3) but act as a measure for ensuring that Article 104c(1) ("Member States shall avoid excessive deficits") of the Maastricht Treaty is not transgressed.

b) Fiscal Policy and EMU

Are the two fiscal criteria sensible as entry conditions, in other words are they attainable objectives for Member States objectives by 1999? It is widely recognised that most EC Member States are far from achieving these objectives; Buiter, Corsetti and Roubini (1993) have estimated what constant % deficit-GDP ratio would have to be maintained to cut the debt-GDP ratio to 60% under various scenarios, and find that the results for Belgium, Italy and Ireland are unrealistically punitive and "describe the economics of the lunatic asylum". The implication being that these criteria are not realistic entry conditions for EMU.

In the context of a monetary union, are fiscal criteria desirable in terms of the credibility of the union and the stance of overall fiscal policy for a Member State? The need for such criteria or rules was set out originally in a paper by Lamfalussy (1989); the most pertinent of the reasons for such criteria are as follows:

- the desirability of an appropriate fiscal policy for the union as a whole;
- the need to avoid disproportionate use of Community savings by one country; and
- a possible bias towards lack of fiscal restraint.

The desirability of a pan-European fiscal policy, as far as Goodhart (1991) is concerned, is the least contentious reason for fiscal EMU criteria. If a certain degree of fiscal sovereignty were allocated to federal institutions, as in other mature federations, then with co-ordination between federal institutions and Member State governments, an appropriate fiscal policy, which would of course include interregional income distribution and regional stabilisation policy, could easily be designed.[4] As the principle source of revenue for the EU budget is currently the VAT resource (at 1.4%), as Annex 6B shows, the EU budget is already largely determined by the fiscal stance with regard to indirect taxes adopted by each Member State.

As the EU budget does not use direct taxation, it has little control over EU fiscal policy, and nor is it envisaged to have such a role in the future, and certainly not before 1999. If fiscal policies were to be co-ordinated as a means of achieving an appropriate fiscal policy for the union as a whole (as Lamfalussy argues), this would still leave the EU budget as grossly inadequate to deal with interregional income redistribution or regional stabilisation.[5] As Courchene et al (1993) suggest, in both the US and Canada, roughly 30 to 40% of primary income disparities between states in mature federations are reduced by the activities of central governments: also, around 20 to 30% of a change in real economic activity in an individual state tends to be offset through federal financial flows. It may be argued that co-ordination would ameliorate some of the undesirable regional effects, but in other federations such as Canada, the US and Australia, federal governments have only a small role in co-ordinating regional fiscal policy, as spill-over effects are recognised as being negligible (see Buiter, Cossetti and Roubini (1993)) and the benefit from coordination may even be negative (Bryant et al (1990)).

Lastly, aggregate EC fiscal stance cannot be adequately determined by two reference criteria, as they have been selected in an arbitrary fashion. The government debt criteria relates almost entirely to past fiscal policy stance, and the government deficit criteria does not allow for counter-cyclical deficits and ignores the distinction between current and capital spending.

So, fiscal criteria appear to be untenable on the basis of Lamfalussy's first justification for having an appropriate pan-EU fiscal policy.

The second of Lamfalussy's justifications for fiscal criteria is the need to avoid undue appropriation of EMU savings by one country. The circumstances under which this could occur are not clear. Lamfalussy recognises that this could only occur "if a particular government encountered refinancing difficulties" which caused the EC to "bail out the government in financial trouble" (p.96). But the Treaty (Article 104b) makes it very clear that the Community or any other "Member State shall be liable for or assume the commitments of central governments, regional, local or other public authorities, other bodies governed by public law or public undertakings of another Member State". So in this case the criteria are clearly excessively stringent. The other circumstance that Lamfalussy gives for this need is if excessive borrowing by one Member State raised the interest rate level throughout the Community, causing 'crowding out' in countries where the interest rate would have been lower. But, market risk premia should act to reflect the size of debt and ability to repay debts. In an appendix to his paper, Lamfalussy points to the fact that governments are not subject to the same market discipline as companies are when participating in the debt market, and in addition he stresses the situation where the financial markets might expect a higher level of government to bail out a lower level of government (- the example of New York is used here). But in political terms this argument makes no sense. In the EU, with the exception of perhaps some "olive belt" Member States, the mere idea of defaulting on sovereign debt would have economic and political consequences that are much too horrendous to imagine for most governments. Even if there were exceptions to this, the no-bail-out clause provides protection for the EU institutions. If a Member State did default on its sovereign debt it remains to be seen if this would have an economic impact on the EU as a whole, through an externality effect.

The third of Lamfalussy's justifications for specifying fiscal criteria is the possible bias towards a lack of fiscal restraint. The example that Lamfalussy uses here is the restraining of regional government expenditure, particularly in the case of Italy. But he readily acknowledges that "the available evidence from federal systems would not seem to suggest a bias towards lack of fiscal restraint" and cites Canada and the US, where evidence confirms that markets differentiate between the various regions as regards credit risk.[6] He then states that "it remains unclear, however, what are the factors ultimately accounting for the apparent lack of a bias *(towards lack of fiscal restraint)* in the states examined. This raises doubts about the extent to which their experience can be of guidance for foreseeable conditions within a European EMU." (italics added to clarify). To deny that the power of the democratic political process in combination with the financial markets is sufficient to ensure fiscal rectitude on the part of Member State governments or ultimately a change in government, is to question the compatibility of a market-based economy with democracy. If this compatibility is questioned, there is still no philosophical reason to choose to reject something just because the situation in which it is to be applied *might* be different from the norm. From a logical perspective, imposing such criteria before the fact would therefore also seem to be inappropriate.

In addition, the Maastricht Treaty is very specific that debt is not to be monetised (Article 104(1)). Many Member States that currently enjoy the ability to monetise debt would thus have this avenue removed, and would therefore be more restricted in their ability to be fiscally irresponsible. Issuing debt appears to be the only route available for Member States post-stage 3.

In summary, therefore, there is apparently no reasonable economic rationale for fiscal entry conditions or national fiscal policy criteria after EMU is achieved, as has been defined in the Maastricht Treaty. The foregoing arguments have been based on the use of fiscal criteria post-implementation of stage 3 of EMU; the following section discusses dynamic aspects of the fiscal criteria in the transition period to stage 3.

c) Dynamic "let-outs"

As the fiscal criteria pose almost insurmountable problems for several EU Member States (notably Italy, Belgium and Greece), 'let-out' clauses were added into the Maastricht Treaty to enable these Member States to participate in EMU even though they might not meet all the specified criteria. The Excessive Deficit Procedure laid out in the Treaty specifies that:

> "The Commission shall monitor the development of the budgetary situation and of the stock of government debt in the Member States with a view to identifying gross errors. In particular it shall examine compliance with budgetary discipline on the basis of the following two criteria:
>
> a) whether the ratio of the planned or actual government deficit to gross domestic product exceeds a reference value, unless either the ratio has declined substantially and continuously and reached a level that comes close to the reference value:
>
> or, alternatively, the excess over the reference value is only exceptional and temporary and the ratio remains close to the reference value;
>
> b) whether the ratio of government debt to gross domestic product exceeds a reference value, unless the ratio is sufficiently diminishing and approaching the reference value at a satisfactory pace." (Article 104c(2))

Firstly, note that it is the Commission that is enjoined to identify whether Member States have committed "gross errors". "Gross errors" clearly refer to whether the reference levels defined in the criteria have been transgressed, but a further arbitrary dynamic component has been overlaid onto these absolute measures to provide "let-outs" for certain Member States.

Secondly, note that most emphasis is placed on the government deficit criteria, as if countries run primary surpluses, then total debt logically falls by definition. Of the high debt countries (as noted recently in Financial Times (1994c)), Belgium, Ireland, Italy and the Netherlands all had significant primary surpluses in 1993. Belgium, Italy and Greece all had debt ratios in excess of 100 per cent of GDP for 1993 and the Netherlands and Ireland all had debt ratios in excess of 80 per cent of GDP for the same year.

These dynamic "let-out" clauses are extremely flexible due to their generic nature and the fact that the Commission, hardly a disinterested party, will decide when and where "gross errors" occur. These subtleties have a further implication: it is clearly in a Member State's best interests to strive to meet as many of the entry conditions to EMU as possible in order to enter stage 3, but these dynamic "let-out" clauses make little sense once EMU is achieved. Given the loss of monetary and exchange rate policy levers on entering stage 3, Member States will have little incentive to abide by the fiscal discipline endemic in the dynamic "let-out" clauses in the longer term: the business cycle coupled with the insipid penalties that the Council could impose upon Member States (Article 104c(11)) would provide enough reason not to 'stay the course'.

So, in brief, there is no economic rationale for the fiscal policy criteria as entry or continuing criteria, but given the criteria remain in force, it makes little sense to continue with dynamic "let-out" clauses after stage 3 begins.

d) <u>Credibility Issues</u>

Excessive flexibility in applying the fiscal policy criteria, both pre- and post-entry into stage 3 of EMU, as well as the abandonment of the narrow margins of fluctuation for the ERM of the EMS may lead to a lack of credibility in the whole EMU process, particularly in light of the significant changes that have taken place in Europe since the signing of the Maastricht Treaty (Annex 6C provides a review of recent events from an economic perspective).

In terms of exchange rate fluctuations, the Maastricht Treaty states that the criterion should be that a "Member State has respected the normal fluctuation margins provided for by the ERM of the EMS without severe tensions for at least the last two years before the examination" by the European Council (Protocol on the Convergence Criteria, Article 3). Following the exchange rate turbulence in the latter half of 1992, Italy and the UK left the ERM and all members, with the exception of the Netherlands, widened their fluctuation bands to +/-15% from the previous "narrow" bands of +/-2.25%. So now, application of this criteria hinges upon the interpretation of what is "normal". A +/-15% fluctuation margin is not "normal" when put in context with the last 15 years of the operation of the ERM of the EMS, and is tantamount to operating a quasi-flexible exchange rate policy. So if the European Council decides to interpret "normal" as +/-15%, then this renders this exchange-rate convergence criteria as effectively redundant (see Financial Times (1994b,c)). The economic policy implication of such an interpretation is that exchange rate policy then becomes a policy lever that can be used by Member States in the transition period to stage 3 of EMU.

In order to enter into stage 3 of EMU, many Member States will be relying on an application of the looser dynamic "let-out" clauses rather than a strict interpretation of the fiscal convergence criteria. But in addition to short-term fiscal restraint (as discussed above), this implies managed depreciation of these Member State currencies in order to boost growth, and therefore GDP. In fact the original rationale for choosing the arbitrary levels of government deficits and debt in the fiscal criteria were based on the steady-state levels of government deficits that would stabilise government debt. But this implies a nominal growth rate of at least 5% in GDP.[7] Attempts to boost growth to these levels could, in turn, impede progress towards meeting the inflation criteria, but nevertheless, might be a risk worth taking for those Member States anxious to participate in the EMU process.

The design of the EMU process in the form of its original blueprint, relied heavily on the credibility of the ERM of the EMS to achieve convergence and a reasonable degree of price stability (which in turn would narrow interest-rate differentials). Without this exchange rate policy anchor, the whole process of EMU becomes arbitrary. The potential for conflict and an over-riding reliance on the degree of emphasis placed on the Commission's decisions as to what is "excessive" becomes operative, which may potentially give Member State governments an incentive to adopt various expedient policies during the transition period. The argument here is similar to that of dynamic inconsistency (see Barro and Gordon (1983)), except that it is the exchange rate that is sacrificed on the altar of EMU rather than monetary policy for short-term growth.

But notwithstanding the above argument, abandonment of the ERM of the EMS could potentially lead to other problems: why should inflation rates converge to within 1.5% of the lowest inflation rates in the EU? Each Member State's inflation rate will be determined by indigenous monetary policy, not, as previously, by the exogeneity of an external exchange rate constraint. Similarly, interest rates need not converge, as the removal of the exchange rate constraint will lead to more divergent risk premiums.

In summary, the convergence criteria, as currently devised, do not, in the present circumstances, represent a consistent set of objectives (or 'means') for achieving the ultimate objective (or 'end') of EMU. If anything, the Maastricht convergence criteria represent obstacles to the attainment of EMU, and will almost certainly ensure that the peripheral Member States have to tread a path of 'greatest resistance' to get to the desired objective.

VI. The Maastricht Treaty and Evaluation of Feasible Alternatives

The Maastricht Treaty is a reality, but EMU is not yet cast in stone. When a review of the progress towards achieving EMU occurs at the Inter-Governmental Conference (IGC) scheduled for 1996, the Maastricht Treaty may not be annulled without significant procedural problems, and with the exception of the UK, there is little will in the Union to take this route. (For an economic perspective in favour of scrapping EMU altogether, see De Grauwe (1994)). As Article B of the Maastricht Treaty suggests:

> "The Union shall set itself the following objectives: ...and through the establishment of economic and monetary union, ultimately including a single currency in accordance with the provisions of this Treaty; ...The objectives of the Union shall be achieved as provided in this Treaty and in accordance with the conditions and the timetable set out therein ..."

But the Treaty might easily be amended or sections of it replaced, as Article F(3) of the Common Provisions specifies:

> "The Union shall provide itself with the means necessary to attain its objectives and carry through its policies."

There is also a legal precedent here, as in the case of the single market legislation, which was amended several times after its original legal adoption in 1986.

a) A Critical Assessment of Maastricht

The virtual abandonment of the ERM of the EMS makes "the transition strategy to monetary union devised in the Maastricht Treaty impracticable" (De Grauwe (1994)). The objective of Maastricht was to replace the current arrangements in the EU with a monetary union and a weak federalist structure, but with restrictions on regional fiscal autonomy. This combination of objectives is inconsistent, given the experience of other federal structures and given existing economic theory.

Economic theory has little to say about transition to a monetary union, but it does have something to say about optimum currency areas. In optimum currency areas, the monetary union works best when there is a flexible labour force with a significant level of mobility so as to offset any asymmetric shocks. Further, in optimum currency areas, some form of fiscal redistributive process should be in place to enhance cohesion among the participants.

Economic theory aside, transition processes should not be dependent on criteria. The example of GEMSU reinforces this point. German monetary union was not dependent on economic criteria but was justified solely on political and social grounds. In Germany, once monetary union was achieved, then the process of economic convergence began, albeit with severe economic distress in some regions, and despite objections from 'economist' viewpoints at the Bundesbank. The economic dislocation in Germany, one might argue, was minimised by a well-educated and mobile labour force in the former East Germany (in addition to the fact that East Germans speak the same language as West Germans), and this would not be mirrored in Europe as a whole (consider the Portuguese, for example).

But arguments about labour mobility miss the point. To refute arguments that economic criteria are necessary to achieve a monetary union, one only has to consider objectives: was the ultimate objective to achieve monetary union or to foster convergence? If the ultimate objective is to achieve monetary union, then it is relatively easy to implement in one rapid ('Hawaiian') step. If the objective is to achieve economic convergence in the Union, then an adjustable-peg exchange rate regime with fiscal transfers is probably the easiest route (as envisaged in the original Delors Report). If the ultimate objective is both monetary union and economic convergence, then it is far easier to implement monetary union and then strive for economic convergence than vice-versa. As the objectives of EMU are by definition both economic and monetary union, then it seems sensible to adopt a 'monetarist' approach. The only issue then becomes how you get to monetary union (i.e. the rate of conversion for national currencies to the Ecu). Economic convergence prior to monetary union virtually disqualifies the poorer, more inflation-prone Member States of the Union from attaining EMU for some years to come, and favours the richer, less inflation-prone Member States. In this sense, the Maastricht Treaty has put the cart before the horse.

If the Maastricht convergence criteria are collectively inconsistent and furthermore are unlikely to be of help in advancing EMU for all but a few Member States, it is unclear from an economic perspective as to why the architects of Maastricht chose this particular combination of timetabling and economic criteria. The combination was probably the result of political 'horse-trading' and ad-hocery. Indeed, Frankel (1993) suggests that the treaty may be a modern-day economic version of the mythological notion of the quest (for example, Jason of the Argonauts) with the fiscal criteria as the object of the quest and EMU the prize. Under this interpretation, the object could either be a test of will or a 'Machiavellian plot' on the part of the Bundesbank to torpedo the plans for EMU altogether!

In the following sections feasible alternatives to Maastricht are presented: firstly in terms of amendments to the current treaty that might address the problems cited above while retaining the whole notion of gradualist approach to EMU, and secondly in terms of replacing sections of the Treaty with other viable alternatives.

a) Amending the Treaty

The original Delors Report (Committee on Economic and Monetary Union (1989)) proposed a strategy for EMU based on two axioms (as Fratianni, von Hagen and Waller (1992b) identify), 'parallelism' and the use of the EMS as the launching pad for the process. The principle of parallelism states that EMU "form two integral parts (economic union and monetary union) of a single whole and would therefore have to be implemented in parallel" (para. 21, parentheses added). The justification for parallelism in the Delors Report is that "monetary union is only conceivable if a high degree of economic convergence is attained" (para. 21). But the report does not really distinguish the process of economic convergence with the attainment of the state of economic union, in terms of linking monetary union with the aims of a single market (supposedly attained at the beginning of 1993). Monetary union clearly enhances the benefits of a single market, but without sufficient fiscal latitude for Member States or fiscal sovereignty at the EU level, the process of economic union will take a much longer time to run its course.[8] So the modifications to the Maastricht Treaty that, following the assessment above, would avert a "two-speed" EMU process and make the treaty workable in economic terms, are ones that enhance convergence, but do not impose a "no-entry" clause for those countries unlikely to meet the static fiscal criteria nor appeal to subjective 'dynamic' criteria. The proposed possible options for modification of the treaty are measured against Maastricht as is, and a slight hardening of the Maastricht conditions. They are as follows:

i) drop the dynamic fiscal criteria and retain all other fiscal criteria with no alterations to projected EU budgets and allow for a multi-speed EMU; or

ii) maintain all fiscal criteria with no alterations to projected EU budgets and allow for a multi-speed EMU; or

iii) drop the fiscal criteria altogether with no alterations to projected EU budgets; or

iv) drop the dynamic fiscal criteria, drop the debt entry condition but maintain the budget deficit entry condition, drop the fiscal conditions post entry into stage 3, and slightly increase the EU budget; or

v) drop the dynamic fiscal criteria, drop the debt condition (both as entry and post entry), maintain the budget deficit criterion (as both an entry condition and as a post-entry into stage 3 condition), and moderately increase the EU budget; or

vi) drop the debt entry condition, maintain the budget deficit criterion (both as an entry condition and as a post-entry into stage 3 condition), maintain the debt condition post-entry into stage 3 and substantially increase the EU budget and increase fiscal competences; or

vii) drop all entry conditions, but maintain post-entry into stage 3 conditions, and substantially increase the EU budget and increase EU fiscal policy competences.

The 7 options are summarised below in table 6.4.

TABLE 6.4

Options for Modifying Maastricht

Option	Drop Dynamic Criteria	Drop Deficit Criteria Pre	Drop Deficit Criteria Post	Drop Debt Criteria Pre	Drop Debt Criteria Post	EU Budget	2-Speed EMU
i)	Yes	No	No	No	No	Same	Yes
ii)	No	No	No	No	No	Same	Yes
iii)	Yes	Yes	Yes	Yes	Yes	Same	No/Yes
iv)	Yes	No	Yes	Yes	Yes	+	(No)
v)	Yes	No	No	Yes	Yes	++	(No)
vi)	No	No	No	Yes	No	+++	No
vii)	No	Yes	No	Yes	No	+++	No

For all seven options, several other permanent alterations to the treaty are recognised. These are firstly, either the abandonment of the narrow bands of the ERM of the EMS as an entry criteria, which probably heralds a death-knell for the ERM, as in fact has happened (a view which was originally espoused by the 'MIT6', a group of academic economists from the MIT - see Financial Times (1993b)), or the imposition of appropriate measures to allow the ERM to operate under narrow bands again (such as capital controls or a tax on foreign exchange rate transactions - see Eichengreen and Wyplosz (1993) on this point). Secondly, there may have to be some change in the timetable for EMU - a 1999 inception for stage 3 would appear more appropriate in the light of recent events, but much depends on the progress of Germany and how the "dynamic" fiscal conditions are to be interpreted.

The first option (option i) would accept all the Maastricht criteria, but would drop the dynamic 'let-out' clauses, and would therefore substantially elongate the period of time over which stage 3 is in force. It has been suggested that Germany is wedded to the notion of a "two-speed" EMU, because it wishes to maintain hegemony over European monetary policy. Indeed recent reports in the press suggest that the fear of losing autonomy over monetary policy has prompted the German Finance ministry to prepare for allowing the DM to circulate alongside the ECU in the first few years of EMU, as an insurance against an undesirable outcome in EMU. Alesina and Grilli (1993) use a simplified model that suggests that by proceeding at "two speeds", the achievement of complete integration would be in jeopardy. In other words, the path dependency of the final outcome would determine the extent of monetary union within the EU. Option ii) is basically the current conditions, as specified in the Maastricht Treaty.

Option iii) completely eliminates the fiscal criteria (and therefore implicitly the Protocol on the Excessive Deficit Procedure). This option recognises that the fiscal criteria are arbitrary in nature and are perhaps desirable, but not necessary conditions, for attaining EMU. A "two-speed" EMU would for the most part be averted under this option. De Grauwe (1994) has recommended a variation of this option, invoking the principle of free choice by letting each Member State decide when and if they wish to join EMU. By invoking this principle, though, a "2-speed" EMU process becomes almost a certainty.

The next four options allow slight variations to the Maastricht Treaty conditions, but all allow EMU to be realised, while allowing increased national fiscal autonomy and altering the current plans for only a slight expansion of the EC budget. Option iv) maintains the budget deficit criteria as an entry condition, thereby recognising the importance of an attempt by the more inflation-prone Member States to curb deficits. Note that maintaining a budget deficit of 3% or less would not necessarily lower debt/GDP levels. To counter this constraint on national fiscal autonomy on the approach to stage 3, the EU budget would undergo a slight increase over current projections to 1999.

Option v) alters option iv) by imposing the budget deficit criterion both as an entry condition and post-entry into stage 3. Under this scenario, the EU budget would need to continue increasing so that it reached levels envisaged by the McDougall Report (over twice the level for 1999 that was agreed upon at the Edinburgh summit).

Option vi) adds the debt condition post-entry into stage 3 but allows the dynamic fiscal criteria to be applied, thereby enforcing a reduction in debt-GDP ratios in addition to constraining budget deficits. Here, not only would the EU budget have to substantially increase to allow moderate budget surpluses, but also the EU would acquire some fiscal sovereignty, in the form of additional policy competences. This increase in the EU budget now goes beyond the levels recommended in the McDougall Report.

Option vii) would be identical to option vi) but would deny the usefulness of fiscal criteria as entry conditions. In other words, option vi) represents a modified 'monetarist' approach to EMU as, unlike option iii) which also drops the fiscal criteria, it takes other federal structures as a model but recognises the need to address the budget deficit and debt problems in some Member States. Again, substantial inter-regional resource flow would be permitted through a larger EU budget with more fiscal policy competences transferred to the EU level.

Economic options are all well and good, but what is politically feasible? In option i), the fiscal criteria are so unrealistic for certain Member States that their entry into stage 3 would be left to the discretion of the "first speed" countries and may not materialise. In option ii), the same fate may befall these Member States, but clearly much depends on the attitude of the Bundesbank to strict adherence to the Maastricht criteria and to the leeway for liberal interpretations of the dynamic "let-out" clauses by the EU. Indeed, with regard to the other options, the Bundesbank appears to have considerable clout in these negotiations, so some post-stage 3 entry conditions may still be necessary; at the other end of the spectrum, the UK government would be violently opposed to any 'federalist' structure with substantial redistributive powers for Brussels. This rules out options iii), vi) and vii), leaving only options i), ii), iv) and v). Option i) is unlikely to materialise, as southern European Member States are not going to give up the dynamic criteria for nothing in return.

From a bargaining perspective, options iv) or v) seem to be the most likely reasonable alternatives to option ii) (the status quo). Clearly, much depends on the price that Germany is willing to pay to eliminate the dynamic "let-out" clauses, as to which of these would be favoured. Perhaps an additional "let-out" clause for Germany to continue using the DM during stage 3 could also be introduced into the bargaining as an appeasement. Both these options, and option v), in particular, would also be entertained by the European Commission, which has, for some time, been trying to justify more fiscal policy competences and give the European parliament more credibility as well as a greater role as a pan-European decision-making body (see Financial Times (1994a) for more on this).

c) Replacing the Treaty

If one accepts that a parallel/gradualist approach to EMU is fraught with political and economic adjustment problems, other options are available. The three options considered are listed below:

i) an abandonment of gradualism and an attempt to pursue political and economic integration before the optional replacement of national currencies with the ECU; or

ii) a competing currency 'Hard ECU' option - issuance of ECUs by the ECB which would circulate alongside national currencies but at a fixed rate with the strongest currency in the EC; or

iii) a reinstatement of the ERM of the EMS as the vital stepping-stone to a single currency with appropriate measures to minimise speculative attacks.

These options are generic in nature, and could be combined: for example, option i) is not incompatible with option iii). Option i) is an 'economists' view of the integration process, with political and economic integration foreshadowing any monetary union - in this scenario monetary integration would come about in an evolutionary manner, once other policy instruments are in place and EU political institutions have had time to evolve. Option ii) would not necessarily call for *a priori* political and economic integration, but would operate in an evolutionary way, in this instance based on individual agent's monetary preferences. EMU then may never be completed as a process, but trade and cross-border transactions would be facilitated and fiscal restraint would be encouraged. Option iii) is perhaps the most controversial, and would necessitate a thorough review of the recent adverse experience of EC Member States with the ERM, as well as substantial reform of the political and defensive mechanisms that are embodied in such a system. John Williamson (Financial Times (1994c)) echoed this view, recently advocating restoration of the EMS but with "rates...pegged at levels that make sense in the light of the fundamentals and that are promptly changed to reflect changes in the fundamentals". If a monetary authority such as the EMI were given complete control of the workings of the EMS, perhaps more prompt and appropriate adjustment would take place, confounding any speculative attacks on the system. Once economic convergence had been achieved, as defined by exchange rate stability and perhaps other criteria defined by an independent EMI, Member States could then proceed to replacement of national currencies with ECUs. Indeed, in the shorter term, whatever route is chosen, the European Commission is likely to push for attainment of EMU as rapidly as possible, as floating exchange rates threaten many of the policies of the Union, notably the common agricultural policy. Table 6.5 summarises these options:-

TABLE 6.5

Feasible Replacements for Maastricht

Option	Exchange Rate Stability?	Economic Union Complete?	"2-Speed" EMU?
Maastricht	(Yes)	Converging	Yes
i)	(Possibly)	Yes	No
ii)	?	?	(Likely)
iii)	Yes	?	(Possibly)

As to the issue of which of these plans is politically feasible, only option i) precludes the possibility to a "two-speed" Europe. Indeed, in option ii), as long as legal tender provisions are in place in all Member States, the decision as to when to introduce EMU is removed from the national governments, and also from Brussels. Option iii) would probably be opposed by the UK, but as participation in the ERM is voluntary, it could hardly claim that its hands were tied. If adopted and effectively implemented, the UK would soon find itself left on the periphery of the integration process.

All of these options have, at some point, been advocated by economists. Nevertheless, replacing whole sections of the Maastricht Treaty is likely to be attempted only after failure to reach a consensus on modifications to the treaty - so in this sense all the above options are second-best political solutions compared with those advocated in section VIb). The interactions of the special interests of all the political parties concerned is the subject of the next section.

d) EMU - Economic Jingoism or a Pyrrhic Victory?

In 1996, Member States will have a chance to amend the Maastricht Treaty at the scheduled Inter-Governmental Conference (IGC). Posturing on the issue of EMU has already started, as of writing, and will no doubt continue up until the IGC.

Among Member States, the critical factor affecting the outcome of this IGC will be the inclusion or otherwise of Germany in EMU. German concerns relate to:

i) the replacement of the DM with the Ecu;

ii) application of the fiscal criteria; and

iii) political union.

The first concern relates to replacement of a currency which the Bundesbank has monopoly control over, with a currency which will be controlled by the ECB Council. The members of this council will, in the transition period, consist of those countries which the European Commission deems to have met the criteria. As the dynamic 'let-out' clauses give the Commission great flexibility in exercising the fiscal criteria, several Member States that have historically had much higher inflation rates could become voting members of the ECB Council, thereby having a potentially large influence over pan-European monetary policy, and by implication, German monetary policy.

Replacement of the DM is the major motivation behind the recent expression of angst over the second German concern, that of credibility of application of the fiscal criteria. Ireland, the European Commission has argued, has a public debt that is "sufficiently diminishing" at a "satisfactory pace", so can proceed with EMU in 1996 (with Luxembourg). Belgium, Greece and Italy are now hopeful of the same leniency regarding the fiscal criteria, even though their public debt levels are over twice those stipulated by the fiscal criteria. This no doubt will be severely resisted by the Germans, but if they are unsuccessful this might prompt an activation of plans to allow the DM to circulate alongside the Ecu to become official German policy.

The third concern is the institutional aspects of EMU, and in particular the state of European Political Union (EPU). The Germans argue that the ECB, however independent, cannot operate effectively in a vacuum - a central bank has to have a governmental framework within which to operate. Besides the issue of democratic accountability, there is no equivalent of a finance ministry or treasury in Europe, so this will not allow the proper interaction between monetary and fiscal policy at the European level.

There are, of course, other concerns about how the Treaty might be amended and interpreted. The British have an opt-out clause for the whole process, but would be reluctant to exercise it if they were the only Member State not to participate in EMU. The southern European Member States are particularly concerned about the prospect of a "two-speed" EMU, if the fiscal criteria were to be strictly adhered to.

Indeed, the prospect of a "two-speed" EMU appears increasingly likely, with the 'borderless' Schengen Treaty countries (France, Germany, Belgium, Luxembourg and the Netherlands) with Ireland, forming the initial Ecu block. In political terms, this would create great divisions in Europe and might cause a severe rupture in cooperative efforts between Member States. Further, such a marked division might derail economic union and reverse the trend in economic convergence among EU Member States as a whole.

It is ironic, however, that if a compromise at the 1996 IGC exists, it is probably to be found in the ERM. Noteworthy, is the fact that despite the currency turbulence of 1991/92, most Member States have kept their currencies close to, or within the old ERM +/-2.25% fluctuation bands. So, if there is an aversion to a "two-speed" EMU, perhaps the ERM may have some role to play in a political compromise. One might envisage the ERM criteria coming back into play as a criteria, but at the same time another of the criteria being overlooked. So, for instance, one of the fiscal criteria could be replaced by the ERM criteria on a selective Member State basis. In this schema, Member States would be eligible to proceed to EMU if they fulfilled four out of the five of the Maastricht criteria. This would be particularly attractive to the benelux countries (with the exception of Luxembourg, which already satisfies all the four remaining criteria), as Annex 6D shows, as both Belgium and the Netherlands would expect to be part of the "hard core" Member States entering EMU initially, yet they both fail to meet both of the fiscal criteria. In such a schema, this would also avoid any indiscriminate use of the dynamic "let-out" clauses.

V. Conclusions

It is unfortunate that the objective of EMU forced upon the EMS a role for which it was not designed. If EMU is to be realised in the current political climate, the EMS will probably remain on the periphery of the integration process, a relic of earlier ambitions to stabilise European exchange rates. Nevertheless, in the light of the severe economic conditions imposed by the Maastricht Treaty on some Member States, perhaps the EMS's demise is not so misfortunate after all.

The natural adjoint to the economic issues surrounding the major obstacles to EMU, notably the fiscal criteria, is not primarily one of exchange rate instability, but rather that of the role of supranational institutions, particularly in relation to overall EU fiscal policy. Indeed, if attainment of EMU is foremost in policy-makers minds (and in some cases this is not at all certain), then reaching an acceptable compromise on modification of the fiscal criteria is paramount. The current Maastricht path and the criteria embodied in this approach will not allow the ultimate objective of EMU to be attained.

The most likely outcome is a political trade-off between abandonment of the dynamic "let-out" clauses to the fiscal criteria and abandonment of the debt criteria, while modestly increasing the evolution of the EU budget. This possible outcome poses important questions about the role of political union in the EU, the implementation of the principle of subsidiarity and the division of economic policy competences between the EU and Member State governments.

EMU is certainly not dead, but the process of keeping it alive has already compromised the objective of European exchange rate stability (the EMS) and will inevitably pose further economic problems and difficult policy choices. It is easy to find examples of common currency areas that do not fulfill the economic conditions of an optimum currency area - perhaps these examples can shed some light through further research on the obstacles still to be overcome in Europe.

Lastly, from a history of thought perspective, it is interesting to note that the European economic debates of the early 1970s are still alive and well, not in their criginal 'economist' versus 'monetarist' guise, but as a "two-speed" versus collective approach to EMU (or northern versus southern European Member States). The fact that this debate is still alive is not because the wheel has been re-invented, but rather because of the fact that the issue of the optimal approach to economic integration has not yet been resolved.

Endnotes

1. As De Grauwe (1992) points out, the Maastricht Treaty approach embodies two principles - firstly that the transition to monetary union should be gradual and secondly that not all EU States have to join EMU at the same time (they join either when Stage 3 begins or when the ECB is satisfied that they have achieved or are approaching the relevant economic criteria). De Grauwe mentions that there is some ambivalence in the Treaty as to whether the final objective is to replace all national currencies with the ECU, or to allow them to circulate alongside the ECU. But Article 1091(4) of the Treaty is very clear on this point - to quote:-

> "At the beginning of the third stage, the Council shall.....adopt the conversion rates at which their currencies shall be irrevocably fixed and at which irrevocably fixed rate the ECU shall be substituted for these currencies, and the ecu will become a currency in its own right.....shall , acting according to the same procedure, also take the other measures necessary for the rapid introduction of the ecu as the single currency of those Member States." (Italics added)

The monetary union envisaged therefore comprises a single currency and complete freedom of capital movements and a single market for financial services.

2. In Canada, much of the economic justification for Quebec's separation has been the erroneous belief that Quebec is a net financial contributor to the Canadian federation.

3. Recent debate in Canada on the apportioning of federal debt to the province of Quebec in the event of separation, seems to suggest that there is an optimum allocation of debt between federal and provincial jurisdictions in terms of minimising the weighted average interest rate payable on the total (federal plus provincial) debt. This may also, in fact, have unexplored political economy implications in terms of the allocation of responsibilities between federal and regional governments. Applying this principle to Europe would tend to suggest that a legally-binding no deficit condition for the EU budget does not minimise interest rates on total government-held debt.

4. In Canada, the federal government has both direct and indirect revenue sources, but also a fund also exists to redistribute monies to the poorer Provinces. The federal government is responsible for nearly half of total federal and provincial expenditures, it receives more than half of total income taxes and possesses exclusive competence over unemployment insurance. The federal government's influence over overall income tax is also substantial as provincial revenue is in the form of a surcharge on federal liabilities (with the exception of Quebec).

5. Compared to other federations, the EU's regional disposable income per capita disparities are much larger (see Masson and Taylor (1992), but disparities measured on the basis of GDP per capita are more in line with those found in Canada (see Coulombe and Lee (1993)).

6. There is no federally imposed constraint on provincial government borrowing in Canada, and this does not appear to have had any effect on Canadian interest rates in general. Indeed the key in the instance is the denial of access to central bank financing to provincial governments in order to subject them to the discipline of the market.

7. See Bini Smaghi, Padoa-Schioppa and Papadia (1993). Here:

$$G = yB$$

where G = government budget deficit (as a % of GDP), y is growth rate of nominal GDP and B = government debt (as a % of GDP). Substituting G = 3% and B = 60% gives y = 5% for steady-state growth rate of GDP.

8. As Vanheukelen (1994) points out, convergence should be measured in terms of reducing real income disparities net of the unilateral fiscal transfers. In most instances economic convergence is a hard variable to measure, and in many countries it depends upon other factors such as labour mobility, the level of welfare payments and the industrial base. For example, it is widely acknowledged in Canada, the Newfoundland has not converged in real income terms (net of transfers) on the Canadian provincial average; it has diverged from the average.

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SUMMARY AND CONCLUSIONS

This thesis has presented six essays on the subject of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS). The issues addressed in this thesis relate to the volatility of exchange rates in the ERM, how well the target zone model corresponds to the empirical data and the prospects for the ERM in the context of economic and monetary integration in Europe.

Much of this thesis used a weekly dataset of exchange rates, interest rates and forward exchange rates that has been hitherto unexplored in the literature. There are definite advantages in using weekly data: it does not suffer from the temporal aggregation problems that monthly data suffers from, and it does not incorporate the day-to-day turbulence of the foreign exchange markets and the problems associated with using extremely large datasets. It therefore appears to be the most appropriate level of temporal aggregation to study volatility and other aspects of exchange rate behaviour.

Another aspect of the thesis that has not been explored in depth in the EMS literature, and only now is attracting significant interest, is the emphasis on the non-normality of changes in financial variables. This non-normality, and in particular the leptokurtosis of empirical distributions, appears to characterise changes in financial variables much better than the normal distribution. Because of the non-normality of empirical distributions of financial variables, non-parametric methods were extensively used in this thesis to analyse volatility and other aspects of variable behaviour.

On volatility of exchange rates, the non-parametric tests used in chapter two and the parametric tests applied to the results of the Autoregressive Conditional Heteroskedastic (ARCH) model of chapter five show that both unconditional and conditional exchange rate volatility decreased after 1979 for ERM currencies. Using the results of the non-parametric tests, the nature of the reduction in volatility differed between currencies, with some currencies experiencing a reduction in small-scale volatility and some currencies experiencing a reduction in large-scale volatility. It was also noteworthy that a further regime shift occurred in 1983, as capital controls began to be eliminated, leading to significant reductions in volatility for all currencies. This tends to support the 'monetarist' school of economic thought, which maintains (in contrast to the 'economist' school) that monetary coordination and moves towards monetary integration should precede economic integration.

Part of the reason that different currencies experienced different types of changes in volatility patterns stems from the fact that capital controls were in widespread use in certain countries throughout most of the 1980s, and this likely affected the behaviour of exchange rates. Capital controls are also supposed to insulate domestic (onshore) interest rates from speculative pressures on exchange rates, allowing offshore interest rates to largely eliminate any potential adverse effects on the domestic economy. If the reduction in exchange rate volatility were to appear were to cause another financial variable to become more volatile, then offshore interest rates would probably be the most likely candidate. Offshore rates were therefore used to assess the degree of volatility transfer from exchange rates to interest rates. Also tests for changes in volatility of forward exchange rates were also reported for both before and after the EMS period.

The results, albeit tentative, regarding volatility transfer tended to confirm that adjustable-peg exchange rate regimes do not significantly exacerbate offshore interest rate fluctuations, although there was little change in volatility of interest rates for those member states that imposed capital controls. The results also stongly suggested that the ERM likely operated as an asymmetric exchange rate regime, given the behaviour of German interest rates. The forward rate results showed that the ERM also encouraged greater stability in exchange rate expectations, as volatility significantly reduced during the early years of the EMS, even though spot exchange rates did not always necessarily exhibit less volatility, particularly for those countries which used capital controls.

The target zone model attempts to characterise the behaviour of exchange rates within announced fluctuation bands and this has led to it achieving a high profile in the literature. To assess the suitability of the target zone model as a reasonable representation of the behaviour of exchange rates in an adjustable-peg exchange rate regime, an empirical investigation of the distributional characteristics of ERM exchange rates was attempted in chapter four. The findings were that the distribution of ERM exchange rates differed significantly from the predicted distribution from the target zone model. Also of relevance here was the implication from simple econometric models that differing monetary policy stances for ERM currencies led to substantially different exchange rate behaviours within the ERM bands.

Chapter five used various of the ARCH family of econometric models to explore exchange rate movements and exchange rate volatility in a time-series context. A new hybrid ARCH model was introduced to take into account the fluctuation bands of the ERM of the EMS as well as the non-normality of exchange rates. This model proved to be successful in improving the explanatory power of the ARCH-type model of exchange rate volatility.

In terms of the prospects for the ERM of the EMS, chapter six stressed that the objective of economic and monetary union (EMU) was a role that was forced upon the EMS for which it was not designed. The EMS may have a future role to play in the integration process, but this is unlikely given the current focus on lack of supranational institutional structures in the European Union and the fiscal criteria which member states have to meet to enter the final stage of monetary union. Given the current timetable as agreed by the Maastricht Treaty, though, EMU will not be acheived as timetabled, and may not be sustainable. Different options for revision of the treaty were presented and evaluated, both in economic and political terms and particularly in relation to the arrangements for fiscal policy post-stage 3 of EMU. For better or for worse, it appears unlikely that the ERM of the EMS will now have an active role to play in the process of monetary integration.

The ERM of the EMS has currently been lain aside as an economic issue and policy instrument. Given the widening of its band widths to +/-15%, it no longer exerts the large influence on economic policy that it once enjoyed. If one thing is certain, however, it is that its legacy will be seen as an important step towards greater coordination between European countries, both from an economic and from a political standpoint, regardless of the outcome of monetary union in Europe.

It has had a profound effect on economic thinking about alternative exchange rate regimes and has challenged the orthodoxy of flexible exchange rates. It has enhanced the extent and degree of cooperation between European governments and central banks, and has resurrected debate on the role of speculators in the foreign exchange market. From an economics standpoint, it is also refreshing to see how it has granted a new lease of life to research on the behaviour of exchange rates in different regimes.

Perhaps in hindsight then, historians may come to view the

ERM not just as an example of one specific type of exchange rate regime, but as an important (maybe *the* most important) step towards a more unified and integrated Europe. If so, this alone will indeed be a worthy testament.

THE EXCHANGE RATE MECHANISM OF THE EUROPEAN MONETARY SYSTEM: VOLATILITY, TARGET ZONES AND PROSPECTS

(Annexes and Graphs)

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ANNEXES

ANNEX 2A

RANK TESTS IN ECONOMETRICS

1. Introduction

Over recent years, it has been recognised that the normal distribution, while being a convenient assumption for econometric modelling, does not fit well with emprircally observed distributions for many economic series. In particular, it has become a stylized 'fact' that financial data series such as exchange rates, stock prices and commodity prices have empirical distribution functions that are significantly different from the normal distribution. Most researchers in this area have recognised that many data series have empirical distributions that are leptokurtic (that is, they have fatter tails and are more peaked than the normal distribution). Econometric modelling of these series then becomes problematic with the standard classical tools of the econometrician, as non-normality can lead to biasedness in model estimates, and the power of many tests in the classical model depend on the distributional assumptions regarding the estimated standard error. Examples of such tests are structural change tests and heteroskedasticity tests.

This apparent shortcoming of the classical model has led empirical researchers to consider alternative test procedures when postulating regime changes or heteroskedastic errors. The first such attempt to account for non-normality was made by Box and Cox (1964) with the Box-Cox transformation, but the problem here is that the researcher must know the nature of the underlying distribution in order to know which transformation to make to approximate normality. Non-parametric testing has been put forward as another alternative, as here no distributional assumptions are made at all, and the tests can be applied regardless of whether the researcher is aware of the nature of any departure of the empirical distribution from normality. For more details on testing for normality, see Spanos (1986) for parametric tests and Gibbons (1985) for non-parametric tests.

When speaking of non-parametric tests, there are several different classes of such tests. The most well-known non-parametric tests are linear rank tests, but there are several other classes of non-parametric tests which do not necessarily employ ranks. In a later section we discuss order staistics with specific reference to tail index statistics.

Lastly, the economic researcher might feel reluctant to embrace rank tests perhaps because of perceived limits that non-parametric tests might have to specific testing procedures covered by the classical tests. In fact Hajek and Sidak (1967) showed this is not the case: every classical procedure has an equivalent rank test. With this reassuring fact, we will proceed to look at tests for location differences.

2. Linear Rank Tests

Before introducing the tests for change in location, a few preliminaries on rank tests are in order. The general class of linear rank statistics has to satisfy certain conditions in order to give valid results.

Following Randles and Wolfe (1989), we define exchangeability as follows:-

> a set of random variables $X = (X_1,\ldots,X_n)$ is called exchangeable if the distribution of $X_1,\ldots,X_n$ is the same as $X_{d_1},\ldots,X_{d_n}$, for all permutations $d_1,\ldots,d_n$.

If $R = (R_1,\ldots,R_n)$ is the vector of ranks of X such that R maps $(X_1,\ldots,X_n)$ into $(1,\ldots,n)$ and letting $r = (r_1,\ldots,r_n)$ be any permutation of the numbers $(1,\ldots,n)$, then the key result in establishing the distribution-free nature of rank statistics is the fact that $\text{prob}(R=r) = 1/n!$ This means that each permutation of $(1,\ldots,n)$ is equally likely, and hence the ranks are uniquely defined. Put another way, the ranks are uniformally distributed. Thus any function of R is distribution free, regardless of the distribution of X. This result is not obtained, however, if there are ties among the ranks - this point is of particular concern when the variable of interest is a first-differenced variable. Note that independent and identically distributed random variables are exchangeable but exchangeable variables may not be independent. Also note that the distribution of the ranks themselves (assuming no ties) will always (under exchangeability) be uniform.

Now a 2-sample linear rank test can be defined as:

$$LRT = \sum_{i=1}^{n} c_i a(R_i) \tag{1}$$

where c_i = 1 or 0 depending on whether the observation is within the subsample under consideration or not, and a( ) is a function of the ranks. In most of the linear rank tests considered below a( ) is chosen to take account of the test alternatives available.

In this paper the non-parametric tests are confined to univariate analysis. Non-parametric tests do exist for multivariate analysis, and the interested reader should refer to Puri and Sen (1971) for more information.

3. Tests for Location differences

Suppose that independent samples of sizes m and n are drawn from two populations with absolute continuous distributions. To test the null hypothesis of identical distributions but with different measure of location or central tendency, form an appropriate null hypothesis:

$$H_0 : F_Y(x) = F_X(x) \qquad \text{for all } x,$$

against

$$H_A : F_Y(x) = F_X(x - \theta) \qquad \text{for all } x \text{ and}$$

some $\theta \neq 0$

where F_Y represents the distribution function of the first independent sample of size m and F_X the distribution function of the other sample of size n. The cumulative distribution function of the Y population under H_A is the same as that of the X population but shifted to the left if $\Theta < 0$ and shifted to the right if $\Theta > 0$. If we assume F to be normal, then the classical test for this problem would be the t test. There are, however, many good and simple non-parametric tests for the location problem that do not require any assumptions other than independent random samples from continuous populations. The distribution of the classical test statistic under this assumption is generally not known beyond the fact that under some assumptions it is asymptotically distributed as a student-t distribution.

Many of these tests are rank tests because the rank of the X's relative to the ranks of the Y's provides information about the relative value of the population medians. An econometric applications of the tests shown below would use the residuals from a chosen regression procedure (for either linear or non-linear estimation techniques).

a) <u>The Median Test</u>

The first test we consider is a non-parametric test but not a rank test. One of the simplest and most widely used procedures for testing whether two medians are equal is the Mood-Westenberg test, which is due to Mood (1950) and Westenberg (1948). Assume that a data set consists of two independent random samples: $x_1,\ldots,x_{n_1}$ and $y_1,\ldots,y_{n_2}$ from continuous distributions. If the measurement scale employed for each sample is ordinal and identical, and if the two samples have the same median, then for each sample the probability, p, that an observed value will exceed the median when the two samples are combined, will be identical to the probability that an observation will be greater than the median in either sample.

The null hypothesis to be tested can now be formulated. We test:-

$$H_0 : m_1 = m_2 \qquad \text{against}$$

$$H_2 : m_1 \neq m_2$$

where m_i, i=1,2, is the median for sample i. Each sample obserabion can be classified according to two criteria - which sample the observation is in and whether the observation is above or below the combined median. The number of observations in each category can then be put into a contingency table:-

	Sample		
Relationship to combined-sample median	1	2	Total
Above	A	B	A+B
Below	C	D	C+D
Total	$A+C=n_1$	$B+D=n_2$	n

If H_0 is true then A and C would be approximately equal to $n_1/2$, and B and D would be approximately $n_2/2$. If the observed proportions above and below the sample median differ very much from what we expect under the null hypothesis, then the null will be rejected. Mood (1950) showed that the sampling distributions for A and B follow the hypergeometric distribution, so that:

$$P(A,B) = \frac{\binom{n_1}{A}\binom{n_2}{B}}{\binom{n}{A\ B}} \qquad (2)$$

The hypergeometric distribution can, however, be approximated by the normal distribution, due to its link with the binomial distribution. When the sample is such that the normal approximation is close enough and the difference in proportions np and n(1-p) are both larger than 5, where n is the sample size and p is the sample proportion with the characteristic of interest, the test statistic is given by:-

$$T = \frac{(A/n_1) - (B/n_2)}{\sqrt{\hat{p}(1-\hat{p})(1/n_1 + 1/n_2)}} \qquad (3)$$

where $\hat{p} = (A+B)/n = 1/2$. See Gibbons (1985) for further details.

b) Wilcoxon Test

This test (see Wilcoxon (1945)) consists of ordering the observations from least to greatest and then summing the ranks over the subsample under consideration. Assuming two subsamples of size n_1 and n_2, and a null hypothesis of $\Theta=0$, then the Wilcoxon test statistic (W) is as follows:-

$$W = \sum_{j=1}^{n_1} R_j \qquad (4)$$

Here the ranks over one of the subsamples are summed together to form the rank statistic. For a one-sided test of H_0, versus an alternative of $\Theta>0$, we compare the value of W with the value of $w(\alpha,n_1,n_2)$ where α satisfies $\alpha = \text{prob}[W \geq w(\alpha,n_1,n_2)]$ for a rejection of the null. For a one-sided test of H_0 versus the alternative $\Theta<0$, we reject the null if $W \leq (n(n+1) - w(\alpha,n_1,n_2))$. In a similar fashion, the critical region for an α-level test of H_0 against the two-sided alternative of $\Theta\neq0$, would reject the null if $W \geq w(\alpha/2,n_1,n_2)$ or $W \leq n(n+1) - w(\alpha/2,n_1,n_2)$. Tables for the critical values of W (above denoted as w) can be found in most textbooks on rank statistics, such as Hollander and Wolfe (1973). In small samples, the test statistics will have a minimum of $n_1(n_1+1)/2$ and a maximum of $n_1(2(n+1)-n_1+1)/2$, and so will thus be symmetric about their mean. Note that the distribution can be calculated exactly, and in this sense rank statistics can be said to possess exact distributions under the null.

When the samples are large, however, using the exact distribution could prove irksome, so large sample approximation is available. If H_0 is true, W has an asymptotic standard normal distribution with mean and variance equal to:-

$$E(W) = \frac{n_1(n+1)}{2} \tag{5a}$$

$$V(W) = \frac{n_1 n_2(n+1)}{12} \tag{5b}$$

If there are ties among the n observations, average ranks can be used to compute W, but in the large sample approximation, V(W) is replaced by:-

$$V(W) = \frac{n_1 n_2}{12}\left(n_1+1 - \frac{\sum_{j=1}^{q} t_j(t_j^2 - 1)}{n(n-1)} \right) \tag{6}$$

where g is the number of tied groups and t_j is the size of tied group j.

c) Mann-Whitney Test

Another test statistic that has been proposed for testing for scale differences between two paired samples, is the Mann-Whitney test. This statistic has the form:-

$$U = \sum_{i=1}^{n_1} \sum_{j=1}^{n_2} \psi(X_i, Y_j) \tag{7}$$

where $\psi(a,b) = 1$ if $a<b$ and 0 otherwise. Hence for each pair of values, observe which is smaller, and if X_i is smaller, assign one for that pair and zero if otherwise. Summing all the zeros and ones together, the U statistic is obtained. Mann and Whitney (1947) found that in the case of no ties, $W = U + (n(n+1)/2)$, where W is the Wilcoxon statistic. This implies that tests based on U and W are equivalent.

Note that the above linear rank tests assume that the two samples do not differ in scale. Sen (1962) and Pothoff (1963) explored ways in which W could be adapted to test for location differences with scale differences.

4. Rank Tests for dispersion differences

Economists frequently encounter problems where it might be of interest to test for the equality of the dispersion parameters of two samples. In the parametric case, the F test is usually employed to test the null hypothesis that two dispersion parameters (usually two sample variances) are equal. The F test, however, as Pearson (1933) first noted, is not very reliable when the samples of interest are not normally distributed. The first non-parametric test for dispersion considered here was originally proposed by Mood (1954). It is assumed that there are two random samples, $x_1, x_2, \ldots, x_{n_1}$ and $y_1, y_2, \ldots, y_{n_2}$, where $n_1 \leq n_2$. The two samples are assumed to be identical and independent with the same median. If the dispersion parameters are denoted by σ_1 and σ_2 respectively, then we are testing for the following null hypothesis:-

$$H_o : \sigma_1 = \sigma_2 \qquad \text{as against}$$

$$H_A : \sigma_1 \neq \sigma_2$$

For an econometric application of such tests, again the change in variance would refer to a change in the variance of the residuals.

a) <u>The Mood test</u>

The Mood test statistic is then:-

$$M = \sum_{i=1}^{n_1} \left[r_i - \frac{n+1}{2} \right]^2 \tag{8}$$

where as before $n = n_1 + n_2$, and r_i is the rank of the ith observation of x in the joint ranking of the x's and the y's, where ranking is done from the smallest to greatest observation. Critical values of Mood's test statistic were obtained by

Laubscher et al (1968); they also showed that asymptotically M is distributed normally with mean:-

$$E(M) = \frac{n_1}{12} (n - 1) \ (n - 2) \tag{9a}$$

and variance:-

$$V(M) = \frac{n_1 n_2}{180} (n + 1)(n - 2)(n + 2) \tag{9b}$$

For large sample size it is possible to compute a standardized test statistic:-

$$z = \frac{M - E(M)}{\sqrt{V(M)}}$$

which is asymptotically normal. Mood (1954) showed that his test has asymptotic efficency of about 0.76 relative to the F test when the sampled poulation is normal.

b) Ansari-Bradley test

Another non-parametric test for dispersion was first proposed by Freund and Ansari (1957) and then its properties were evaluated in detail by Ansari and Bradley (1960). The same assumptions as for the Mood test are made for the Ansari-Bradley rank test, the difference here is the assigning of the number of the rank to the ordered combined samples. As for the Mood test, the combined sample is ordered from smallest to largest, but then rank 1 is assigned to the smallest and largest observation, rank 2 to the second largest and smallest observations etc. Thus the ranking of the observations should appear as:-

1,2,3,4,5,......,(n+1)/2,.......5,4,3,2,1

As before, let r_i be the rank of x's in the combined sample, then the Ansari-Bradley test (AB) is:-

$$AB = \sum_{i=1}^{n_1} r_i \tag{10}$$

The AB statistic also has an asymptotic normal distribution (see Ansari and Bradley (1960)) when n tends to infinity, so that in large samples, when N is even:-

$$E(AB) = \frac{n_1(n + 2)}{4} \quad \text{and when n is odd:-} \tag{11a}$$

$$E(AB) = \frac{n_1(n + 1)}{4}$$

$$V(AB) = \frac{n_1 n_2 (n + 2)(n - 2)}{48(n - 1)} \tag{11b}$$

Having calculated E(AB) and V(AB), a z statistic can be calculated as with the Mood test.

c) <u>Siegel-Tukey test</u>

A variation of the Ansari-Bradley test was developed by Siegel and Tukey (1960), which is asymptotically equivalent to the AB test. The Sigel-Tukey test orders the combined sample in the same manner, but then assigns ranks differently. The smallest observation receives a rank of 1, the largest receives 2, the second largest 3, the second smallest 4, and the third smallest 5, etc. The ranking of the observations should thus appear as:-

1,4,5,8,9,.......,n,.......7,6,3,2

The asymptotic results are as follows:-

$$E(ST) = \frac{n_1(n + 1)}{2} \tag{12a}$$

$$V(ST) = \frac{n_1 n_2 (n + 1)}{12} \qquad (12b)$$

and a z statistic can then be constructed. It transpires that the Siegel-Tukey test is also asymptotically equivalent to the Mann-Whitney rank statistic for testing between different location parameters (see Hajek and Sidak (1967) for an explicit discription).

The situation where the medians of the distributions are known to be different, or are more likely unknown, occurs frequently in economics. One way of dealing with this problem is to use one of the the rank tests described above and subtract the sample median from the observations in the two samples. The problem (particularly in small samples) is that the null distribution of the test statistic is then affected, so the test becomes invalid. For large sample sizes, however, as Conover (1971) notes, the error associated with this approach does not appear to be one of serious magnitude.

d) <u>Moses test</u>

There is one test available to the researcher that takes a different approach to testing for differences in dispersion between two samples when the medians are not the same. This is the Moses test (see Moses (1963). The procedure is as follows. Firstly select a positive integer $k \geq 2$, and randomly divide the x's and y's into a and b subgroups of size k, respectively. Shorack (1969) recommends that k be as large as possible but not greater than 10, and that a and b be large enough to permit meaningful results from the application of the test. Hollander and Wolfe (1973) also add that the subgroup size must be chosen only on the basis of a and b and not on the values of the x's and y's. Now, for i = 1,...,a, let $x_{i1},...,x_{ik}$ denote the ith subgroup of k x-type observations. Similarly, for j = 1,...b, let $y_{i1},...,y_{ik}$ denote the jth subgroup of k y-type observations.

Now define $c_1,...,c_a$ by:-

$$c_i = \sum_{s=1}^{k} (x_{is} - \mu_i)^2 \qquad i = 1,...,a$$

where μ_i is the mean of the k observations. Now define $d_1,...,d_b$ by:-

$$d_j = \sum_{t=1}^{k} (y_{jt} - \mu_j)^2 \qquad j = 1,...,b$$

where μ_i is the mean of the k observations. Now apply the Mann-Whitney test by combining the c's and d's, and then ranking them in ascending order. The Moses test is then:-

$$MO = \sum_{i=1}^{a} r_i - \frac{a(a+1)}{2} \tag{13}$$

where r_i is the rank of the c_i's in the combined sample of c's and d's. When we test H_0, we then refect H_0 for either a sufficiently small or a sufficiently large value of MO. H_0 is therefore rejected if the computed value of MO is less than $w_{\alpha/2}$ or $w_{1-\alpha/2}$ where $w_{\alpha/2}$ is the critical value for T given in the Mann-Whitney tables. The value of $w_{1-\alpha/2}$ is given by:-

$$w_{1-\alpha/2} = mn - w_{\alpha/2}$$

The Moses rank test posesses certain specific disadvantages compared to regular 'identical median' rank tests. Shorack (1969) refers to the Moses test as "a useful inefficient statistic". This stems from estimates of the asymptotic efficiency of the test, conducted by Moses (Moses (1963), where he found the efficiency to be 0.50 when k=3 and the observations are drawn from normally distributed populations. This disadvantage of relative inefficiency is perhaps minor compared with the fact that on repeated applications, even with the same values of k,a and b, different inferences can be made. Put another way, the results obtained on repeated applications of the test can yield ambiguous results. One way to incorporate this difficulty into the test procedure is to perform the test p times, where p is an odd integer, and with a given level of significance, make 'strong' and 'weak' inferences about the null hypothesis.

5. <u>Tests for Heteroskedasticity and Serial Correlation</u>

Following McCabe (1989), if we consider a model such as:-

$$y_t = \alpha + \beta x_t + \varepsilon_t$$

where $V(\varepsilon_t) = \xi(t)$. The assumption of exchangeability, as described in section 2, must hold here. In the context of an econometric model, this assumption is non-trivial, as shown if non-stochastic regressors are used, or if the data has explicit lag structures. Given that the assumption of exchangeability of the residuals from estimation of the model holds, Then a suitable rank test for heteroskedasticity would be the rank of the residual squared (RRS):-

$$RRS = \sum_{i=1}^{n} iR_i^* \tag{14}$$

where R_i^* is the rank of the residual squared. The standard rank correlation test would then be applied. For more information see Gibbons (1985).

For a rank test for serial correlation, McCabe (1991) uses a rank von Neumann ratio:-

$$VN = \sum_{t=1}^{n-1} (R_t - R_{t+1})^2 \tag{15}$$

where R_t is the rank of the residual at time t. The significance points for this rank test are available in Bartels (1982).

6. Hajek and Sidak 'Maintained' Distribution test

One of the problems with the linear rank tests described above, is that although the actual empirical distribution need not be known by the researcher, the rank tests vary in their power according to the nature of the actual underlying distribution. Hajek and Sidak (1967) developed a rank test procedure that permits a uniformally most powerful test, given knowledge of the underlying distribution.

Some preliminaries are again in order when considering the approach taken by Hajek and Sidak to rank testing. Firstly let J be an open interval containing zero. A family of densities, $d(x,\theta)$, $\theta \in J$, will be considered if:-

i) $d(x,\Theta)$ is absolutely continuous in Θ for almost every x;

ii) the limit:

$$\dot{d}(x,0) = \lim_{\Theta \to 0} \frac{1}{\Theta} [d(x,\Theta) - d(x,0)]$$

exists for almost every x; and

iii) $$\lim_{\Theta \to 0} \int_{-\infty}^{\infty} |\dot{d}(x,\Theta)| \, dx = \int_{-\infty}^{\infty} |\dot{d}(x,0)| \, dx < \infty$$

holds, with $\dot{d}(x,\Theta)$ denoting the partial derivative with respect to Θ.

Now consider the alternative,

$$\delta = \prod_{i=1}^{N} d(x_i, \Delta c_i)$$

where Δc_i represents a shift in a distribution parameter (this shift could vary with the x's, as it would with heteroskedastic errors. Now, given the definition of a distribution function, D(x):-

$$D(x,\Theta) = \int_{-\infty}^{x} d(y,\Theta) \, dy \tag{16a}$$

and let $D^{-1}(u)$ be the inverse of D, or more precisely:-

$$D^{-1}(u) = \inf\{x : d(x,\Theta) \geq u\} \tag{16b}$$

for the associated density function d. Now introduce the scores, $\varphi(u,d,\Theta)$, defined as:-

$$\varphi(u,d,\Theta) = \frac{\dot{d}(D^{-1}(u,\Theta),\Theta)}{d(D^{-1}(u,\Theta),\Theta)} \quad ; \; 0 < u < 1 \tag{17}$$

where also:-

$$\varphi(u,d,\Theta) = \varphi(x,\Theta) = \frac{\partial}{\partial\Theta} \ln d(x=D^{-1}(u,\Theta),\Theta) \tag{17a}$$

From the above, note here that these scores are related to the Fisher information function:

$$E(\varphi^2) = I(u,d,\Theta) = \int_{-\infty}^{\infty} \left(\frac{\dot{d}(D^{-1}(u,\Theta),\Theta)}{d(D^{-1}(u,\Theta),\Theta)} \right)^2 d(x,\Theta)\ dx \tag{18}$$

Now, for the problem of a change in location parameter, then Θ would take on the value of the median and $d(x,\Theta) = f(x - \Theta)$ for a given distribution density function f. If, however, we are interested in a change in scale, then we might consider a function such as:-

$$d(x,\Theta) = e^{-\Theta}f[(x-\mu)e^{-\Theta}] \tag{19}$$

At first sight this choice of function might seem unsuitable, but if e^{Θ} is set to equal σ, then this function becomes more recognizable. Now we can derive $\dot{d}$ as follows:-

$$\dot{d}(x,\Theta) = -d(x,\Theta) - (x-\mu)e^{-2\Theta}f'[(x-\mu)e^{-\Theta}] \tag{20}$$

so the score function now becomes:-

$$\varphi(u,d,\Theta) = \frac{\dot{d}(D^{-1}(u,\Theta),\Theta)}{d(D^{-1}(u,\Theta),\Theta)} = \left(-1 -x\frac{f'(x)}{f(x)} \right) =$$

$$\left(-1 -F^{-1}(u)\frac{f'(F^{-1}(u))}{f(F^{-1}(u))} \right) \tag{21}$$

Now using the definition of a linear rank statistic as given in equation (1), take a vector $c = (c_1,\ldots,c_n)$ such that

$$\sum_{i=1}^{n}(c_i - \bar{c})^2 > 0$$

where $\bar{c}$ is just the mean of c_i. Using the notation from (1) again, define a test statistic S:-

$$S = \sum_{i=1}^{n} c_i a^{\varphi}(R_i, d) \tag{22}$$

where $a^{\varphi}(R_i,d)$ is the score function associated with the φ function defined above, where u_t is given as $R_i/(n+1)$ where R_i is the rank of x_i in a set of n independent observations $x_1,..,x_n$ each with density d. Hajek and Sidak (1967, page 70-71) now go on to show that this test will be locally most powerful for tests of H_0 against alternatives of two samples differing in location or scale, or regression differing in location or scale.

All that remains is to obtain the asymptotic results to avoid any arduous computations (see Hajek and Sidak (1967 page 159-60)). Let:-

$$\bar{\varphi} = \int_0^1 \varphi(u)\ du \tag{23}$$

and assume:

$$\int_0^1 \left(\varphi(u) - \bar{\varphi}\right)^2 du > 0 \tag{24}$$

If we assume H_0, then the statistic S is asymptotically normal with mean:-

$$\mu_c = \bar{c} \sum_{i=1}^{n} a^{\varphi}(R_i, d) \tag{25}$$

and variance:-

$$\sigma^2 = \left(\sum_{i=1}^{n} (c_i - \bar{c})^2\right) \int_0^1 \left(\varphi(u) - \bar{\varphi}\right)^2 du \tag{26}$$

All that remains to be done is to define the asymptotic score function for various density functions. A table of these functions can be found in Hajek and Sidak (1967, page 16).

Note that the value of the statistic S under different 'maintained' distributional assumptions necessitates no knowledge about what the actual underlying empirical distribution looks like, or theoretically what it most closely resembles. The one weakness in the Hajek-Sidak procedure, is the assumption that each observation in the sample has identical distribution d. The test then cannot account for any change in distribution that occurs with a change in regime. It only tests for a change in location or scale given that a certain distribution is maintained for the sample observations.

6. Order Statistics

Rather than 'maintaining' a distribution (as in the previous section), and hypothesising a change in a distribution parameter, we should be more interested in the nature of the empirical distribution itself. Hols and De Vries (1991) (following on from Koedijk, Schafgans and De Vries (1990)) focus on the distribution of extremal exchange rate changes (or returns), hence characterising the empirical distribution by the nature of the tails observed in the data. It is an empirically observed stylized fact that most financial data series are fat-tailed, so have a significantly higher level of kurtosis than is observed in the normal distribution.

The extremal types theorem (see Leadbetter, Lindgren and Rootzen (1983)) shows that in the leptokurtic case, the limiting distribution will be of the form (known as Type II max-stable):-

$$G(x) = 0 \qquad ;x \le 0 \qquad (27)$$
$$= \exp(-x^{-\alpha}) \qquad ;x > 0$$

with the tail index $\alpha>0$. α is important here, as if $F(x)<1$ for all x and:-

$$\int_{1}^{\infty} t^{k}\, dF(t) \quad \text{is finite}$$

for all k, then all moments exist. Otherwise, if the above condition applies but the expression in (26) is finite for $k<\alpha$ and infinite for $k>\alpha$, then higher moments do not exist and the distribution is fat-tailed. Note that leptokurticity does not necessarily imply fat tails as discrete mixtures of normal density functions would give higher kurtosis but no fat tailedness - these non-fat-tailed leptokurtic distributions are not considered here. The types of distribution that would give fat-tails are t, sum-stable and pareto (ARCH) distributions, all with values of $\alpha \ge 2$. The feature that distinguishes the different fat-tailed distributions is the value of α. If $\alpha < 2$ then the sum-stable distribution is appropriate, whilst if $\alpha \ge 2$, the t and pareto distributions are relevant.

In estimating the tail index, for convenience its inverse $\gamma = 1/\alpha$ is used. Largest-order non-parametric statistics are used by Hols and De Vries (1991) to estimate γ, as the extremes turn out to follow the limit law only approximately (rendering maximum likelihood unsuitable on an efficiency criteria).

Three tail index estimators were proposed:-

$$\gamma_p = \left[\log \frac{x_m - x_{2m}}{x_{2m} - x_{4m}}\right] / \log(2) \tag{28}$$

$$\gamma_H = \frac{1}{m-1} \sum_{i=1}^{m-1} \log x_i - \log x_m \tag{29}$$

$$\gamma_K = [\log x_1 - \log x_m] / \log m \tag{30}$$

where x_i are the descending order statistics form the empirical distribution and the m is the value of the order of the observation chosen so as to suitably characterise the tail. The following properties of the estimators have been established in the literature, assuming x_i is i.i.d. Firstly, Mason (1982) showed that γ_H is a consistent estimator for γ. $(\hat{\gamma}_P - \gamma)m^{0.5}$ is asymptotically normal with zero mean and variance:

$$\gamma^2(2^{2\gamma+1} + 1)/\{2(2^\gamma - 1)\log 2\}^2$$

It follows then that $(\hat{\gamma}_H - \gamma)m^{0.5}$ is asymptotically normal with mean zero and variance γ^2. $\hat{\gamma}_R$ is not asymptotically normal.

All point estimates for exchange rates were for values of $\hat{\alpha}$ in excess of 2, but $\hat{\gamma}_H$ was the only statistic that rejected the alternative at the 5 per cent level with varying values of m.

7. Issues

There are several pertinent issues that economists and econometricians planning to use non-parametric tests need to address. The first relates to the performance of these tests, statistically and econometrically speaking, versus their classical equivalents, the second to their availablity in standard software packages, and the third to their limits of usefulness.

In connection with the performance of these tests, it should first be noted that non-parametric tests are not based on a specific distribution, so are in this respect distribution-free. Secondly, as McCabe (1991) notes, when the underlying distribution is likely to be non-normal, rank tests in particular tend to be more efficient than their classical counterparts (the Wilcoxon test even dominates its classical counterpart in location tests). Thirdly, in econometrics, these tests do not depend on the estimation techniques or the model structure being used, if residuals are being used to evaluate how well a model is specified (given that the residuals are exchangeable). Fourthly, the null distributions of these test statistics are not dependent upon the existence of moments, so that the asymptotic arguments usually used can be dispensed with. And lastly, it is possible to compute the exact small sample distribution of these (rank) statistics, and there is no loss of power for the optimal test in small samples under normality (in fact in general there is an improvement).

As for their ease of use, non-parametric tests are still not widely available as part of the standard battery of tests in statistical and econometric software packages. For the occasional practitioner, this is a problem and needs to be addressed. However, for those seasoned in statistical and econometric work, these tests are fairly easily programmable using such software packages as RATS or GAUSS.

Last but not least, the limitations of these tests. As discussed above in section 4, these tests usually assume, that only one parameter is under examination. If in fact two parameters have to be estimated together, then the basic tests outlined above become invalid. This can present the researcher with some problems. Also, and maybe most importantly, non-parametric tests tell you nothing about the nature of the underlying empirical distribution.

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ANNEX 2B

Derivation of the Asymptotic Score Function for the Student-t distribution

The asymptotic score function is derived from the density function according to the following formula (taken from Hajek and Sidak):-

$$\psi(u) = -F^{-1}(u)\left(\frac{f'(F^{-1}(u))}{f(F^{-1}(u))}\right) - 1 \tag{B1}$$

where $F^{-1}(u)$ is the inverse of $F(x)$ and $f(x)$ is the density function. Now let $F^{-1}(u) = v$, so that the Student's t distribution is defined by:-

$$f(v) = \frac{c}{\sigma^n}\left(1 + \frac{\gamma^{-1}}{\sigma^2}v^2\right)^{-1/2(n+\gamma)} ; c = \frac{\Gamma\left(\frac{(n+\gamma)}{2}\right)}{(\pi\gamma)^{(n/2)}\Gamma(\gamma/2)} \tag{B2}$$

where Γ is the gamma function, γ is the degrees of freedom and n and σ are parameters. Now set n=1:-

$$f(v) = \frac{c}{\sigma}\left(1 + \frac{\gamma^{-1}}{\sigma^2}v^2\right)^{-1/2(1+\gamma)} \tag{B3}$$

The derivation of $\psi(u)$ is now straightforward. For $\gamma = 2$ the result is:

$$\psi(u) = \frac{2(v^2-\sigma^2)}{(2\sigma^2+v^2)} \tag{B4}$$

and for $\gamma = 3$, the result is as follows:

$$\psi(u) = \frac{3(v^2-\sigma^2)}{(3\sigma^2+v^2)} \tag{B5}$$

ANNEX 2C

Comparison with the Artis-Taylor Results

The Artis and Taylor (1988) results use real exchange rates on a monthly basis from the beginning of 1973 until the end of 1986, with the data sourced from the International Financial Statistics of the International Monetary Fund.

TABLE C1 - Test Results for a Change in Volatility of Monthly Real Exchange Rates 1973-1986

Currency	Logistic	D-Exp	Normal	Cauchy	t(2)	t(3)
Ffr	4.56	4.45	4.47	3.83	4.47	4.58
	(2.5E-6)	(4.2E-6)	(3.9E-6)	(6.4E-5)	(4.0E-6)	(2.3E-6)
UK£	-1.10	-1.15	-0.89	-1.83	-1.53	-1.36
	(0.136)	(0.126)	(0.185)	(0.034)	(0.063)	(0.088)
Ilira	5.56	5.59	5.45	5.06	5.48	5.58
	(1.3E-8)	(1.1E-8)	(2.5E-8)	(2.1E-7)	(2.2E-8)	(1.2E-8)
Bfr	2.74	2.81	2.65	2.79	2.79	2.79
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
Hfl	4.11	4.07	4.22	2.69	3.54	3.85
	(2.0E-5)	(2.4E-5)	(1.2E-5)	(0.004)	(2.0E-4)	(6.0E-5)
Spta	0.18	0.12	-0.19	1.27	0.99	0.70
	(0.43)	(0.45)	(0.42)	(0.10)	(0.16)	(0.24)

Notes: Statistics are asymptotically standard normal variates under the null hypothesis. Figures in parentheses are marginal significance levels. Positive figures indicate a reduction in volatility.

The results using the weekly data are of the same order of magnitude of those of Artis and Taylor, and they yield the same qualitative results.

The exercise was repeated for the period under consideration in this study - i.e. August 1971 to January 1992, but the t(2) and t(3) distributions are added for completeness. These results are tabulated in table C2 below.

TABLE C2 - Test Results for a Change in Volatility of Monthly Real Exchange Rates 1971-1992

Currency	Logistic	D-Exp	Normal	Cauchy	t(2)	t(3)
Ffr	6.15	6.02	6.06	4.97	5.89	6.11
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
UK£	-0.38	-0.40	-0.21	-1.10	-0.81	-0.63
	(0.35)	(0.34)	(0.42)	(0.14)	(0.21)	(0.26)
Ilira	6.64	6.65	6.61	5.57	6.28	6.51
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Bfr	4.41	4.47	4.25	4.40	4.53	4.52
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Hfl	4.89	4.88	4.97	3.56	4.35	4.64
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Spta	0.96	0.84	0.61	1.64	1.66	1.45
	(0.17)	(0.20)	(0.27)	(0.05)	(0.49)	(0.07)

Notes: Statistics are asymptotically standard normal variates under the null hypothesis. Figures in parentheses are marginal significance levels. Positive figures indicate a reduction in volatility.

The results in table C2 tend to be larger than those in table B1, thereby confirming the Artis-Taylor results and strengthening the view that the ERM of the EMS enjoyed a long period of relatively stability from around the middle of the decade onwards.

ANNEX 2D

Testing for a Change in Volatility post-1983

The same tests are run on the series to evaluate the hypothesis first advanced by Giavazzi and Spaventa (1990), that the ERM of the EMS underwent a significant change after capital controls were removed. Giavazzi and Spaventa approximate the date for the removal of capital controls as the end of March 1983. The tests below therefore use this date, to test whether volatility reduced between the two periods March 1979 to March 1983 and April 1983 and January 1992.

First, the test for a change in distribution from table 2.7 was repeated and appears in table D1 below.

TABLE D1 - Test for Distribution Change
1979 to 1983 and 1979 to 1992

Currency	Maximum Distance
Ffr	0.120
UK£	0.066
Ilira	0.128
Dkr	0.102
I£	0.090
Hfl	0.142
Bfr	0.173
Spta	0.134
DM/$	0.129

Note: Kolmogorov-Smirnov test significance levels: 5% = 0.110, 1% = 0.135

Table D1 now shows that there has been a change in the form of the distribution for all the currencies with the exception of UK£, Dkr and I£.

The linear rank tests conducted in table 2.11 were repeated for the period following the inception of the EMS, with the null hypothesis that exchange rate volatility fell post April 1983. These results are reported in table D2 below.

TABLE D2 - Linear Rank Tests for a Change in Scale
(1979-83 and 1983-92)
(Figures are standardised normal variates)

Currency	Ansari-Bradley	Siegel-Tukey	Mood
Ffr	4.18	4.37	-4.57
UK£	1.55	1.74	-2.07
Ilira	4.83	5.03	-4.90
Dkr	2.15	2.34	-2.47
I£	3.21	3.39	-3.52
Hfl	8.48	8.69	-8.07
Bfr	7.09	7.28	-7.56
Spta	3.73	3.92	-3.75
DM/$	-0.99	-0.49	1.92

As with table 2.11, the test statistic results in table D2 are instructive. The results illustrate how the Ansari-Bradley and the Siegel-Tukey give very different results - in fact asymmetrically opposite results. The Ansari-Bradley and Siegel-Tukey rank tests suggest that the volatility has increased for all ERM currencies, with no change in volatility for the UK£ and the DM. The Mood statistic suggests that volatility has fallen, for all currencies with the exception of the DM. This suggests that the ERM currencies, post-1983, experienced not only a reduction in higher-order volatility, but also an increase in lower-order volatility.

The Hajek-Sidak 'maintained' hypothesis tests from table 2.12 were again repeated for the 1979-83 and 1983-92 periods, and are reported below in table D3.

TABLE D3 - Test Statistics for a Shift in Volatility

Currency	Logistic	D-Exp	Normal	Cauchy	t(2)	t(3)
Ffr	5.55	5.55	5.66	4.07	4.85	5.16
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
UK£	2.43	2.28	2.44	1.40	2.12	2.35
	(0.007)	(0.011)	(0.007)	(0.080)	(0.13)	(0.009)
Ilira	5.35	5.36	5.25	4.90	5.23	5.32
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Dkr	3.15	3.10	3.28	2.00	2.61	2.85
	(0.0)	(0.0)	(0.0)	(0.023)	(0.005)	(0.0)
I£	4.20	4.14	4.23	2.93	3.74	4.02
	(0.0)	(0.0)	(0.0)	(0.002)	(0.0)	(0.0)
Bfr	7.42	7.34	7.11	6.99	7.61	7.63
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Hfl	7.77	7.92	7.39	8.18	8.18	8.05
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Spta	3.78	3.73	3.52	3.66	4.00	4.05
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
DM/$	-1.13	-1.21	-0.82	-2.29	-1.80	-1.56
	(0.130)	(0.114)	(0.207)	(0.011)	(0.036)	(0.060)

Note: Statistics are asymptotically standard normal variates under the null hypothesis. Figures in parentheses are marginal significance levels. Positive figures indicate a reduction in volatility.

The table confirms the results from table D2 for the Mood statistic, and suggests that the Giavazzi and Spaventa hypothesis is indeed supported by the data presented here, with the exception of the UK£ under certain distributional assumptions and the DM. The DM/$ rate underwent a notable increase in volatility between the two periods, under certain distributional assumptions.

ANNEX 4A

Sign Test for Mean-Reversion in Exchange Rates

Currency	Reverting +ve proportion	Reverting -ve proportion	Sign test +ve	Sign test -ve	Sign test all
Ffr	0.557	0.497	0.025	0.564	0.101
UK£	0.539	0.463	0.500	0.752	0.688
Lira	0.547	0.495	0.043	0.592	0.122
Dkr	0.611	0.472	0.000	0.871	0.073
I£	0.378	0.465	0.999	0.919	0.999
Hfl	0.571	0.572	0.005	0.005	0.000
Bfr	0.640	0.508	0.001	0.380	0.037
Spta	0.443	1.0	0.913	-	-

Notes: i) the probabilities in columns 3,4 and 5 indicate the statistical significance of the null hypothesis that the probability of positive changes/negative changes are 0.5;

ii) the sign test is documented in Green and Margerison (1978); and

iii) the number of negative observations for the Spta was not sufficient to make any statistical deductions.

ANNEX 4B

Linear Model of Exchange Rate Volatility and Band Position with Realignment Dummies (1979-92)

$$|\log(e_{t+1}) - \log(e_t)| = \alpha + \beta|\%d_t| + D_i + u_t$$

(All coefficient values and $\Sigma\hat{e}^2$ are $\times 10^{-3}$)

Currency	Ffr	UK£	Lira	Dkr	I£	Hfl	Bfr	Spta
α	0.848	3.32	2.30	2.67	1.88	1.01	1.72	4.61
	(2.43)	(5.78)	(7.13)	(9.98)	(7.35)	(10.30)	(4.78)	(5.20)
β	0.595	0.376	0.057	-0.09	0.06	1.26	0.52	-0.15
	(2.40)	(1.08)	(0.39)	(0.48)	(0.25)	(5.99)	(2.06)	(0.58)
D_1	0.999		1.19	1.41	0.91	-0.20	1.61	
	(1.25)		(1.48)	(2.39)	(1.20)	(0.48)	(1.72)	
D_2	1.859		2.04	5.74	1.43	0.56	2.86	
	(4.02)		(3.92)	(5.80)	(3.10)	(2.66)	(5.43)	
D_3	2.694		3.61	0.01	1.81		6.63	
	(3.73)		(4.41)	(0.02)	(2.59)		(6.11)	
D_4	2.362		2.15	0.00	2.30		1.13	
	(3.45)		(2.98)	(0.00)	(3.21)		(0.92)	
D_5	0.932		1.58	1.97	0.77		1.12	
	(2.27)		(2.29)	(2.52)	(1.86)		(1.43)	
D_6	0.624		1.47	0.75	4.62		0.56	
	(0.91)		(3.14)	(1.50)	(1.84)		(1.22)	
D_7			0.30	-0.30	2.39		0.28	
			(0.42)	(1.02)	(2.77)		(0.36)	
D_8			-0.70	-0.28				
			(1.01)	(0.55)				
$\Sigma\hat{e}^2$	10.44	0.54	10.49	5.41	9.48	2.53	13.75	2.30
R^2	0.06	0.02	0.07	0.08	0.07	0.12	0.09	0.00
F	5.77	1.17	5.14	6.45	6.17	31.29	8.39	0.34
p-value	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.56

Notes: i) a value of the t-statistic greater than 1.96 is significant at the 5% level;
ii) all exchange rates are against the DM;
iii) $\%d_t$ = percentage divergence from central parity;
iv) R^2 measures are centred measures; and
v) Dummy variables are constructed relative to the period after 1987 to 1992.

ANNEX 4C

The Pesaran and Samiei Limited Dependent Variable Model

Pesaran and Samiei (1992b in chapter 4) take a linear rational expectations model, such that:-

$$e_t = \gamma E_{t-1}[e_t] + \beta' x_t + u_t \qquad \text{(C1)}$$

where e_t is the exchange rate and the disturbance term, $u_t \sim N(0,\sigma_u^2)$ and x_t is a vector of exogenous variables.

The equilibrium rational expectations solution is:-

$$e_t = \frac{\gamma}{(1+\gamma)} \beta' E[x_t] + \beta' x_t + (1+\gamma) u_t \qquad \text{(C2)}$$

assuming that the government countenances no foreign exchange intervention. It is possible to assume some generating process for x_t using pre-determined variables, but here this complication is not included.

Suppose that a target zone is announced for the exchange rate such that:-

$$e_t = \begin{cases} \bar{e}_t & \text{if } e^{\bullet} \geq \bar{e} \\ \gamma E_{t-1}[e_t] + \beta' x_t + u_t & \text{otherwise} \\ -\bar{e}_t & \text{if } e^{\bullet} \leq -\bar{e} \end{cases} \qquad \text{(C3)}$$

where $\bar{e}_t$ and $-\bar{e}_t$ are the zone limits either side of central parity and $e^{\bullet}$ is the latent exchange rate. Thus, if $e^{\bullet}$ (the free-floating exchange rate) lies outside the target zone, announced as $[-\bar{e},\bar{e}]$, then e_t automatically takes on the value of e at the boundary of the target zone, that is, $-\bar{e}$ or $\bar{e}$. Now, let:-

$$C_{tL} = \frac{(-\bar{e} - \gamma E[e_t] - \beta E[x_t])}{\sigma} \qquad \text{(C4)}$$

$$C_{tU} = \frac{(\bar{e} - \gamma E[e_t] - \beta E[x_t])}{\sigma} \tag{C5}$$

$$W_t = \frac{u_t}{\sigma} \tag{C6}$$

where $\sigma = \sigma_u$ and $W_t \sim N(0,1)$. Equation C3 can now be rewritten as:-

$$e_t = \begin{cases} \bar{e}_t & \text{if } C_{tU} \leq W_t \\ \gamma E_{t-1}[e_t] + \beta' x_t + \sigma W_t & \text{if } C_{tU} > W_t > C_{tL} \\ -\bar{e}_t & \text{if } C_{tL} \geq W_t \end{cases} \tag{C7}$$

The expected exchange rate can now be solved as above in equation C7, except that we replace x_t with $E[x_t]$. Following similar logic to that used to solve for a tobit model, this yields:-

$$E[e_t] = [\Phi(C_{tU}) - \Phi(C_{tL})]E[e_{1t}] + \Phi(C_{tL})[-\bar{e}_t] + [1-\Phi(C_{tU})]\bar{e}_t \tag{C8}$$

where:-

$$E[e_{1t}] = E\{e_t^{\bullet} \mid -\bar{e}_t - \gamma E[e_t] - \beta' x_t < u_t < \bar{e}_t - \gamma E[e_t] - \beta' x_t\} \tag{C9}$$

Now the expected value of a freely-floating exchange rate is given by:

$$E[e_t^{\bullet}] = \frac{\beta' E[x_t]}{(1-\gamma)} + \frac{E[u_t]}{(1-\gamma)} \tag{C10}$$

Therefore use of equations C9 and C10 yields:-

$$E[e_{1t}] = \frac{\beta' E[x_t]}{(1-\gamma)} - \frac{1}{(1-\gamma)}\left(\frac{\sigma\phi_{tU}}{\Phi_{tU} - \Phi_{tL}} - \frac{\sigma\phi_{tL}}{\Phi_{tU} - \Phi_{tL}}\right) \tag{C11}$$

where ϕ is the standard normal density function and Φ is the standard normal distribution function. Hence, Φ_{tU} represents the standard normal distribution for the value $\bar{e}$ at time t.

Consolidating equation C11:-

$$E[e_{1t}] = \frac{\beta' E[x_t]}{(1-\gamma)} - \frac{\sigma}{(1-\gamma)}\left(\frac{\phi_{tU} - \phi_{tL}}{\Phi_{tU} - \Phi_{tL}}\right) \tag{C12}$$

Substituting C9 into C12:-

$$E[e_t] = [\Phi_{tU} - \Phi_{tL}]\frac{\beta' E[x_t]}{(1-\gamma)} + [\phi_{tU} - \phi_{tL}]\frac{\sigma}{(1-\gamma)} + \Phi_{tL}[-\bar{e}_t] + [1-\Phi_{tU}]\bar{e}_t \qquad (C13)$$

But if the target zone is symmetric about zero, then as $[1-\Phi_{tU}] = \Phi_{tL}$, then equation C13 collapses as the last two terms cancel each other out. In this case it is easy to see that a unique solution exists for $E[e_t]$ inside the band (that is, such that $-\bar{e} < e_t < \bar{e}$), as long as $\gamma < 1$. From this, the likelihood function is now straightforward to construct:-

$$L = \prod_0 \text{prob}\{e^* < -\bar{e}\} \prod_1 \text{prob}\{e^* | -\bar{e} \le e^* \le \bar{e}\} \text{prob}\{-\bar{e} \le e^* \le \bar{e}\} \prod_2 \text{prob}\{e^* > \bar{e}\} \qquad (C14)$$

where the subscripts under the products refer to whether the exchange rate is at, or below, the lower limit of the zone (subscript 1), between the two limits (subscript 2) or at or above the upper limit for the zone (subscript 3).

ANNEX 4D

OLS Estimates of Equation 4.24

(1979-1992)

Coefficient	Ffr	Lira	Hfl	UK£
$\alpha (x10^{-4})$	2.632 (1.38)	3.652 (1.44)	0.100 (0.10)	-2.971 (0.38)
$\beta (x10^{-4})$	-8.994 (8.53)	1.784 (0.96)	1.123 (0.37)	-87.122 (2.67)
$\gamma (x10^{-2})$	10.030 (3.66)	7.031 (2.57)	17.122 (5.68)	-2.750 (0.41)
$\Sigma \hat{e}^2$	0.013	0.018	0.004	0.006
R^2	0.115	0.012	0.046	0.068
F	43.45	3.88	16.19	3.77
Significance	0.00	0.02	0.00	0.03

Notes: i) N=670 observations, with the exception of the UK£, where there are 107 observations.
ii) In the case of the UK£, the exchange rate is the DM/UK£ rate.
iii) Figures in parenthesis are t-statistics.

ANNEX 5A

SUPPLEMENTARY ARCH TEST RESULTS FOR TABLES 5.1-5.3

Table 5A1

Tests on Residuals from ARCH Random Walk Model
Spot Exchange Rates

	Pre-EMS			Post-EMS	
Exchange Rate	Engle Test	Kurtosis	Serial Correlation	Kurtosis	Serial Correlation
Ffr	8.51	14.17	9.73	59.15	2.32
	(0.00)	(0.00)	(0.14)	(0.00)	(0.89)
UK£	27.86	5.23	14.50	2.50	14.62
	(0.00)	(0.00)	(0.02)	(0.00)	(0.02)
Ilira	14.59	16.89	30.61	11.67	4.06
	(0.00)	(0.00)	(0.00)	(0.00)	(0.67)
I£	57.99	12.13	20.17	4.97	12.72
	(0.00)	(0.00)	(0.00)	(0.00)	(0.05)
Hfl	35.49	5.26	14.42	23.39	10.50
	(0.00)	(0.00)	(0.03)	(0.00)	(0.11)
Bfr	14.58	10.60	8.02	7.58	37.73
	(0.00)	(0.00)	(0.24)	(0.00)	(0.00)
Spta	43.77	5.82	14.34	11.64	37.14
	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)
DM/US$	260.92	25.68	7.19	104.02	12.15
	(0.00)	(0.00)	(0.30)	(0.00)	(0.06)

Notes: i) Figures in parentheses below coefficient estimates are t-statistics; and

ii) The figures below likelihood test statistics are marginal significance levels. The likelihood ratio statistic tests for a shift in the coefficients post-March 1979.

Table 5A2

Maximum Likelihood ARCH: Supplementary Tests
3-month Euro-interest Rates

	Pre-EMS			Post-EMS	
Interest Rate	Engle Test	Kurtosis	Serial Correlation	Kurtosis	Serial Correlation
Ffr	0.22 (0.64)	8.71 (0.00)	10.05 (0.12)	69.49 (0.00)	21.61 (0.00)
UK£	203.91 (0.00)	0.65 (0.06)	1.61 (0.95)	8.52 (0.00)	13.22 (0.04)
Ilira	11.58 (0.00)	128.86 (0.00)	2.16 (0.90)	5.67 (0.00)	9.64 (0.14)
Hfl	71.05 (0.00)	4.64 (0.00)	7.33 (0.29)	10.65 (0.00)	10.05 (0.12)
DM	13.30 (0.00)	3.04 (0.00)	9.39 (0.15)	8.82 (0.00)	16.10 (0.01)
US$	40.55 (8.50)	2.20 (0.00)	5.21 (0.52)	11.90 (0.00)	13.35 (0.04)

Notes: see table 5A1

Table 5A3

Tests on Residuals from ARCH Random Walk Model
3-month Euro-interest Rate Differentials

	Pre-EMS			Post-EMS	
Interest Rate	Engle Test	Kurtosis	Serial Correlation	Kurtosis	Serial Correlation
Ffr	0.19 (0.66)	7.93 (0.00)	8.46 (0.21)	60.32 (0.00)	21.34 (0.00)
UK£	172.12 (0.00)	0.40 (0.24)	2.85 (0.83)	7.51 (0.00)	7.90 (0.25)
Ilira	7.73 (0.01)	122.98 (0.00)	1.53 (0.96)	4.94 (0.00)	12.49 (0.05)
Hfl	59.90 (0.00)	4.16 (0.00)	7.42 (0.28)	6.75 (0.00)	11.45 (0.08)
US$	71.60 (0.00)	1.56 (0.00)	10.86 (0.09)	13.93 (0.00)	19.25 (0.00)

Notes: see table 5A1

ANNEX 5B

SUPPLEMENTARY ARCH TEST RESULTS FOR TABLES 5.4-5.6

Table 5B1

Coefficients and Tests on Scaled Residuals from ARCH Estimation
Log Change in Spot Exchange Rates

	Ffr	UK£	Ilira	Dkr	I£	Hfl	Bfr	Spta	DM
Engle	294.78	164.16	198.47	204.59	194.33	217.13	238.81	204.27	104.69
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
1971-79									
β_0(e-3)	1.183	-1.764	1.875	0.824	-1.763	0.340	0.387	-0.193	-1.795
	(3.11)	(2.88)	(2.28)	(1.71)	(2.86)	(1.39)	(1.61)	(0.71)	(2.84)
β_1	0.182	0.109	0.217	-0.192	0.105	-0.123	-0.178	0.162	-0.030
	(3.26)	(1.73)	(3.60)	(3.11)	(1.65)	(1.90)	(3.13)	(7.34)	(0.49)
K	16.03	8.08	14.82	19.72	8.12	15.67	42.66	29.33	7.03
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
χ^2	8.88	8.27	22.01	11.26	8.30	4.45	8.29	5.33	15.59
	(0.18)	(0.22)	(0.00)	(0.08)	(0.22)	(0.62)	(0.22)	(0.50)	(0.02)
1979-92									
β_0	0.729	-0.332	0.225	0.317	-0.672	0.019	0.160	-19.77	-0.422
	(13.26)	(0.76)	(1.33)	(2.27)	(7.34)	(0.26)	(1.55)	(0.22)	(0.68)
β_1	0.223	0.052	-0.073	-0.061	-0.188	-0.141	-0.310	-0.160	0.013
	(10.54)	(1.16)	(2.85)	(1.35)	(16.38)	(5.03)	(12.61)	(1.06)	(0.32)
K	61.45	2.48	11.42	5.66	22.87	8.20	14.46	103.76	0.86
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
χ^2	6.25	11.38	2.93	9.29	2.07	25.31	19.43	15.02	5.83
	(0.40)	(0.08)	(0.82)	(0.16)	(0.91)	(0.00)	(0.00)	(0.02)	(0.44)

Notes: i) Figures in parentheses below coefficient estimates are t-statistics;

ii) The K statistic tests whether kurtosis is significantly different from a normal distribution; and

ii) χ^2 test statistics are tests for serial correlation. The figures in parenthesis below test statistics are marginal significance levels. This LM statistic tests for serial correlation up to order 6.

Table 5B2

Coefficients and Tests on Scaled Residuals from ARCH Estimation
Change in 3-month Eurointerest Rates

	Ffr	UK£	Ilira	Hfl	DM	US
Engle	330.75 (0.00)	11.72 (0.00)	186.68 (0.00)	88.07 (0.00)	214.92 (0.00)	268.42 (0.00)
1975-79						
β_0	-0.037 (0.64)	0.002 (0.05)	0.069 (0.40)	0.010 (0.26)	0.009 (1.06)	0.014 (1.02)
β_1	-0.143 (2.14)	-0.135 (1.73)	-0.212 (1.45)	-0.121 (2.79)	0.072 (1.19)	0.023 (0.38)
K	8.11 (0.00)	0.50 (0.14)	138.66 (0.00)	4.69 (0.00)	2.94 (0.00)	2.12 (0.00)
χ^2	7.47 (0.28)	2.60 (0.86)	2.42 (0.88)	9.61 (0.14)	6.66 (0.35)	4.49 (0.61)
1979-92						
β_0	-0.020 (6.37)	-0.005 (0.37)	-0.008 (0.50)	0.008 (0.85)	-0.003 (0.54)	-0.019 (2.62)
β_1	0.316 (55.32)	0.104 (2.29)	-0.113 (8.10)	0.006 (0.20)	0.114 (6.65)	0.266 (46.31)
K	23.33 (0.00)	8.36 (0.00)	186.81 (0.00)	10.55 (0.00)	8.92 (0.00)	10.74 (0.00)
χ^2	6.95 (0.33)	6.38 (0.38)	9.35 (0.15)	9.62 (0.00)	6.68 (0.35)	1.94 (0.92)

Notes: see table 5B1

Table 5B3

Coefficients and Tests on Scaled Residuals from ARCH Estimation
Change in 3-month Eurointerest Rate Differentials

	Ffr	UK£	Ilira	Hfl	US$
Engle	331.26	14.70	191.63	97.68	200.08
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
1975-79					
β_0	-0.020	0.017	0.079	0.063	0.011
	(0.34)	(0.37)	(0.51)	(1.68)	(0.64)
β_1	-0.107	-0.142	-0.220	-0.151	0.243
	(1.44)	(1.87)	(1.63)	(3.32)	(3.29)
K	7.64	0.32	131.70	4.46	1.17
	(0.00)	(0.34)	(0.00)	(0.00)	(0.00)
χ^2	6.48	3.55	2.31	8.70	5.37
	(0.37)	(0.74)	(0.89)	(0.19)	(0.50)
1979-92					
β_0	-0.107	-0.025	-0.013	0.004	0.004
	(13.86)	(1.87)	(0.91)	(0.39)	(0.68)
β_1	0.096	0.051	-0.113	-0.111	0.383
	(26.04)	(1.32)	(9.13)	(5.71)	(32.35)
K	32.38	7.01	4.23	5.94	9.75
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
χ^2	9.45	11.07	11.82	17.59	14.26
	(0.15)	(0.09)	(0.07)	(0.01)	(0.03)

Notes: see table 5B1

ANNEX 6A

THE POLITICS OF EMU

a) Some pre-Maastricht history

Attempts were made to forge a federalist structure in Europe as early as 1948, in the form of the Council of Europe, but such hopes were prematurely dashed when it became clear to European federalists that economic cooperation was much likely to garner more support than a political union.

This placed European federalists in what political scientists have labelled the 'neo-functionalist school', after such theorists as Haas (1958) and Lindberg (1963). This school believes that economic integration has a cumulative logic, which, if followed, ultimately leads to political integration. It is also a school that is firmly grounded in the belief that supranational agencies, once accepted, attract greater responsibilities because of the dynamic properties of economic tasks. Tsoukalis (1977) describes this:-

> "Because economic tasks are functionally related to each other, it was expected that, once co-operation on some specific issues had been initiated, this would bring about a need both for a strengthening of such co-operation in the areas already covered by international agencies and for its extention to other related areas of economic policy. The process would continue until the moment that the nation-state would be virtually deprived of its autonomy." (Chapter 2, page 23)

Another distinguishing feature of the neo-functionalist school was that they believed that welfare issues could be separated from politics and that such issues can be decided by experts and technical specialists. This feature was integral to the way in which neo-functionalists supposed that integration would proceed, in that loyalties of citizens would be transferred to the international level if international agencies concentrated on utility-improving policies, which, it was contended, could be more efficiently undertaken by international agencies than national governments. The Common Agricultural Policy (CAP) is a good example of a utility-improving policy initiative, taken on this basis.

Although neo-functionalist ideas were markedly absent from early Treaties adopted by the Community, the system of 'enrenage', that is, the incorporation of as many people and organisations in it's decision-making process, was adopted to try and transform the loyalties of key political players in Europe. But the neo-functionalist school believed that the process of integration is cumulative and will therefore lead to much more than just a web of supranational organisations and a complex process of consultation. And indeed, this has come to pass. Both the Werner Report (1971) and the Delors Report (1989) are both neo-functionalist in nature. The Werner Report specifically states that for the EC, EMU is a "lever for the developments of political union, which in the long run it cannot do without" (Page 12).

Neo-functionalism has not had a complete monopoly on political economy theories of integration, and indeed the Werner Report was buried by precisely these political forces. The 'Power Politics' school (examples here are Aron (1964) and Hoffman (1965)) believe, in common with the neo-functionalist school, that there is a division between welfare and high politics, but that there is a discontinuity between the two. However, and more importantly from an integration point of view, all supranational organisations are just a sum of their constituent parts so that the nation-state is still always the principal actor in the political and economic system. A good example of this view would be much of Charles de Gaulle's thinking on this subject ("There is no European reality other than our nations and the states which are their expression.") or Margaret Thatcher's famous Bruges Speech (September 30, 1989) when she railed against the idea of ceding any economic or political autonomy to Europe.

Several other important historical differences of opinion mark the early plans for EMU, some of them stemming from the neo-functionalist/Power Politics debate. During the Werner Group negotiations, it became clear (see Tsoukalis (1977) and De Grauwe (1990)) that two opposing groups of economic thinkers had formed and crystalised their views on strategies to attain EMU. These two groups were labelled the 'monetarists' (in the discussions these views were held by France, Belgium and Luxembourg - it should be noted that the 'monetarist' label bears no relation to the macroeconomic monetarist school) and the 'economists' (- Germany, the Netherlands and Italy - see Salin (1980), for example), the former adopting typically neo-functionalist arguments that early progress in the monetary field would force an effective co-ordination of economic policies. 'Monetarists' therefore adopted arguments that an early narrowing of margins of fluctuation would be beneficial and the establishment of an Exchange Stabilisation Fund would aid adjustment to EMU. In contrast to neo-functionalists, however, 'monetarists' felt that monetary policy issues had become significantly important as to blur any distinction between welfare and high politics (and hence the name 'monetarists') - they contended that it was paramount for Europe to establish as a first priority, an autonomous exchange rate system, so as to present a common monetary "face" to the rest of the world. The 'economists', however, believed that harmonisation of economic policies should take priority before any important measures of Community monetary policy are embedded in the system. On the issue of the Exchange Stabilisation Fund, it was felt by the 'monetarists' that such a fund was necessary to fund intervention to protect intra-European exchange rate parities, whereas for 'economists' the burden of adjustment should lie with deficit countries without the need for surplus countries to finance deficit ones.

Although the Werner Report ended up as a compromise between the 'monetarists' and the 'economists' (brokered in fact through the Ansiaux (Experts) Subcommittee of the Committee of Governors of Central Banks), it bears a remarkable resemblence in many respects to the Maastricht Treaty (Council of the European Communities (1992)), which was the eventual adopted means of achieving EMU. Indeed, the mix of the 'monetarist' Delors Report approach, with the 'economist' economic pre-conditions for acceptance into EMU, balances exactly the same economic views that were present in Werner.

Lastly, two other important institutional economic items were mentioned in Werner - firstly, the creation of a 'Community System of the Central Banks' to be modelled on the Federal Reserve System, but with an independent role (except in decisions about exchange rate parities) and secondly a 'Centre for Decisions on Economic Policy' which would formulate European economic policy and be directly answerable to the European Parliament.

The Werner Report was before its time - political consensus on integration was not forthcoming and the recommendations were shelved.

b) Delors and Maastricht

After the Werner Report, there was little activity towards the goal of integration with the exception of the All Saints' Day Manifesto (Basevi etc. (1975)), up to the Delors Report (The Committee on the Study of Economic and Monetary Union (1989)). In the meantime, the introduction of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) in 1979 had proved successful in reducing monetary differences (such as inflation and interest rates) between most EC countries to an inconsequential level. The drive for monetary union by gradualist means was foremost in the Delors Report. The plan was in three stages, and at each stage the degree of convergence and co-operation was to be increased. In the final stage only the European currency unit (Ecu) would circulate.

The issuance of the Delors Report provided new impetus towards monetary unification in Europe. There were two dissenting voices against the means of achieving monetary union, the UK government and the German government (as well as the Bundesbank). The UK government objected to the report on the basis that it ceded monetary sovereignty to a European monetary institution and that it implicitly sought the abolition of national currencies. The UK government issued two documents (HM Treasury (1989) and (1990)) as alternatives to the Delors plan which embodied the Hayekian parellel-currency principle (and harked back to the All Saints' Day Manifesto). This approach came to be known as the "Hard Ecu" plan. The Bundesbank's objections were of an 'economist' nature. The Bundesbank wanted strict criteria to be incorporated into the plan before countries could proceed towards monetary union and the German government also sought greater European political integration so that the European Central Bank could be answerable to a European Parliament that possessed real powers.

It soon became plain that the "Hard Ecu" proposal, whilst it obtained a polite reception, was unacceptable to most of the UK's European partners. At the Inter-Governmental Conference, that was held in Maastricht in December of 1991, agreement was reached on a compromise that satisfied the Germans. This consisted of five convergence criteria to be attained before countries could proceed to monetary union. The UK, still dissatisfied, along with Denmark, which foresaw political problems in making the Treaty palatable to its citizens, negotiated opt-out clauses.

ANNEX 6B

THE EU BUDGET

Prior to 1973, the European Commission (EC) had adopted a policy of harmonisation at all levels, and had largely been frustrated in its attempts to attract more responsibilities in key areas. In 1974 it decided to commission a report to help it to try and use the budget to make the Community more cohesive and foster more convergence. In 1977, the MacDougall Report was published (Commission of the European Community (1977)) which "examined the criteria for assigning functions to the different levels of a multi-tier government" (Plender (1991)). The report identified 4 principles, as follows:-

i) Externalities - when costs or benefits apply to more than one body politic;

ii) Indivisibility or Economies of Scale - where the Community can undertake programs that no single state could afford;

iii) Cohesion - resource transfers to the regions with weaker economies; and

iv) Subsidiarity - keeping functions with lower levels of government when there is no advantage to transferring them to higher levels.

Since the 1977 MacDougall Report, the Commission has reformed its budget concerning the Common Agricultural Policy (CAP), and has applied these principles to its policy-making and its overall purview, with the result that its budget and its law-making powers have increased significantly. Indeed this garnering of power has been so successful that it has caused outcry among European leaders (most notably the Bruges speech by Margaret Thatcher). In 1972, EC general budget expenditure amounted to around 0.3% of EC GDP, whilst a decade later it had jumped to around 0.8% of GDP, and in 1992 this had risen to just under 1.2% of GDP.

Table B1 gives the most recent EU budget:-

TABLE B1

The Composition of the EU budget

(1993)

Item	Million ECU	% of budget
Expenditures		
Agricultural Policy	35 052	53.4
Structural Operations	20 709	31.6
External policy	2 997	4.6
Research policy	2 201	3.3
Administrative expenditure	3 401	5.2
Other policies	1 161	1.8
Total	65 523	100.0
Revenues		
Agricultural and sugar levies	2 239	3.4
Customs duties	13 118	20.0
VAT	35 677	54.5
Additional resource (GNP)	14 030	21.4
Miscellaneous	457	0.7
Total	65 523	100.0
In % of EC GDP	1.20	

Source: European Commission.

ANNEX 6C

RECENT EVENTS IN THE EU

Since the Treaty was signed four events have been of significance to the path envisaged to EMU. First German Economic Monetary and Social Union (GEMSU), which has left Germany preoccupied with the domestic problem of integrating former East Germany into the federal republic. Second the completion of the Single market in January 1993, which removed all obstacles to the free flow of goods, services, labour and capital between the European Union (EU) states. Thirdly, the repeated and successful speculative attacks mounted against the ERM of the EMS in September 1992 and thereafter, which led to the withdrawal of the UK pound and Italian lira and several realignments of other currencies. Eventually to prevent a political row about where the burden should lie in terms of realignment, agreement was reached to widen the bands to +/-15% for all currencies except the Hfl (which amounts to a free float). And fourthly, the recent agreement to widen EU membership to incorporate four new members, Sweden, Finland, Norway and Austria (after significant wrangling on the part of the UK and Spain on blocking votes), which decisively shifts the balance of power towards the Northern (higher income) states.Two recent political events are also important in the context of EMU. The first significant event was the failure of the Council of Ministers to unanimously appoint a successor to Jacques Delors at the Corfu Summit (July 1994), due to the UK vetoing all candidates put forward. Only at a subsequent special summit did the ministers agree to appoint Jacques Santer (currently Prime Minister of Luxembourg) as President of the European Commission from January 5, 1995. Jacques Delors, who was a European federalist and came from the French socialist "centralising tradition", became the driving force behind the Single European Act, the European Economic Area (EEA) and EMU. The direction of EMU in political terms will largely depend on whether Santer decides to pursue the same type of European federalism as Delors and to what extent the appointment might weaken the institutional power and political leadership role of the European Commission.

The second important recent event was the agreement to widen the European Union to include Austria and the Scandinavian countries of Sweden, Finland and Norway and the sharp disagreement with the UK over blocking votes that took place in these negotiations. As these countries join the EU in 1995, but they will shift the balance of power to the Northern states, which have traditionally been less enthiusiastic supporters of EMU. So if revisions are made to the Maastricht Treaty at the Intergovernmental conference in 1996, as many of the new Member States will not have been members of the EU for any length of time, they will not have been subject to, or in a position to satisfy the economic criteria for EMU for some years to come. The new configuration of votes and blocking rules may therefore have a profound influence on the outcome of the review.

ANNEX 6D

EVALUATING THE MAASTRICHT CRITERIA FOR EU MEMBER STATES

The Maastricht criteria are as follows (Article 109j):-

i) Price Stability - an annual average rate of inflation that does not exceed by more than 1.5% that of, at most, the three best performing Member States;

ii) Interest Rates - observed over a period of one year, a Member State has had an average moninal long-term interest rate on government bonds that does not exceed by more than 2% that of, at most, the three best performing Member States in terms of price stability;

iii) Government Deficits - the deficit should not exceed 3% for the ratio of the planned or actual government deficit to gross domestic product at market prices; and

iv) Government Debt - the debt should not exceed 60% for the ratio of government debt to gross domestic product at market prices; and

v) ERM - a Member State has respected the "normal" fluctuation margins provided for by the exchange-rate mechanism of the EMS without severe tensions for at least the last 2 years before the examination; it should not have devalued its currency within the mechanism during this period.

The last criteria has effectively been dropped by the European Monetary Institute (EMI) as a criteria, following the widening of the bands from their original +/-2.25% margin around parity levels to a +/-15% margin.

As of October 1994, following the decision by the European Commission to apply the dynamic "let-out" clause to the Irish public debt, table D1 indicates whether each EU country satisfies the remaining four economic criteria:-

TABLE D1

Which EU Members States Satisfy the Maastricht Criteria?

Member State	i) Inflation rate	ii) Interest rates	iii) Budget deficit	iv) Public debt
Belgium	Yes	Yes	No	No
Denmark	Yes	Yes	No	No
Germany	Yes	Yes	Yes	No
Greece	No	No	No	No
Spain	No	No	No	No
France	Yes	Yes	No	Yes
Ireland	Yes	Yes	Yes	Yes
Italy	No	No	No	No
Luxembourg	Yes	Yes	Yes	Yes
Netherlands	Yes	Yes	No	No
Portugal	No	No	No	No
United Kingdom	Yes	Yes	No	Yes

GRAPHS

Figure 2.1a

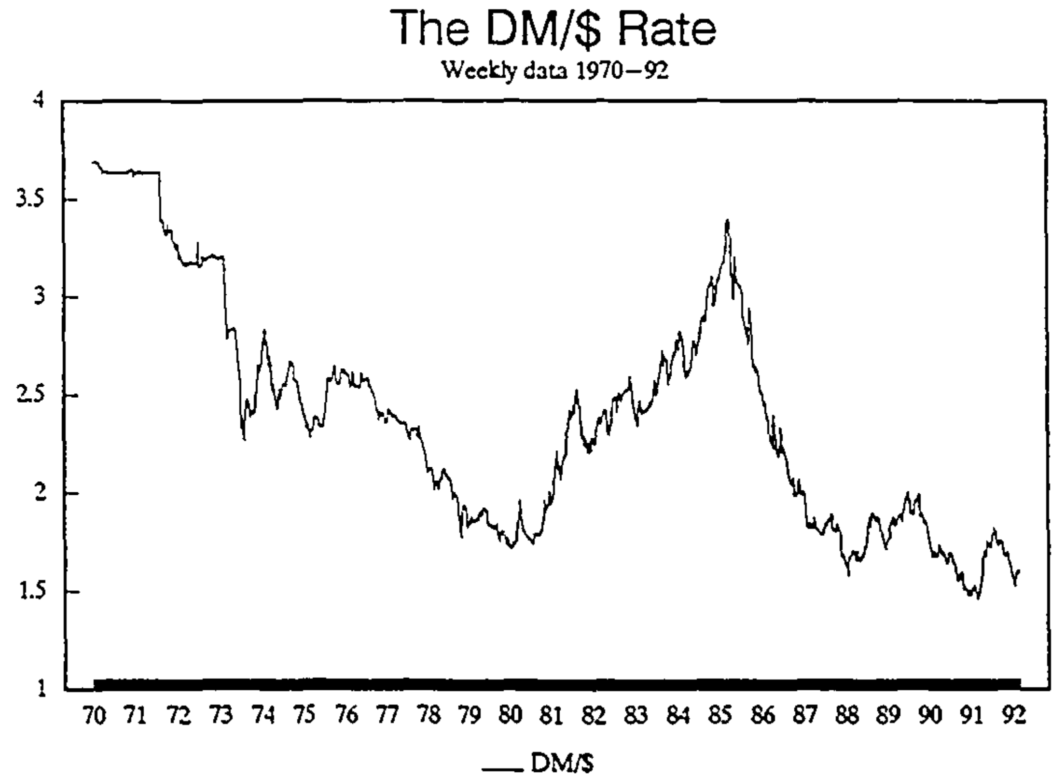


Figure 2.1b

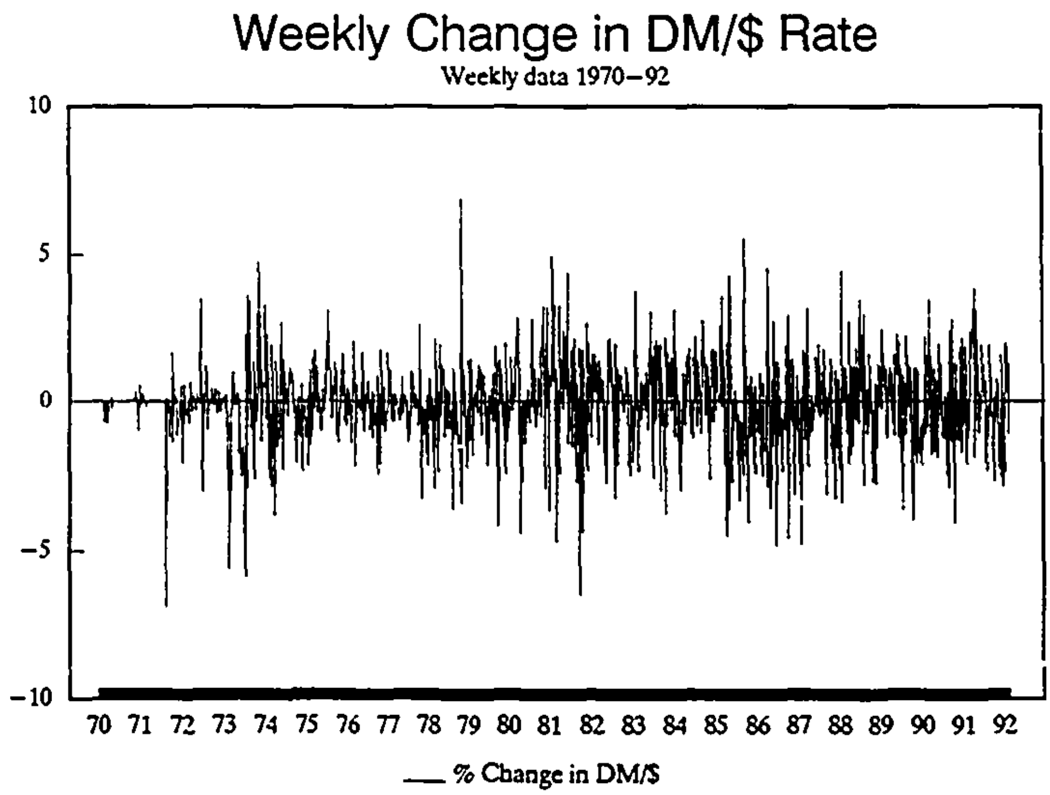


Figure 2.2a

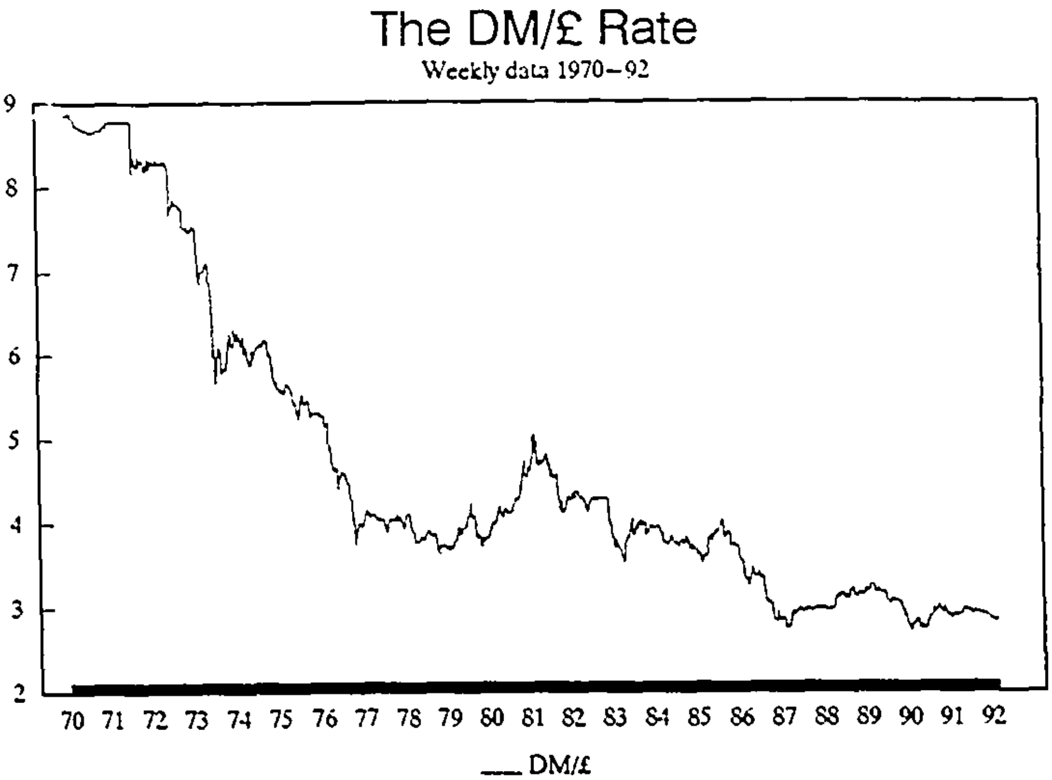


Figure 2.2b

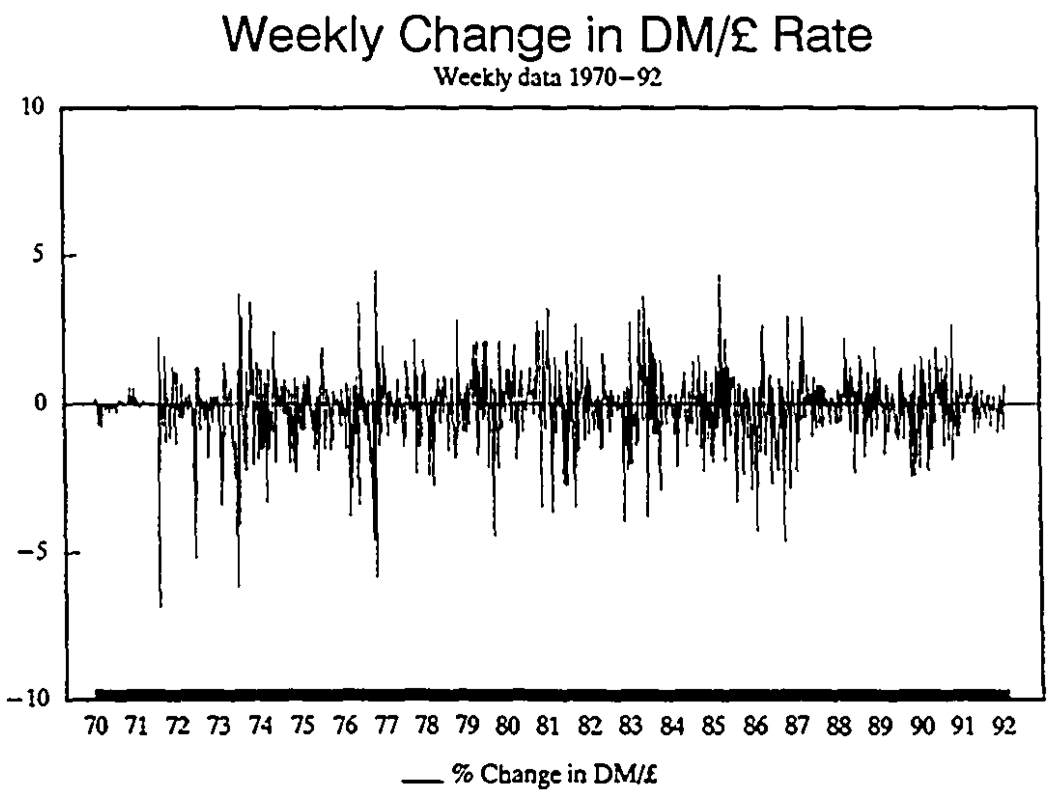


Figure 2.3a

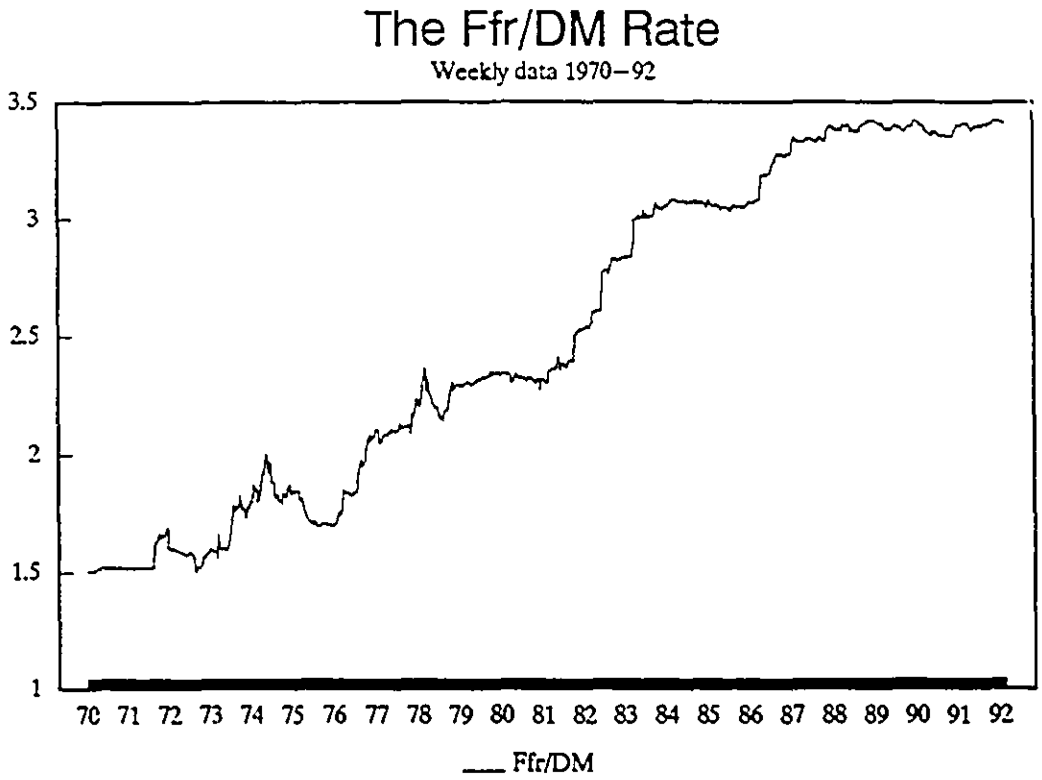
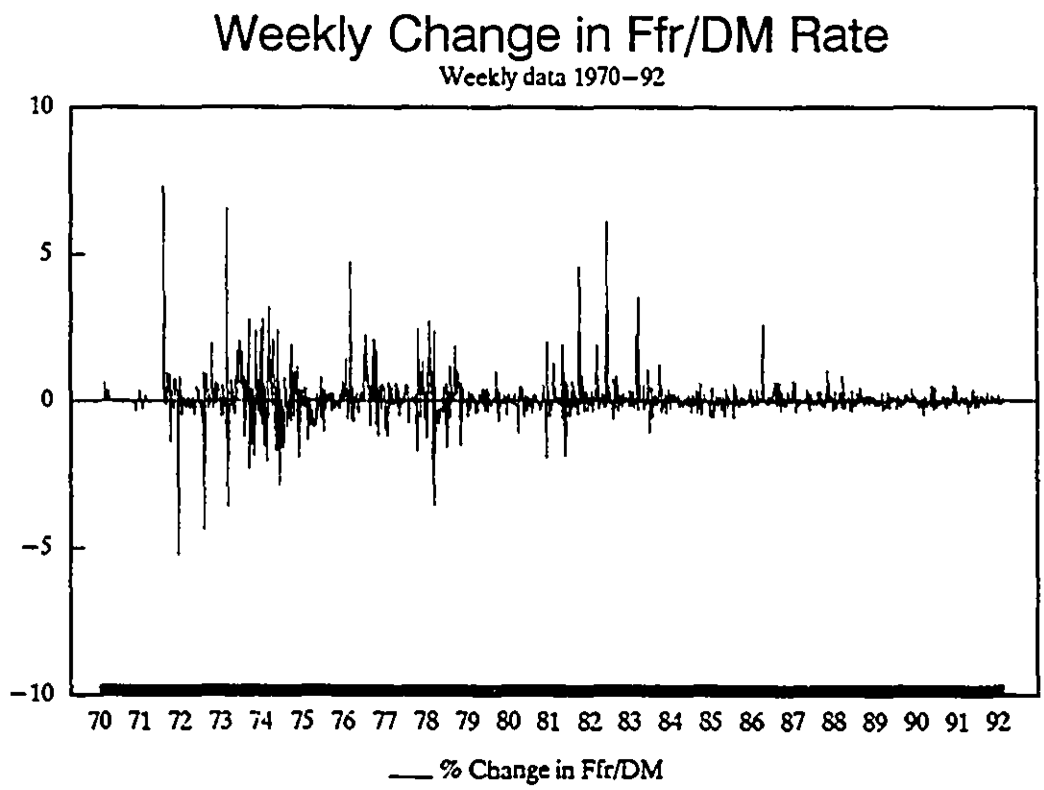


Figure 2.3b



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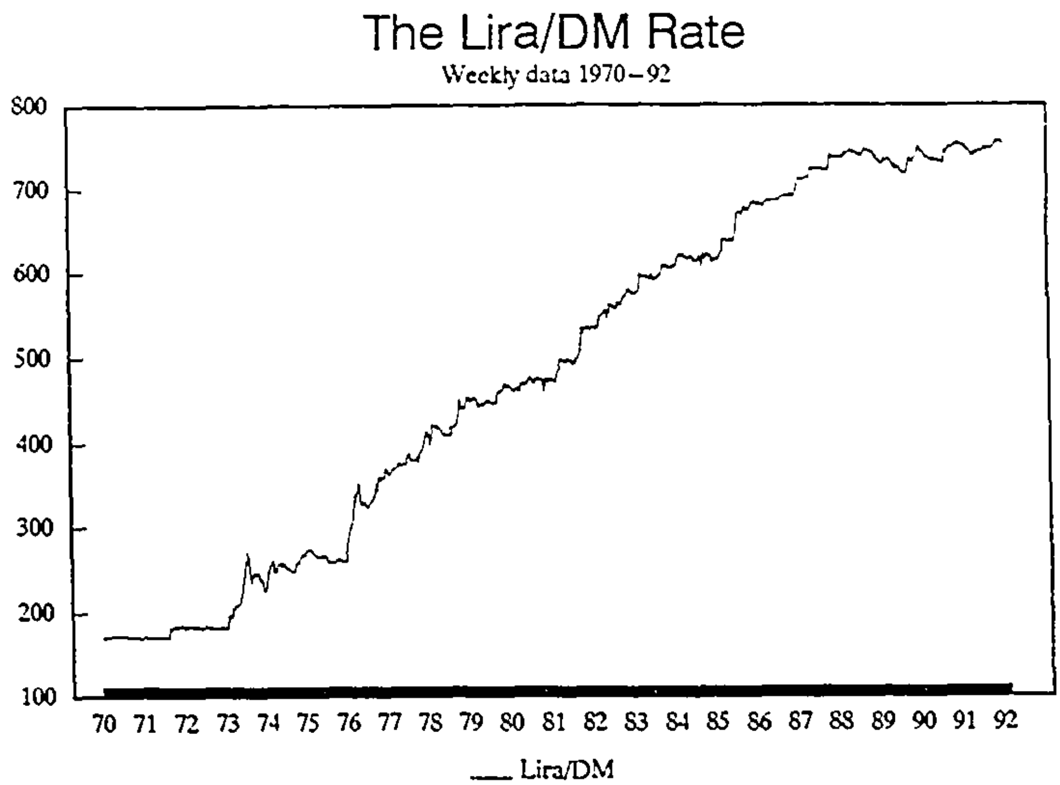

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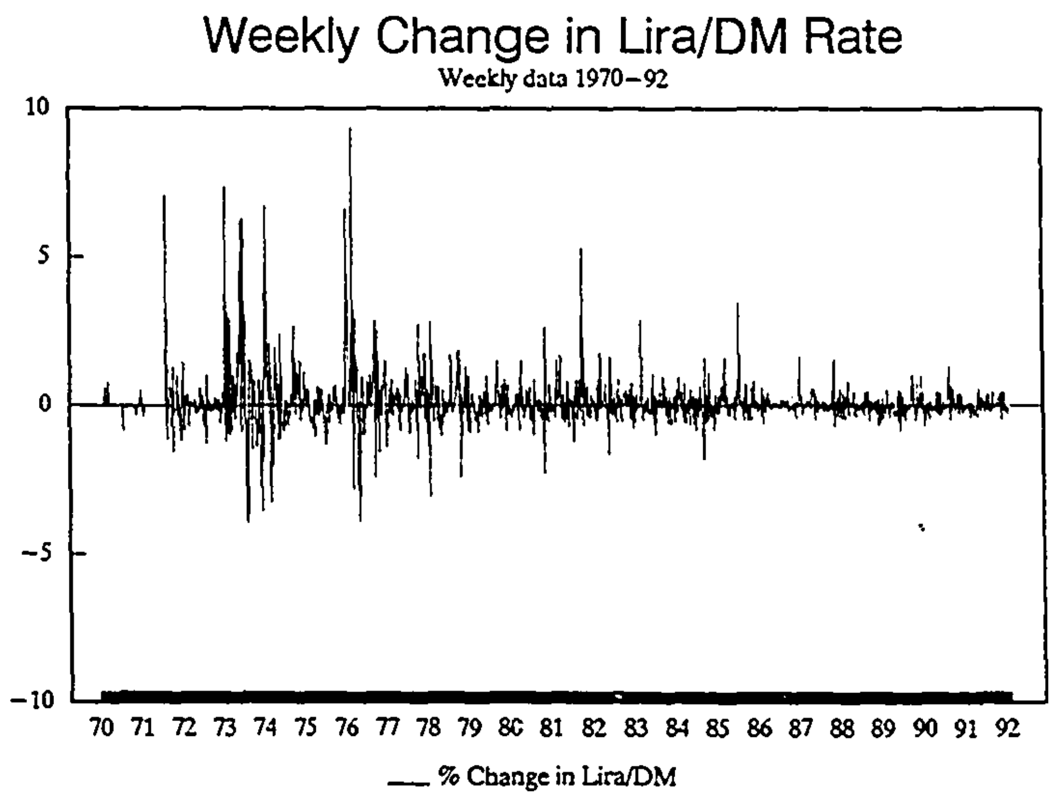

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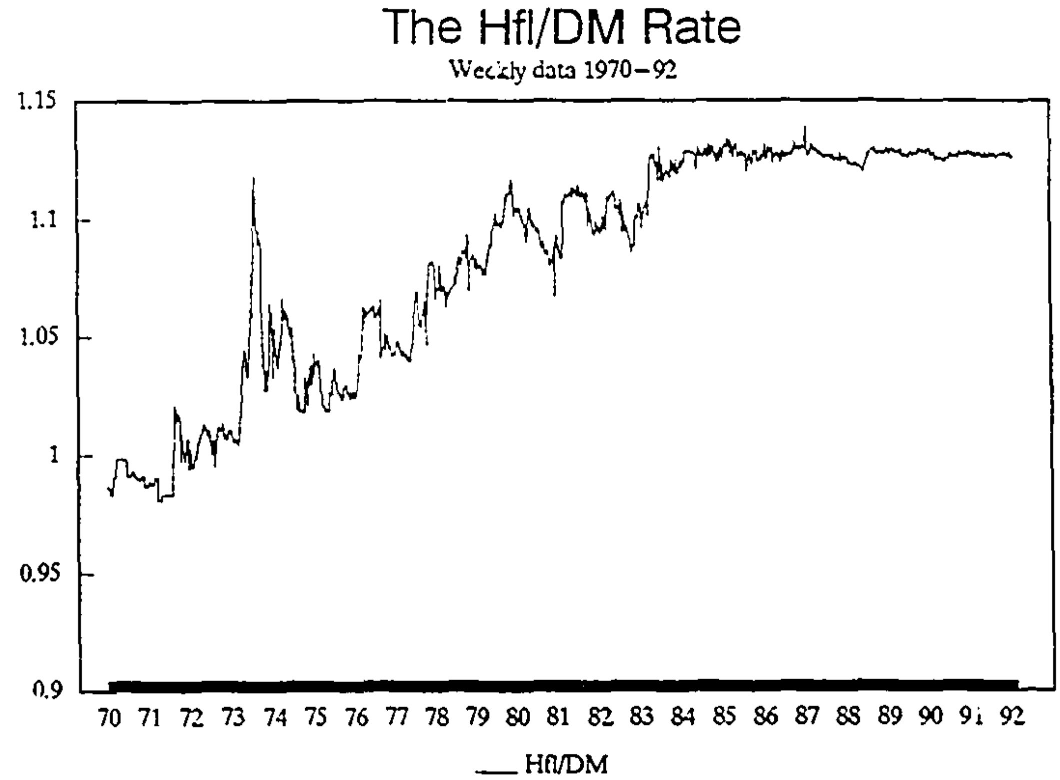

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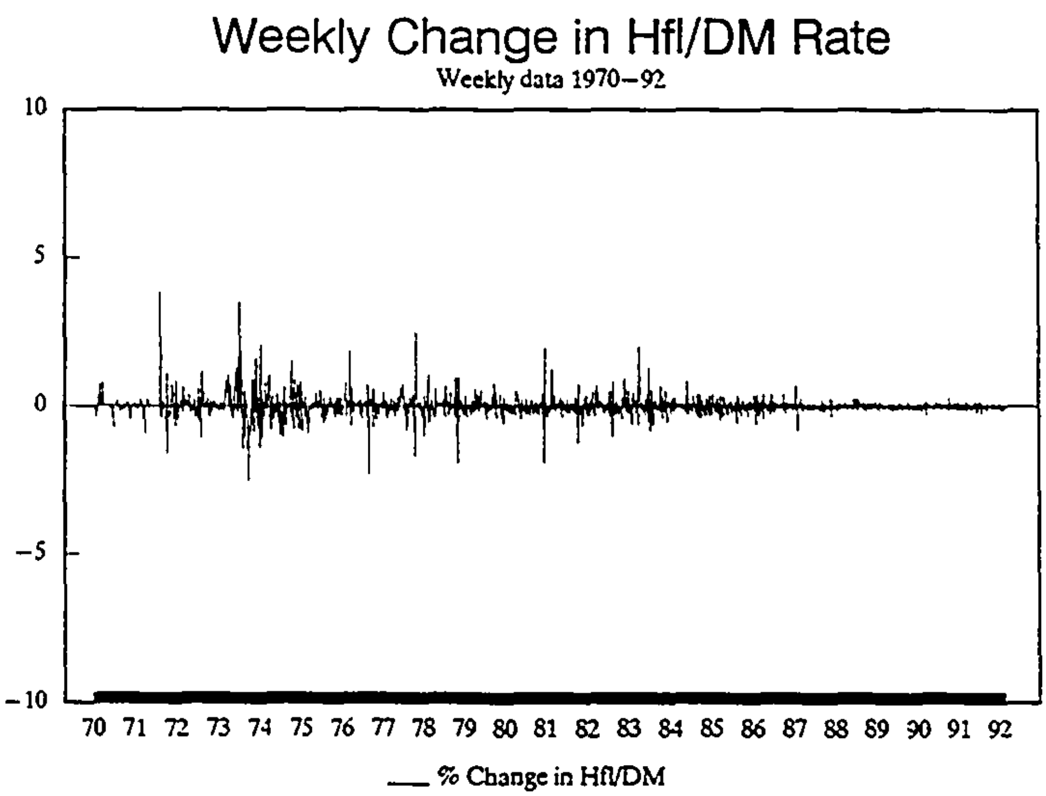

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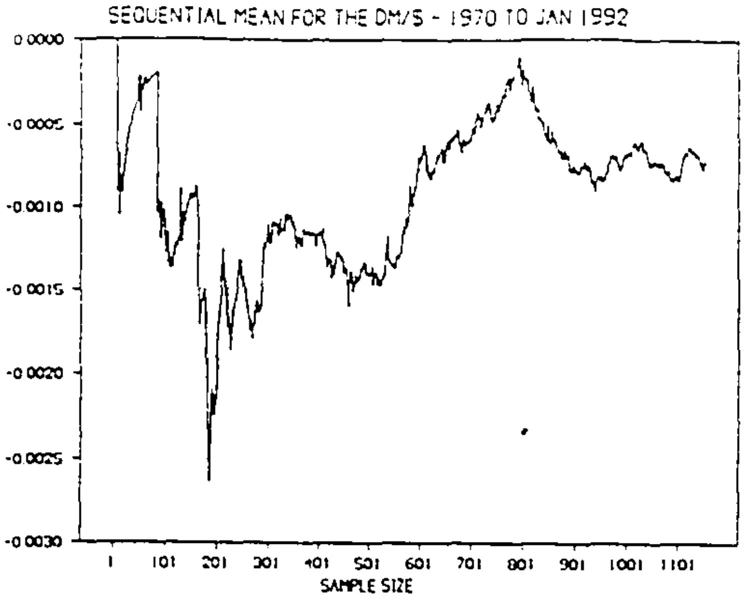

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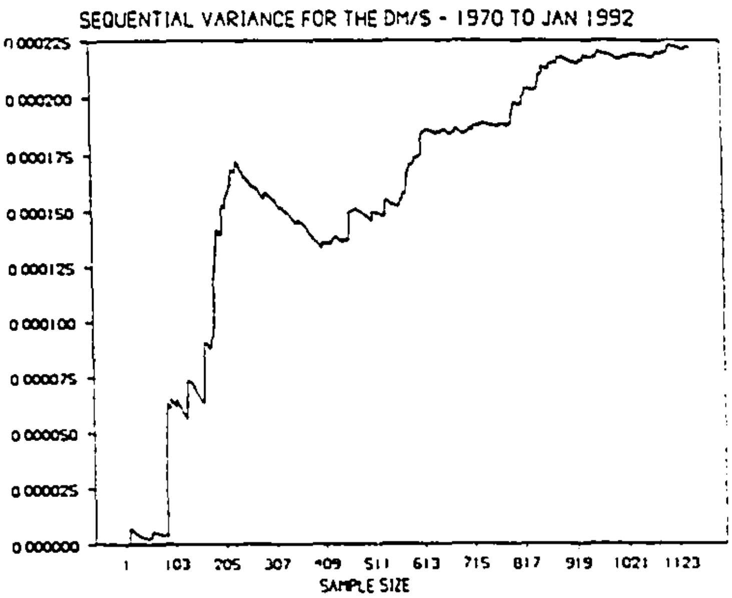

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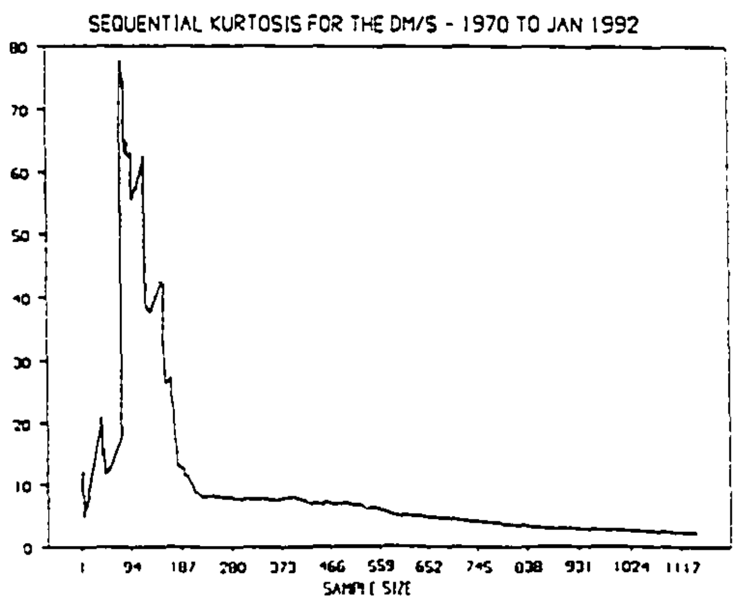

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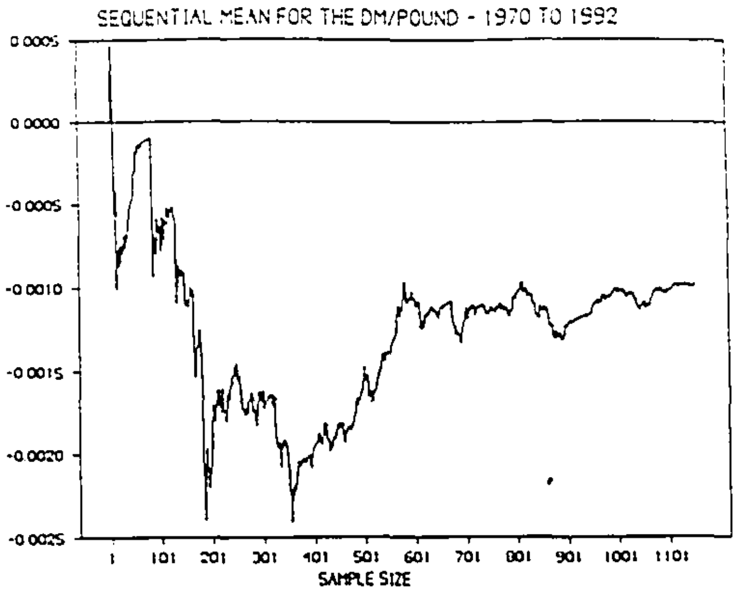

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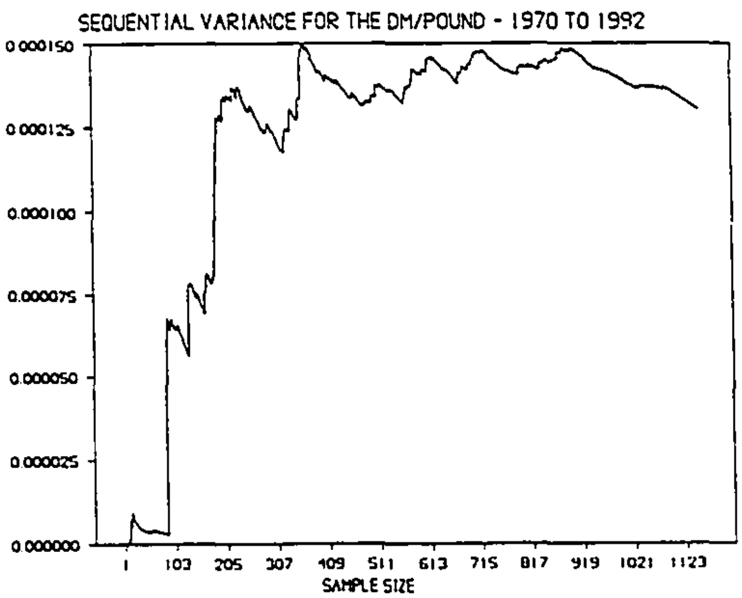

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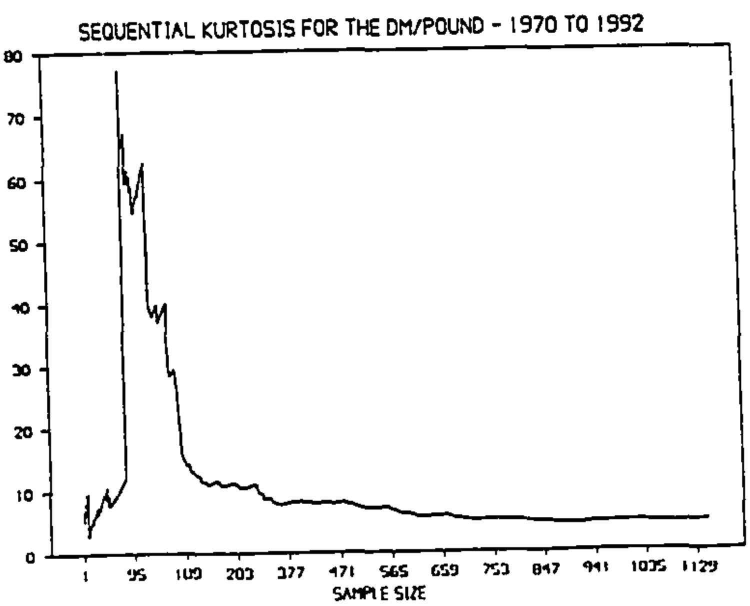

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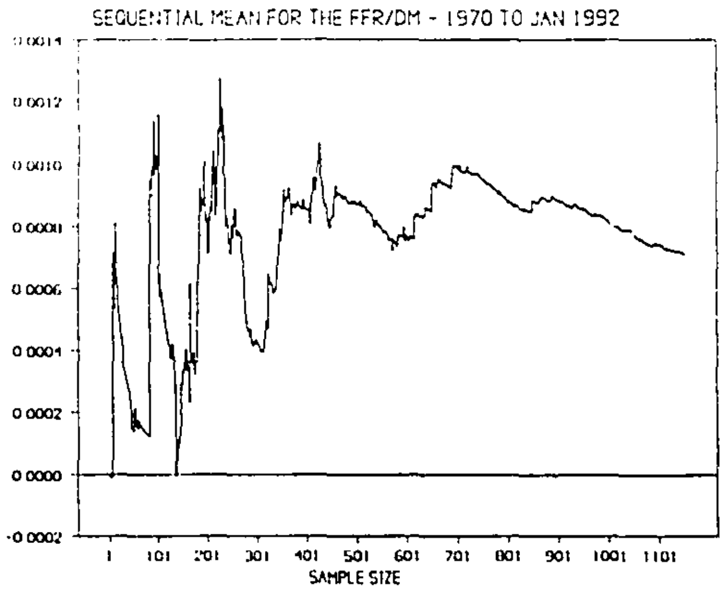

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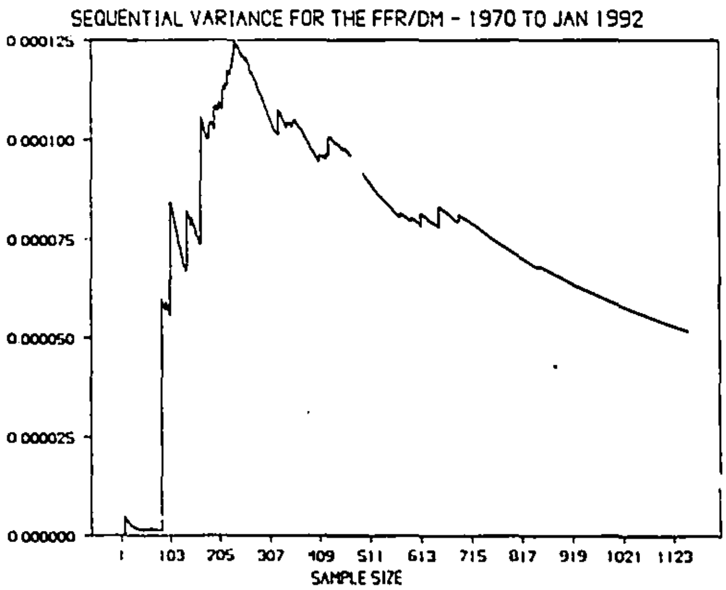

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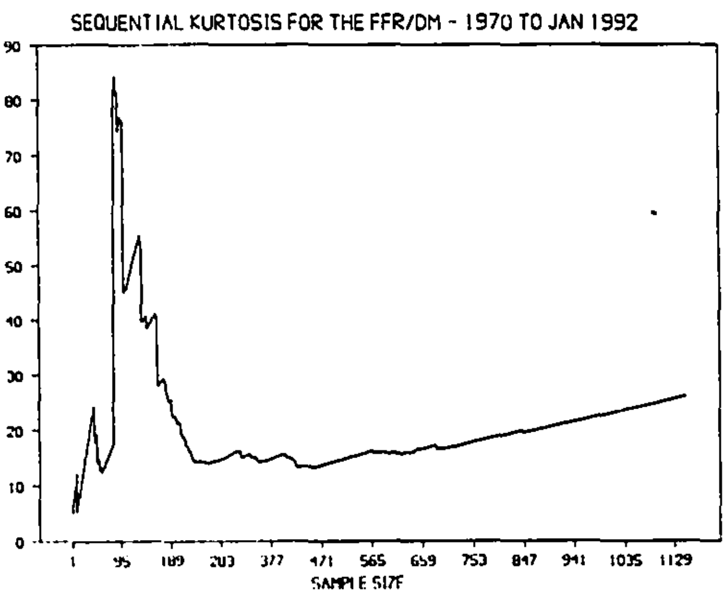

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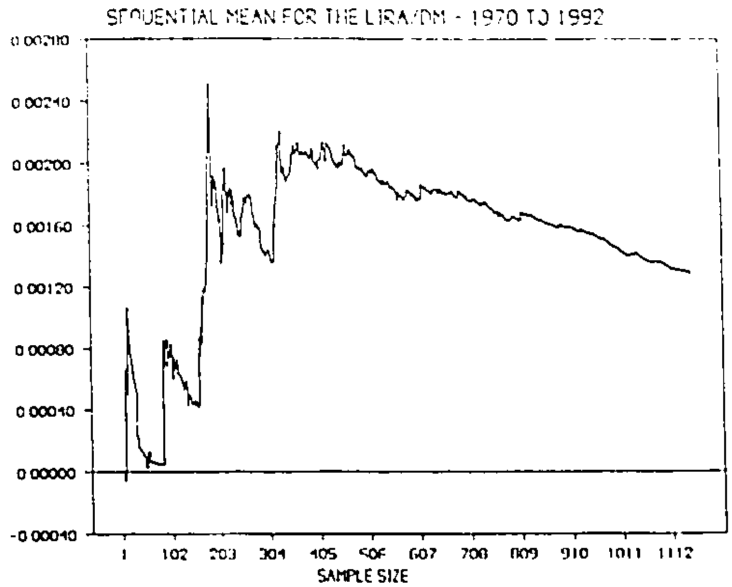

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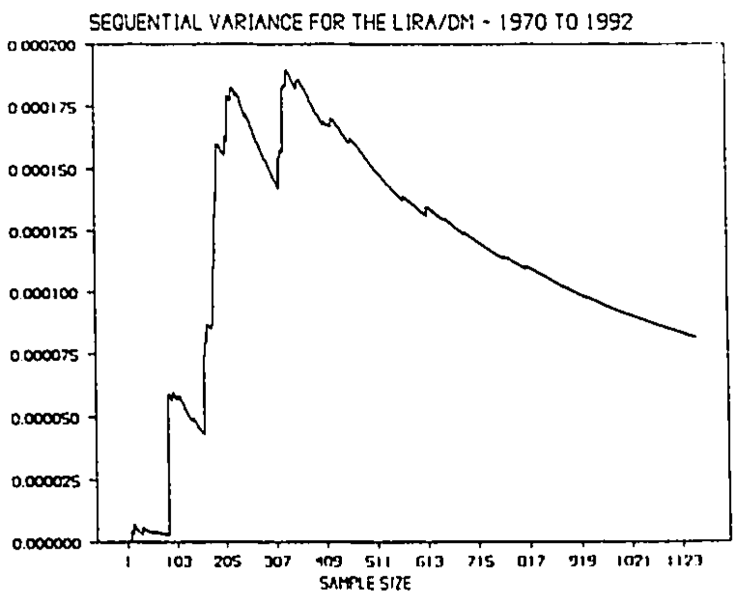

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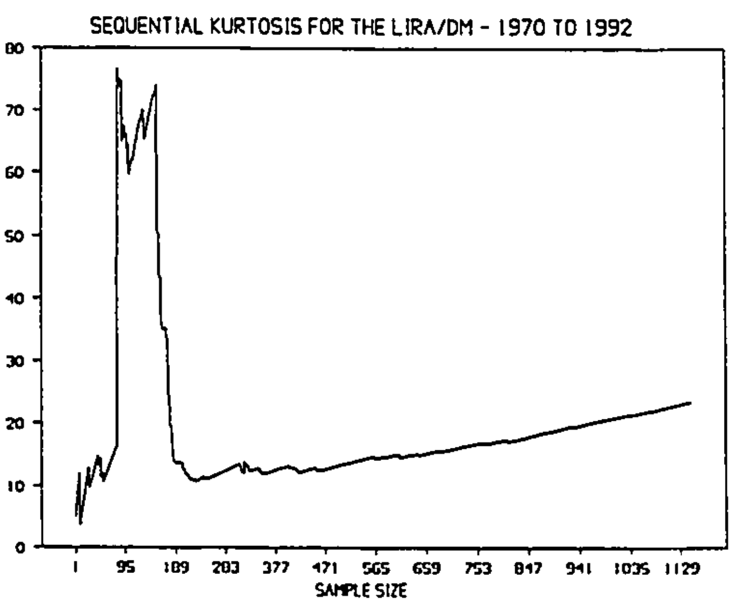

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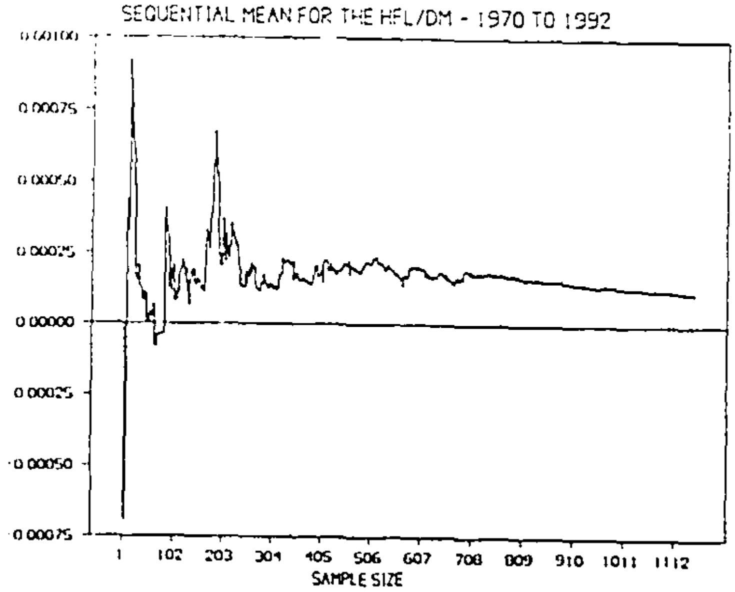

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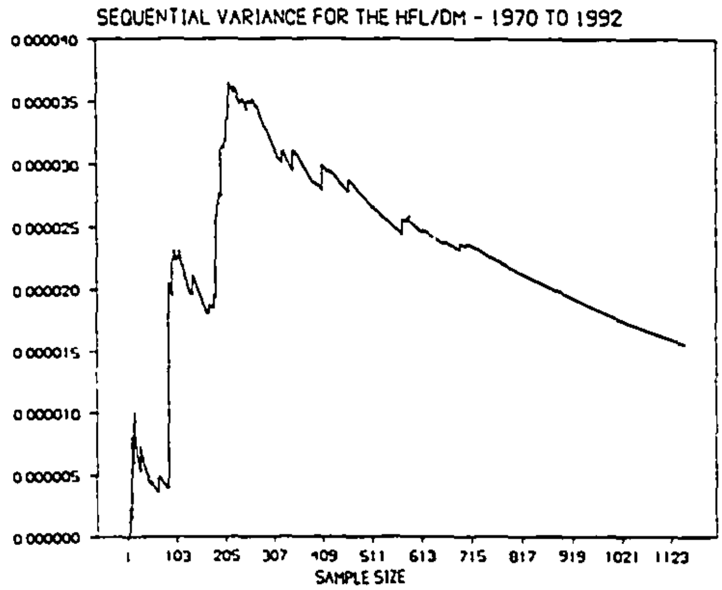

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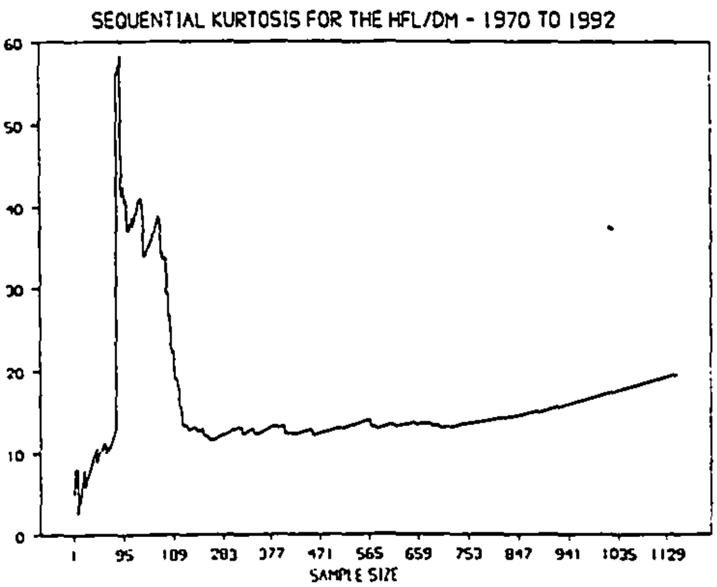

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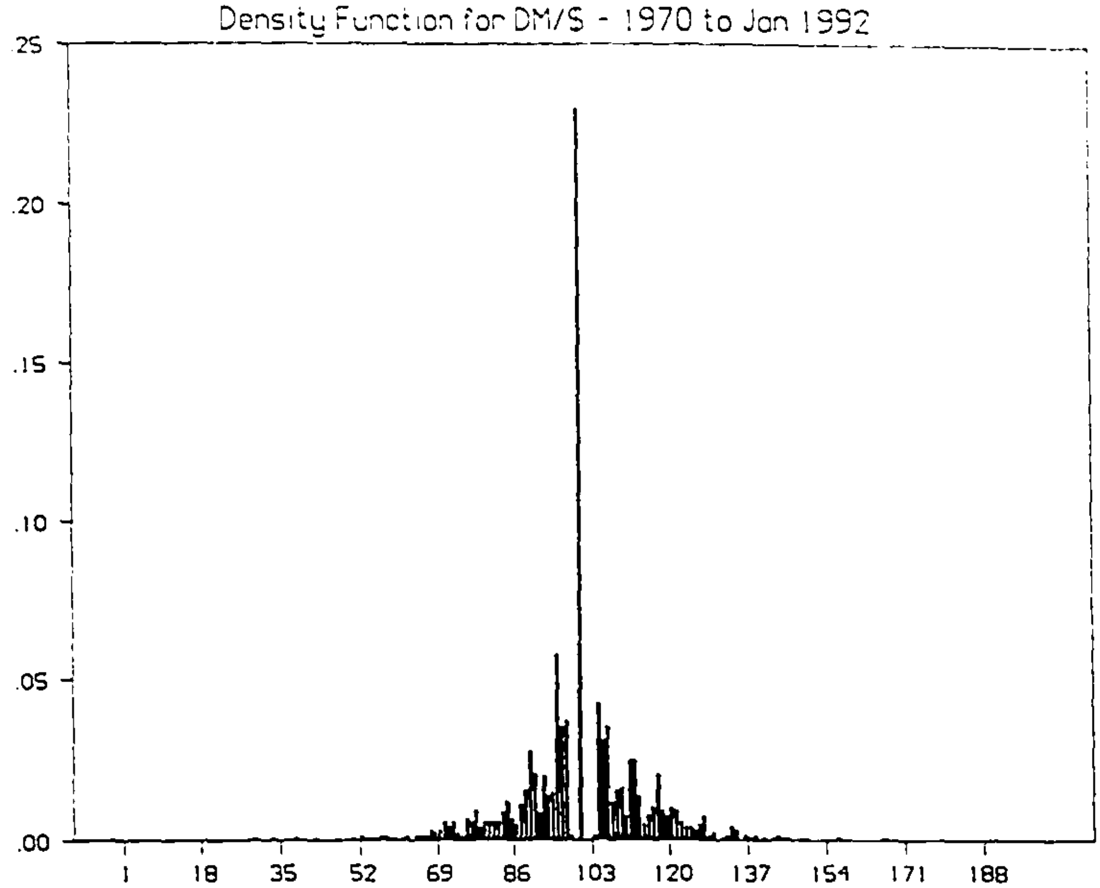

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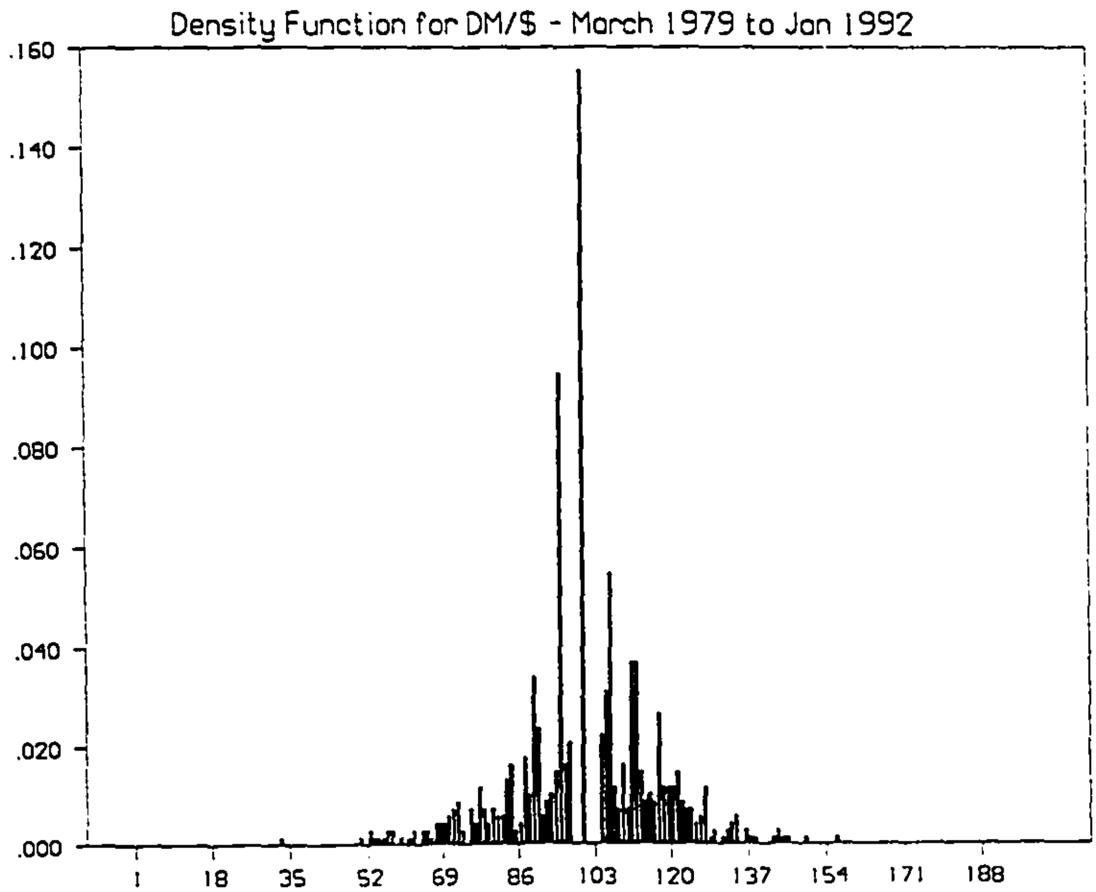

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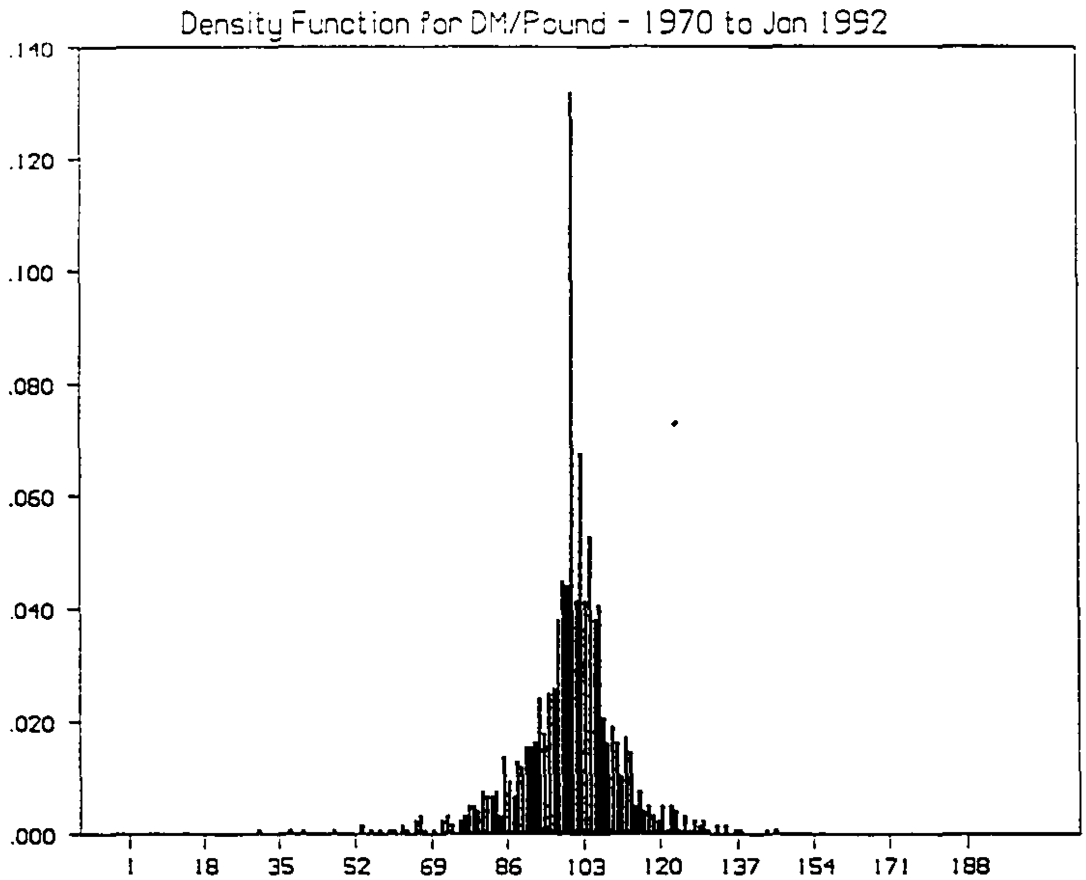

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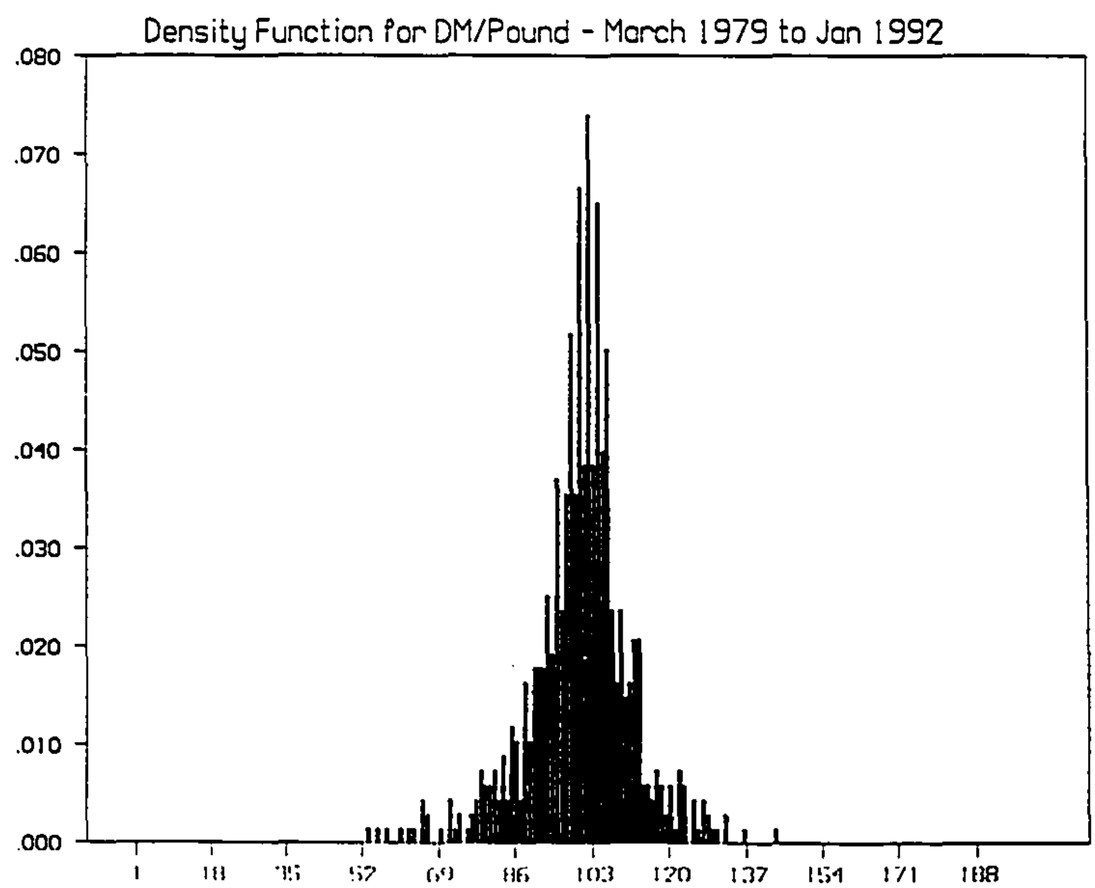

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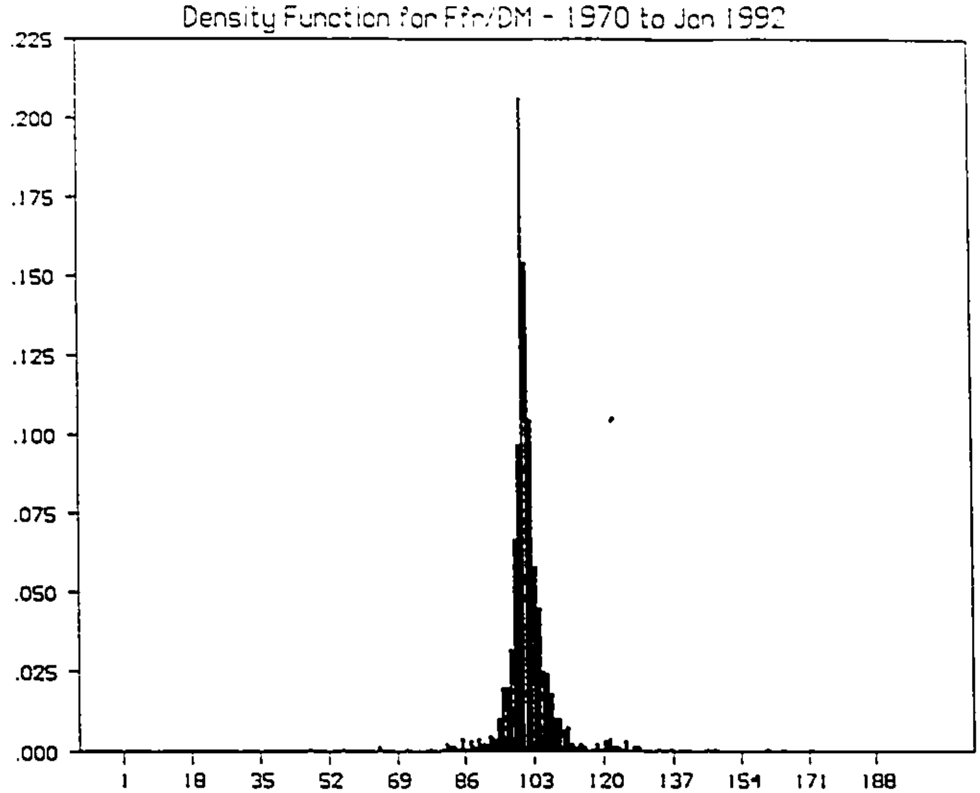

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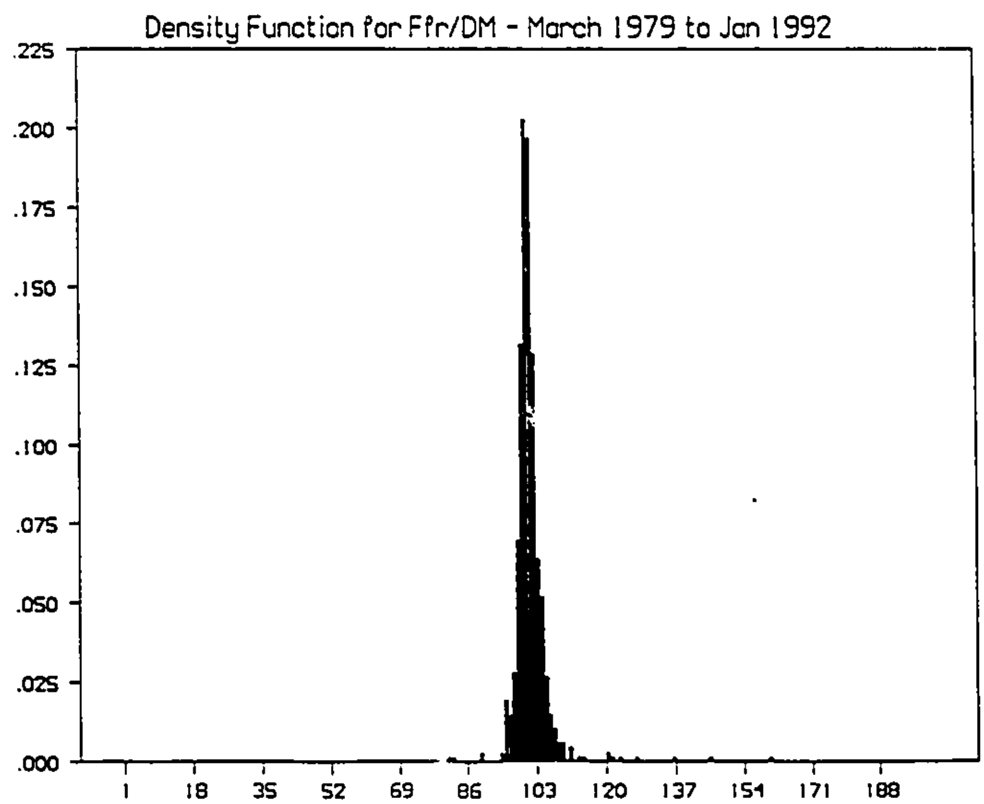

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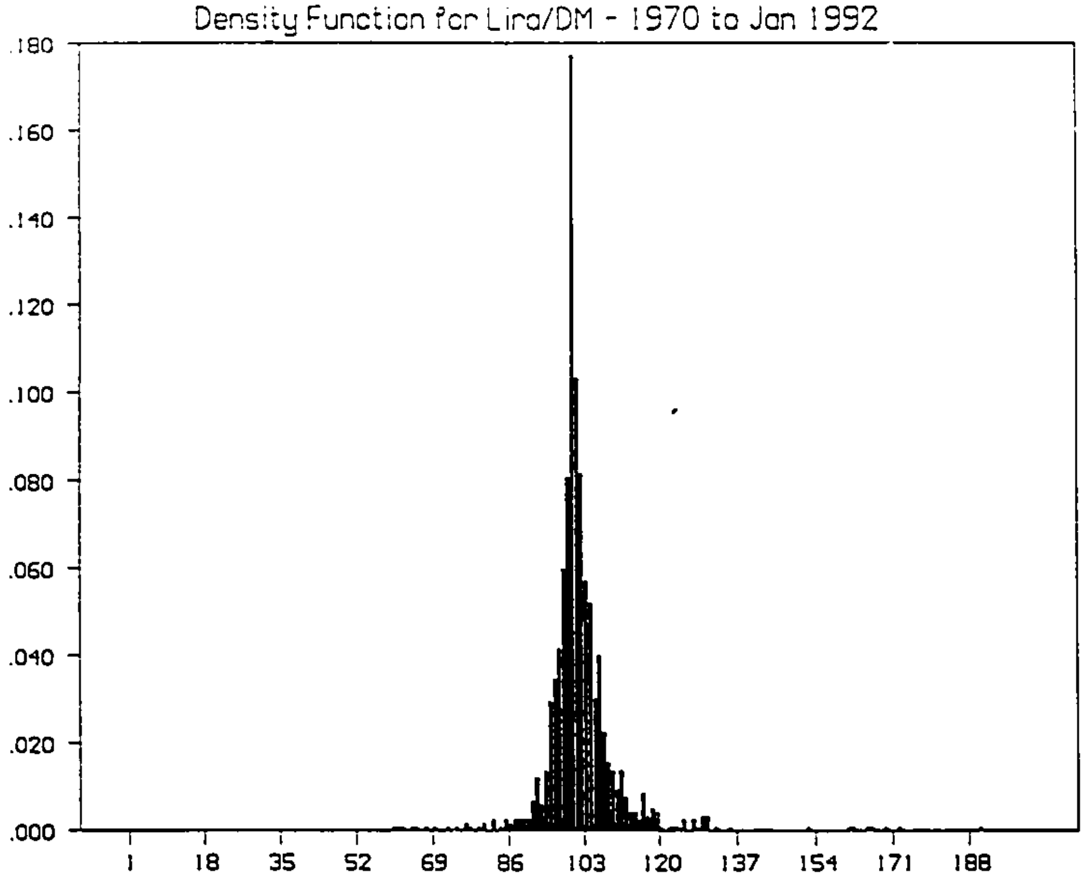

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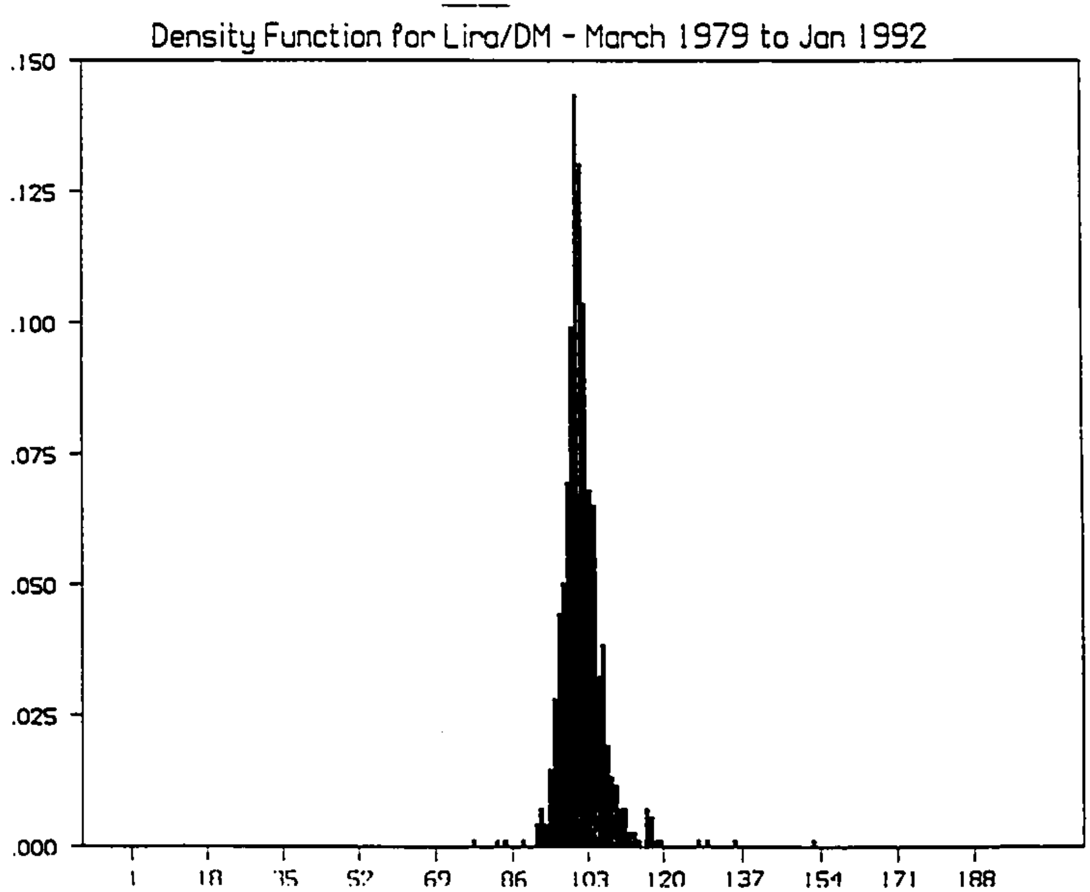

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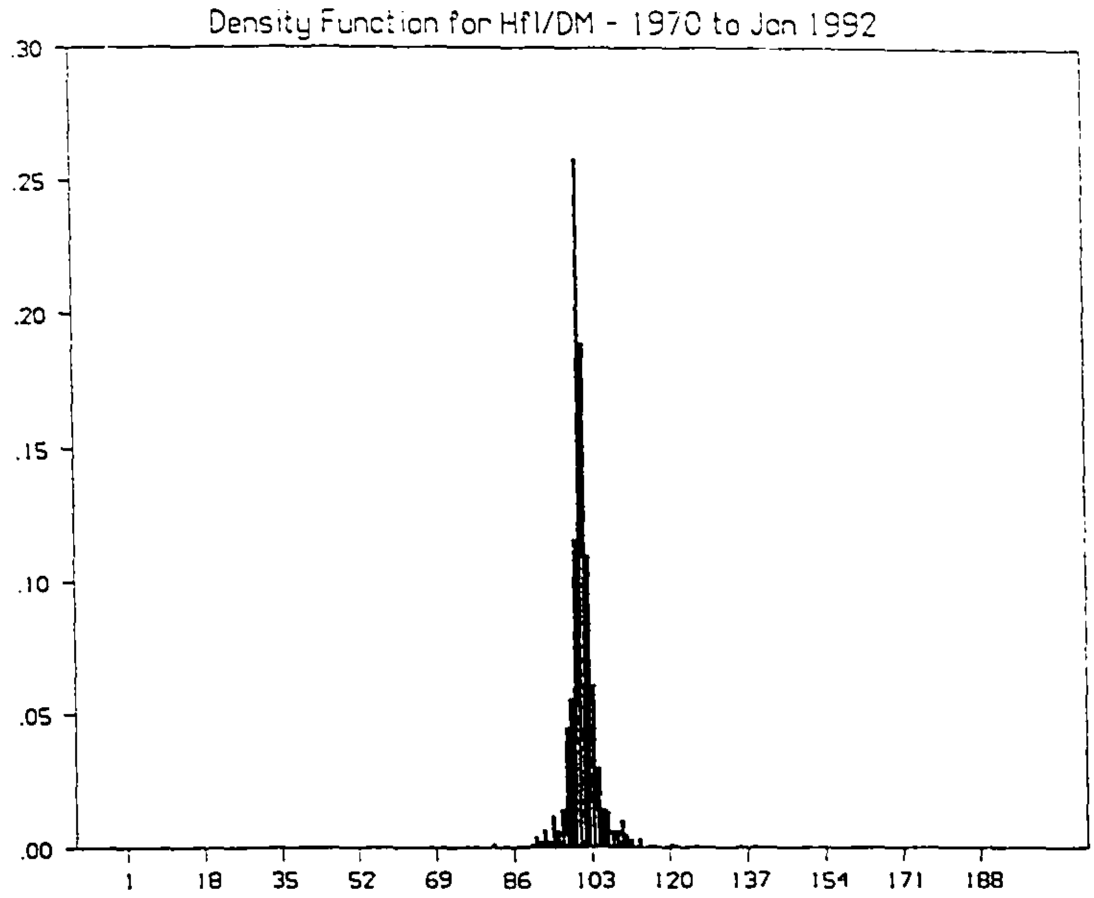

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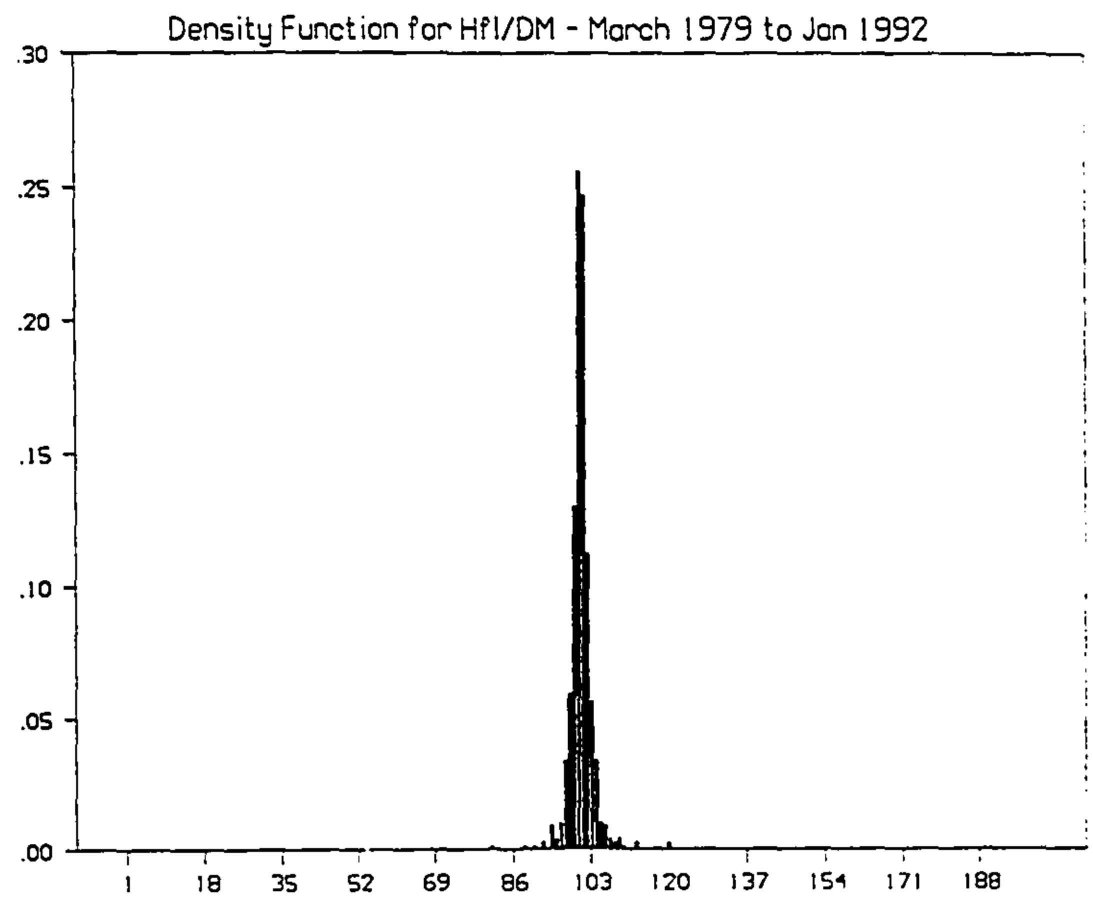

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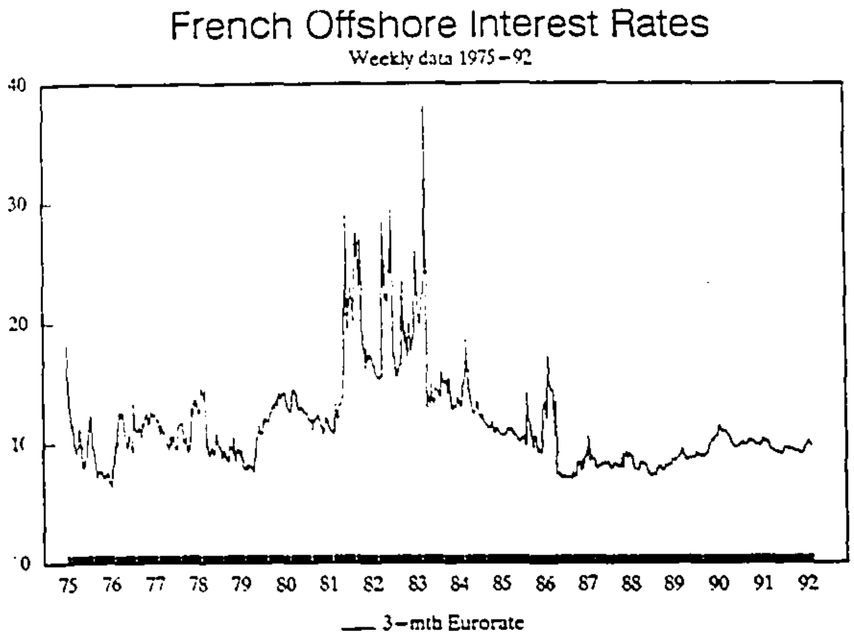

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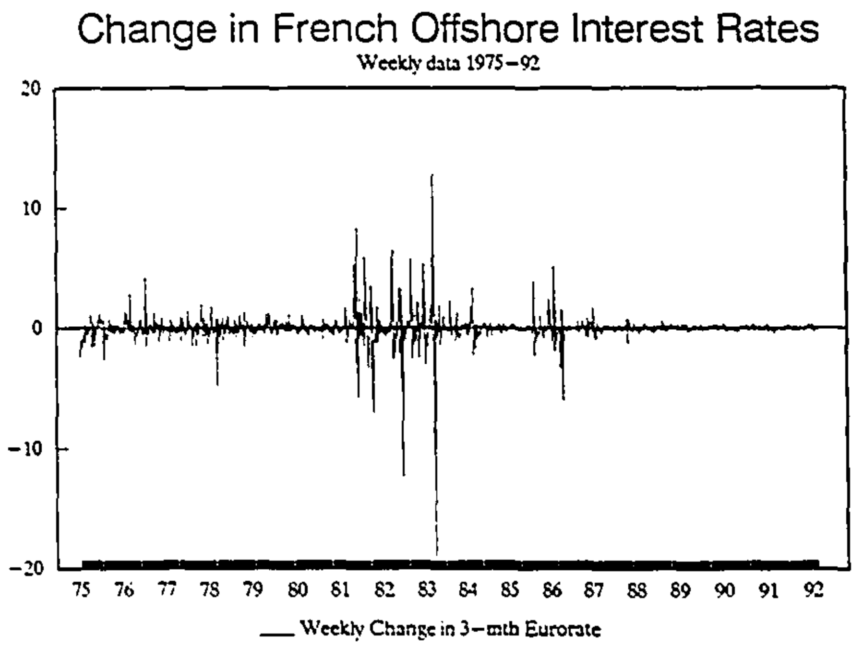

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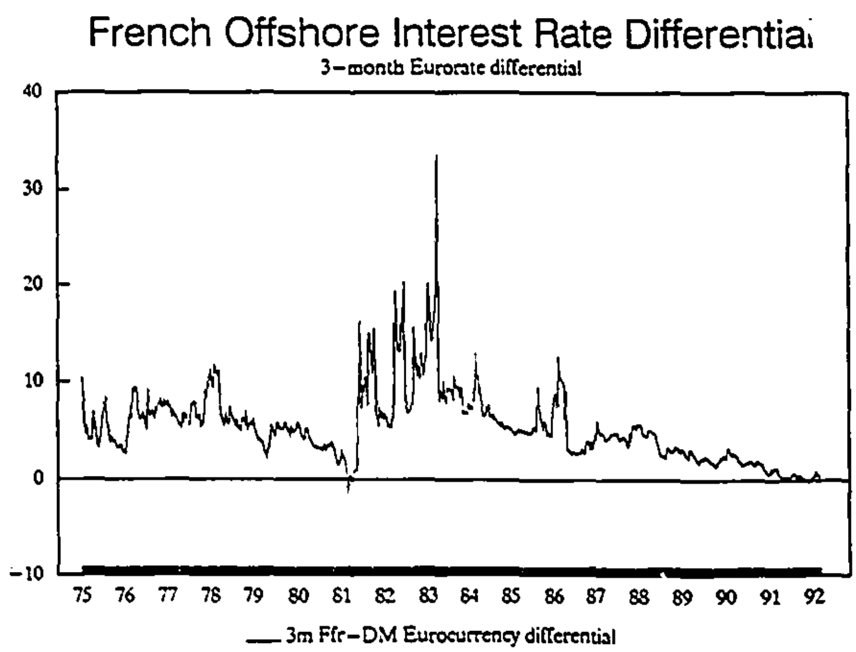

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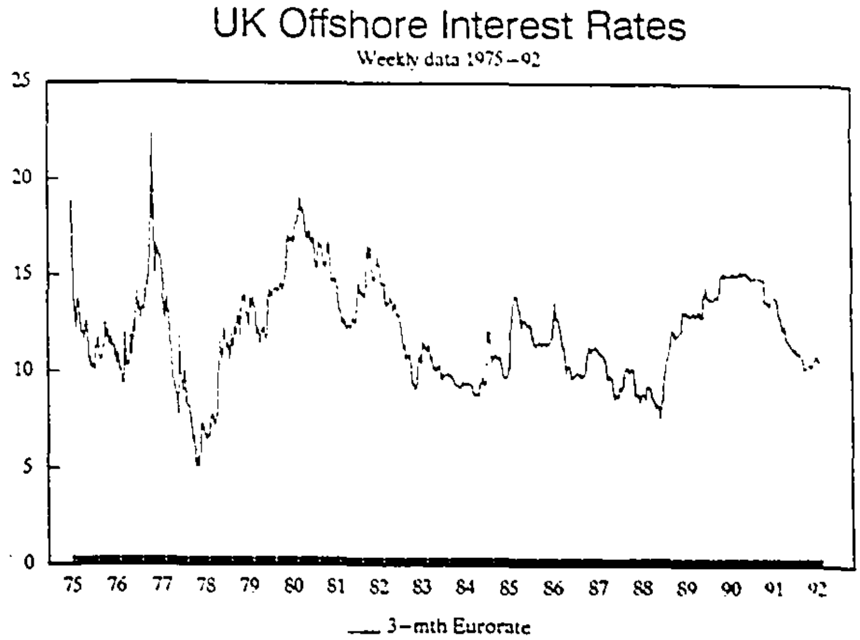

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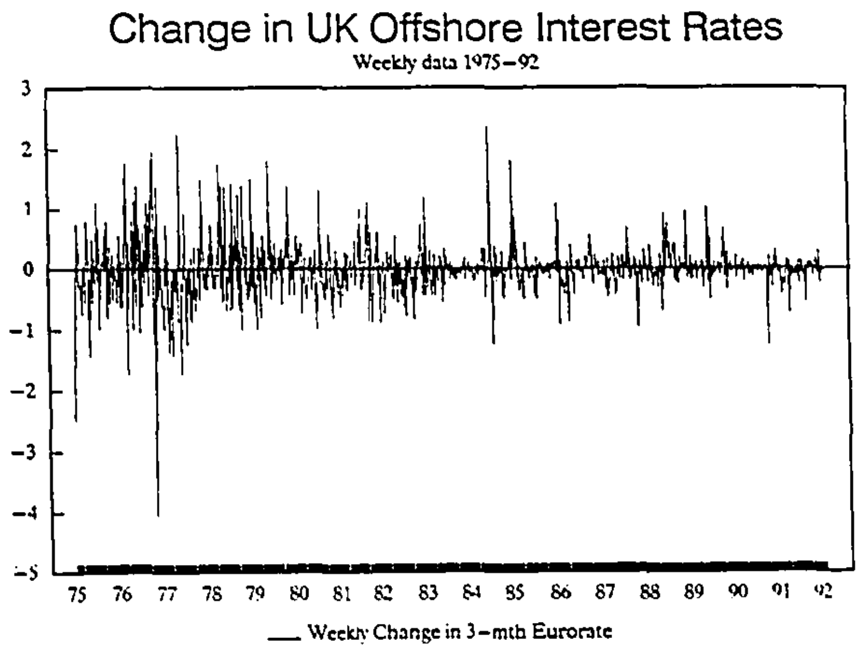

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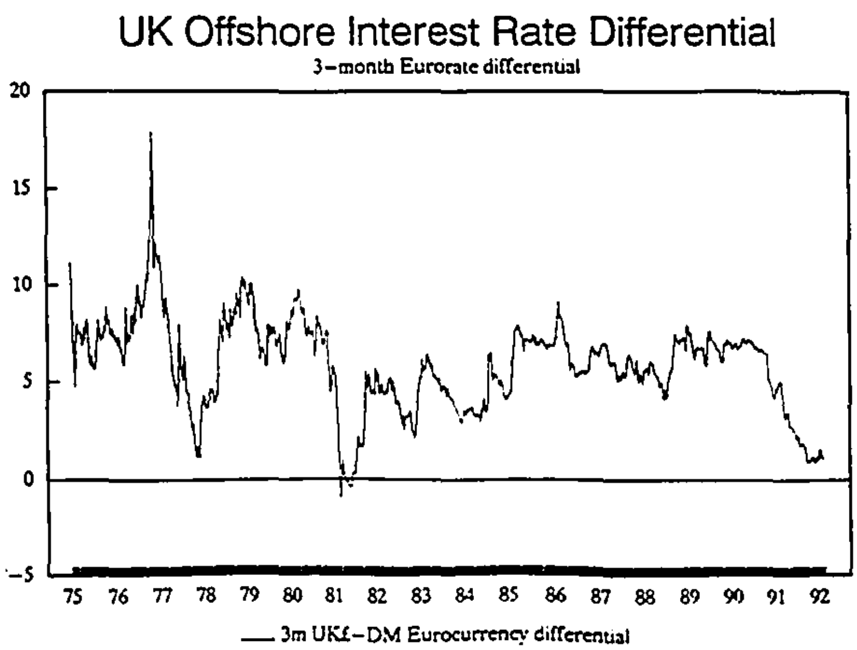

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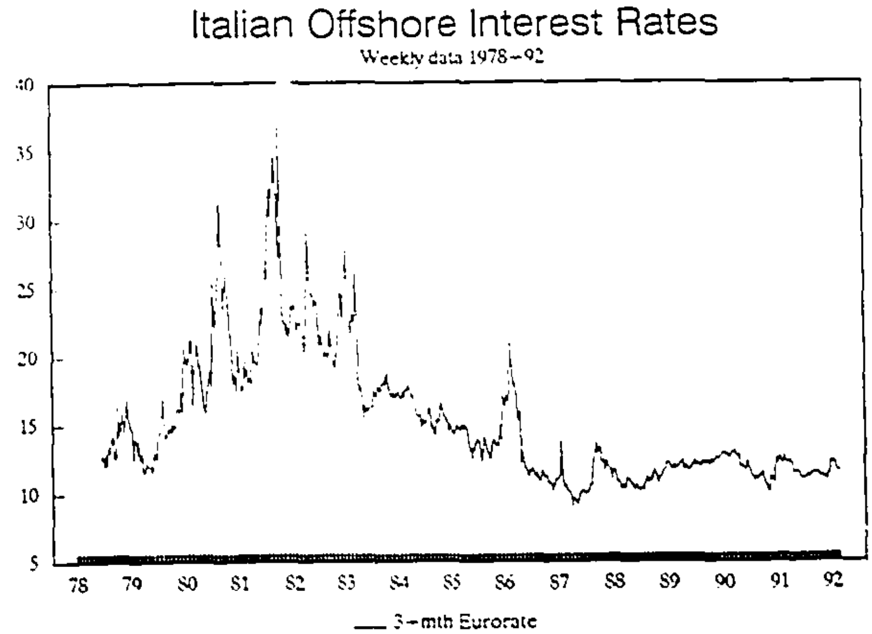

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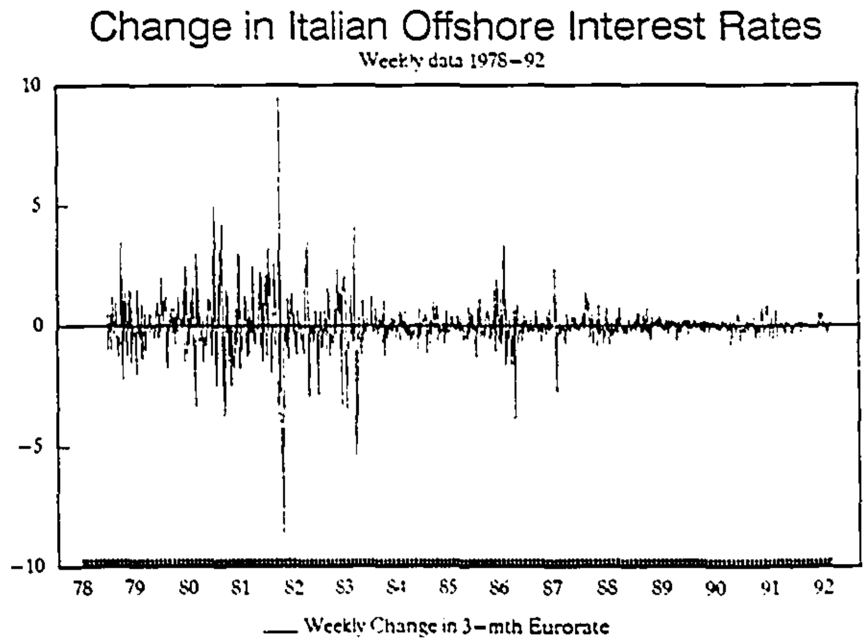

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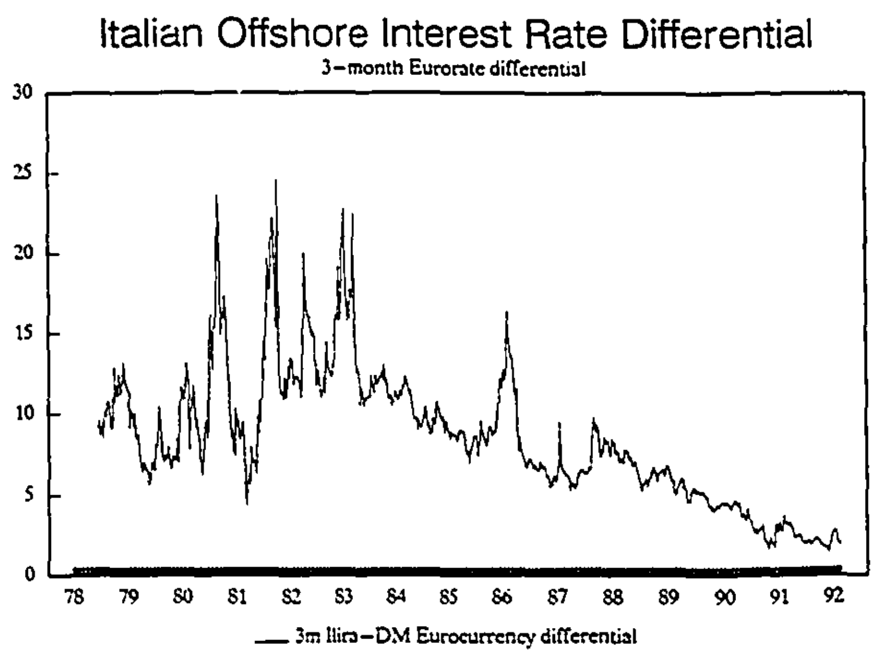

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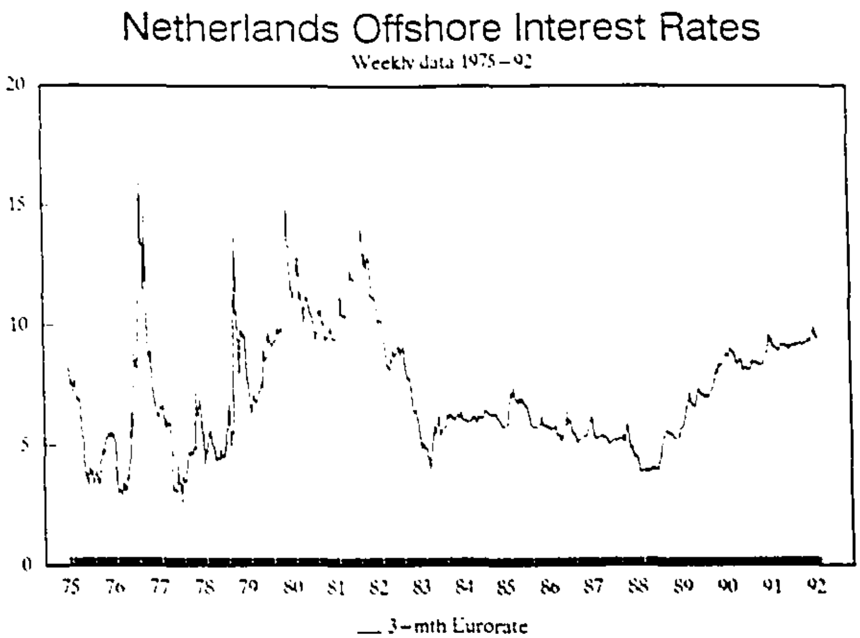

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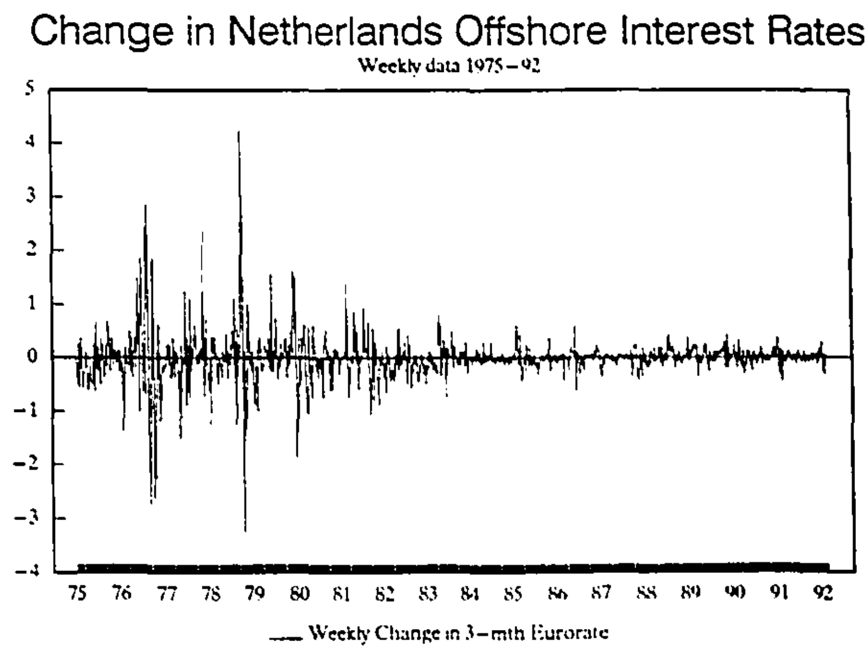

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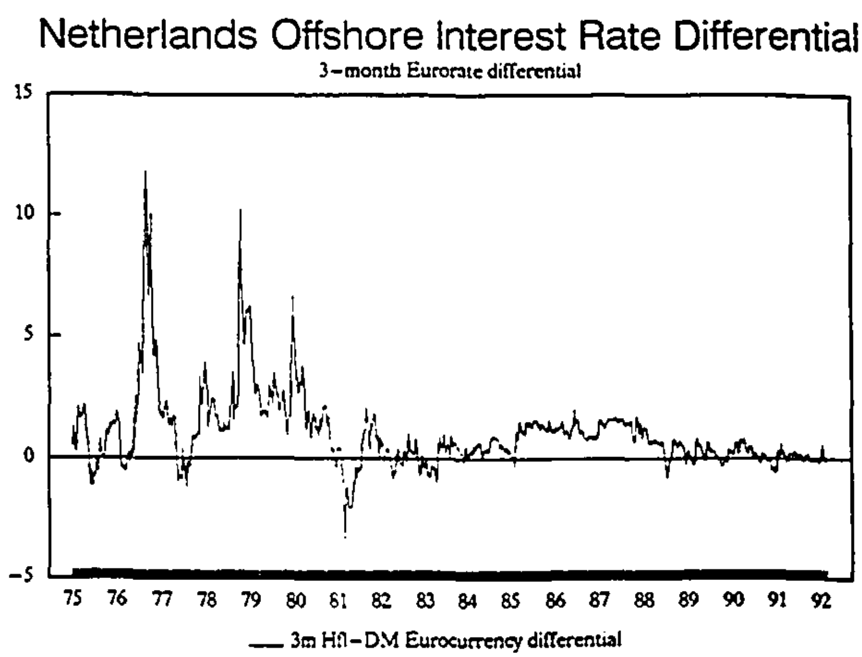

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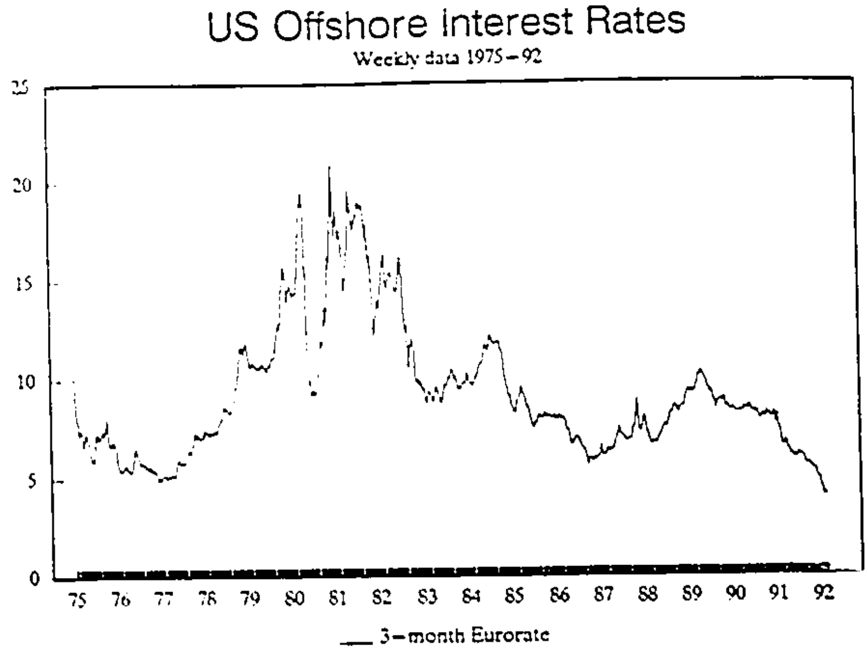

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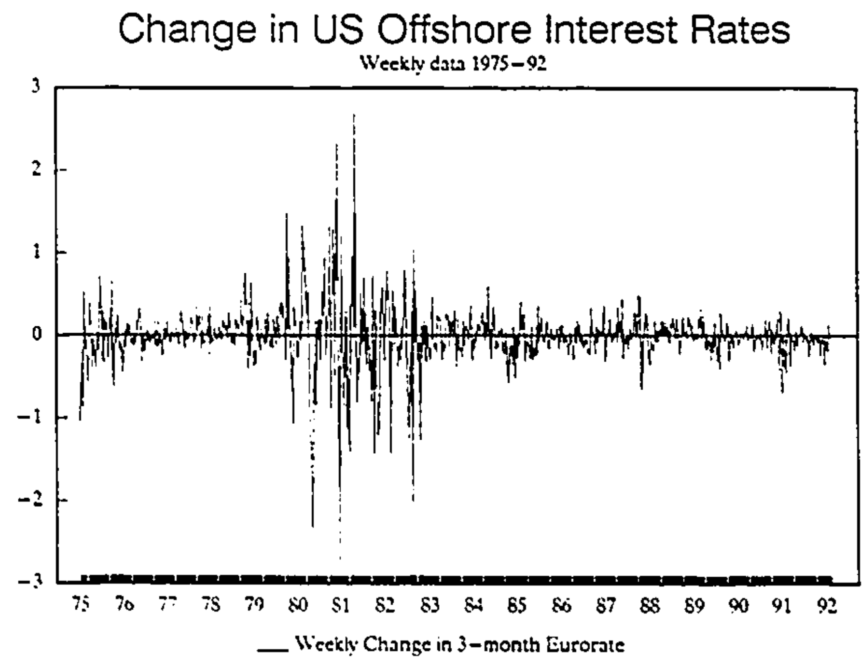

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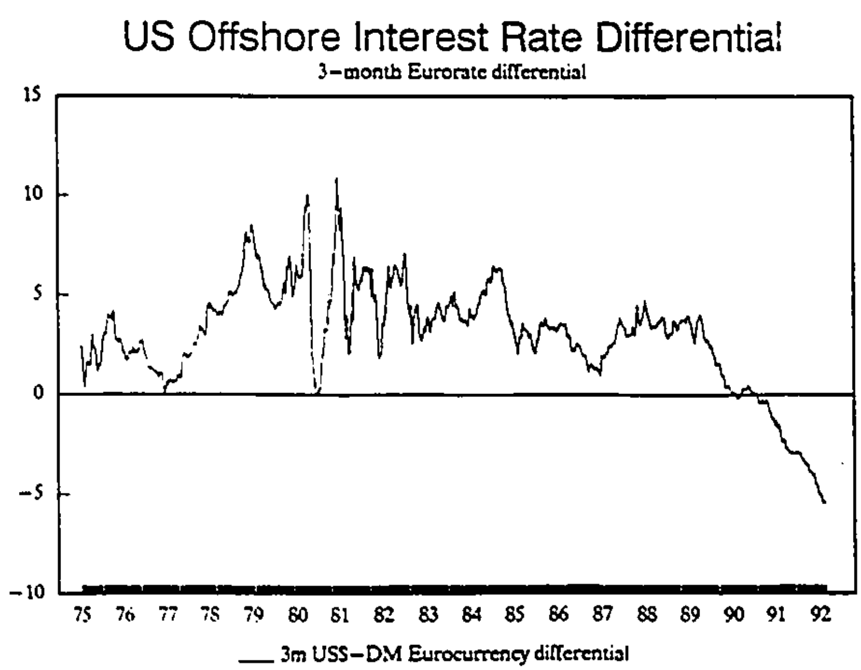

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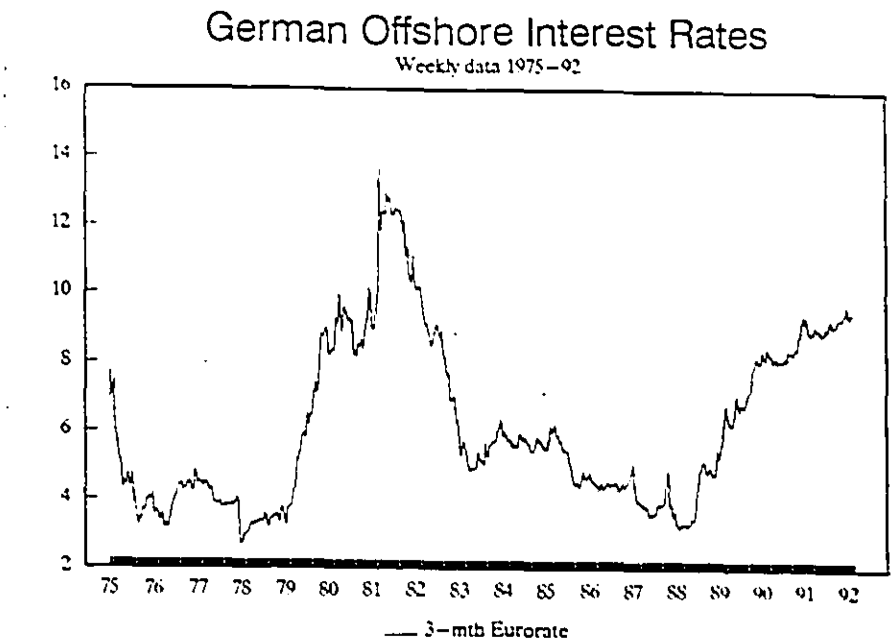

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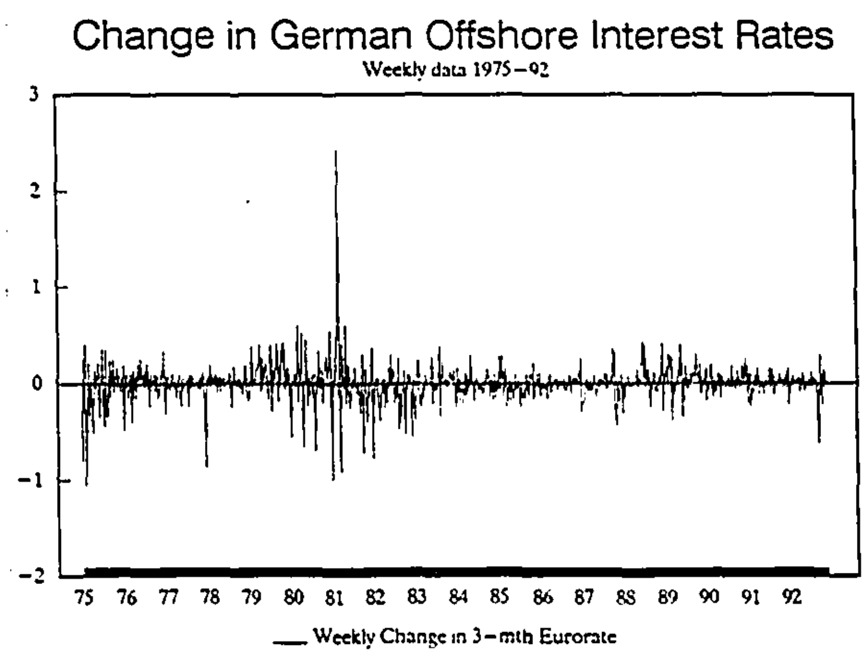

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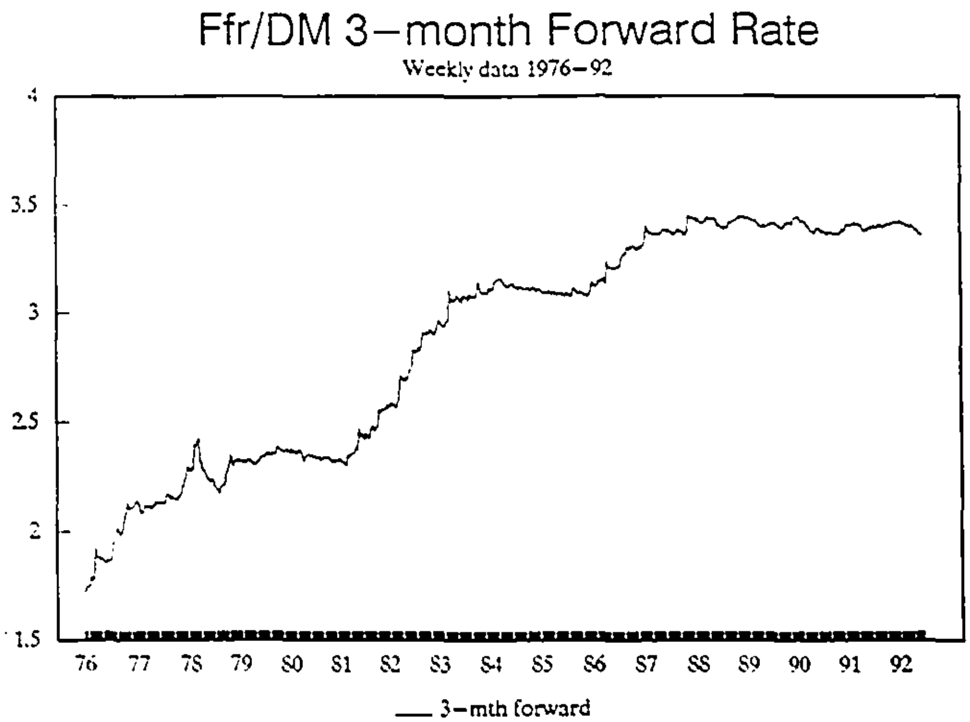

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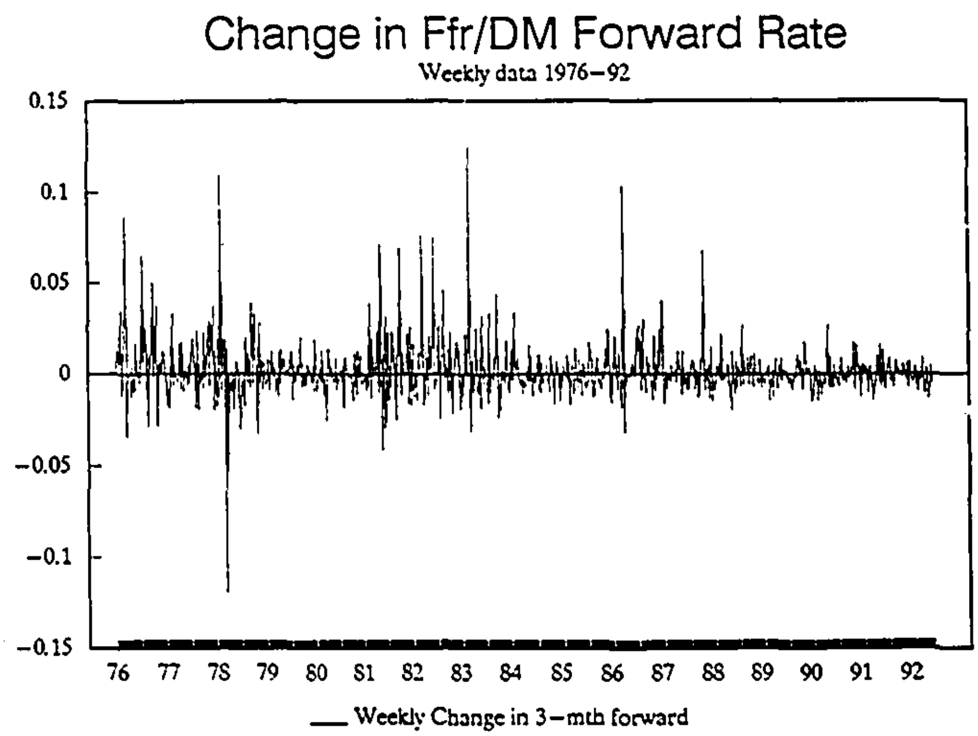

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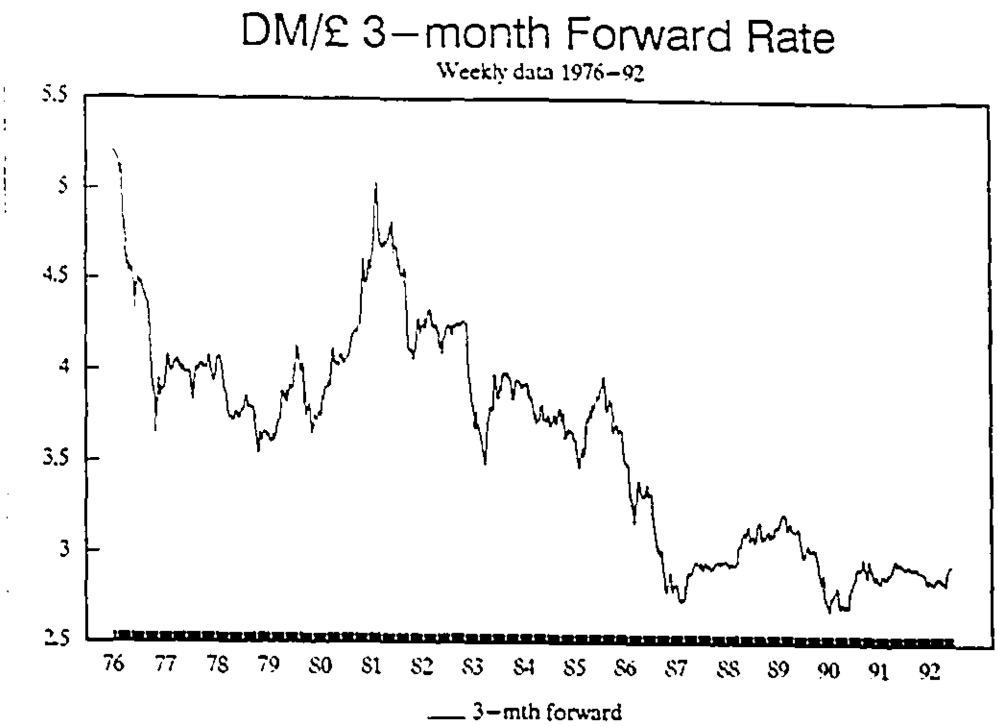

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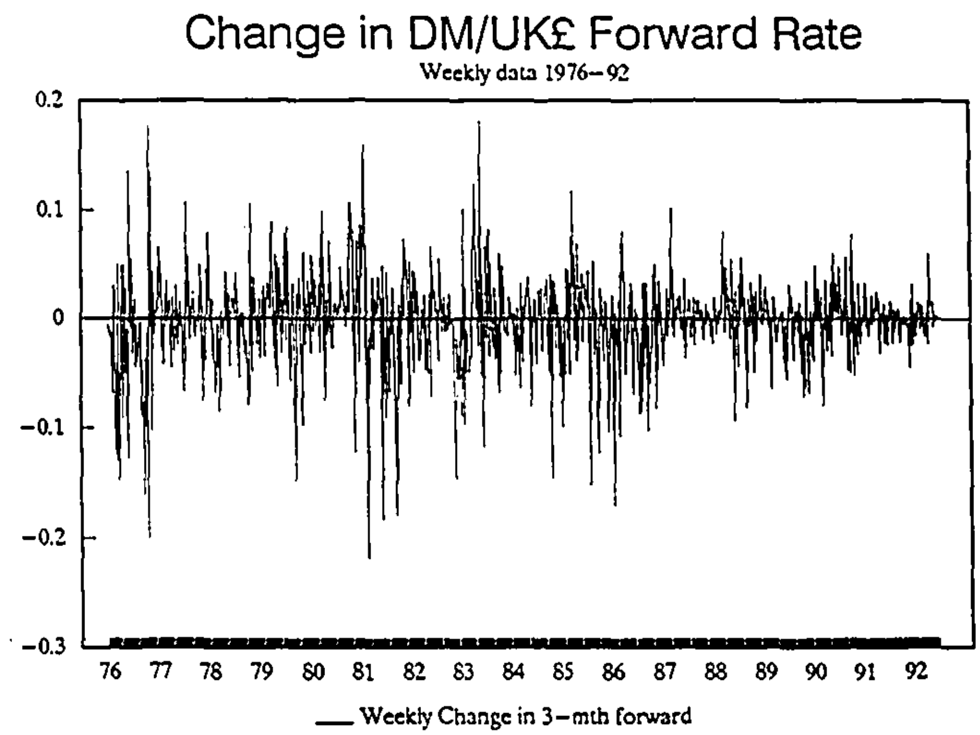

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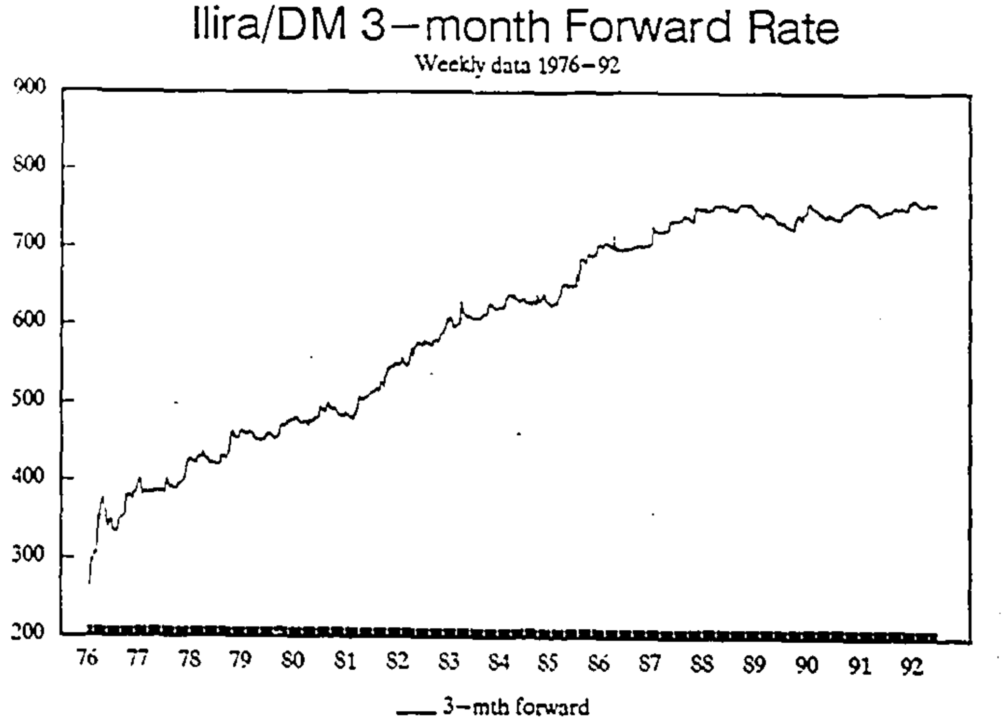

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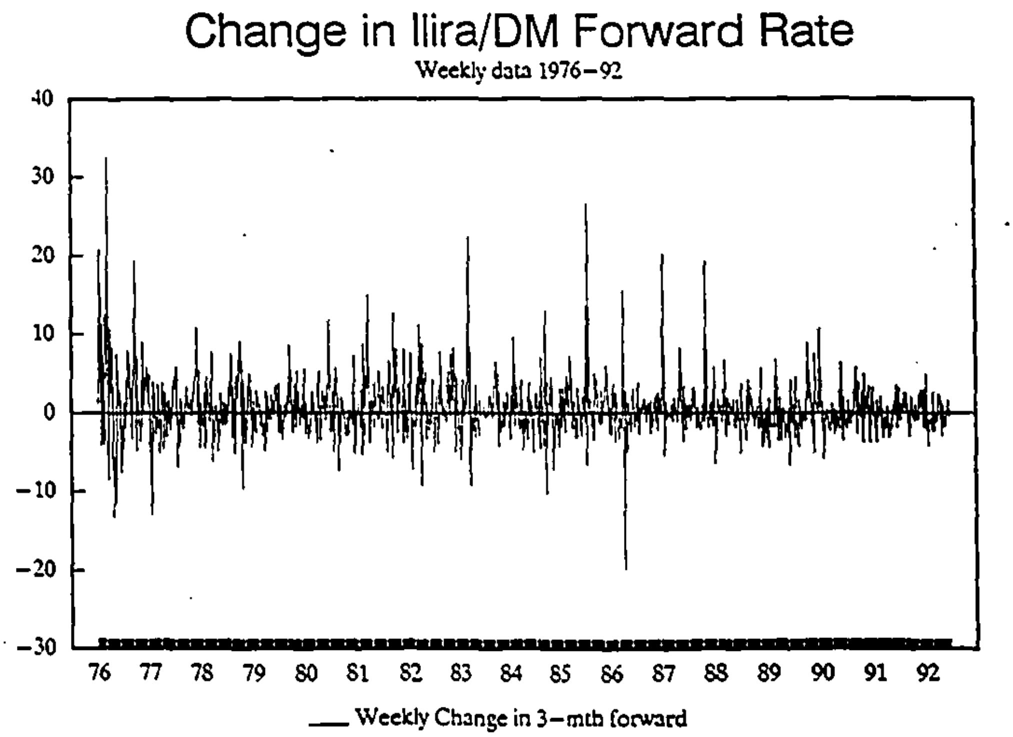

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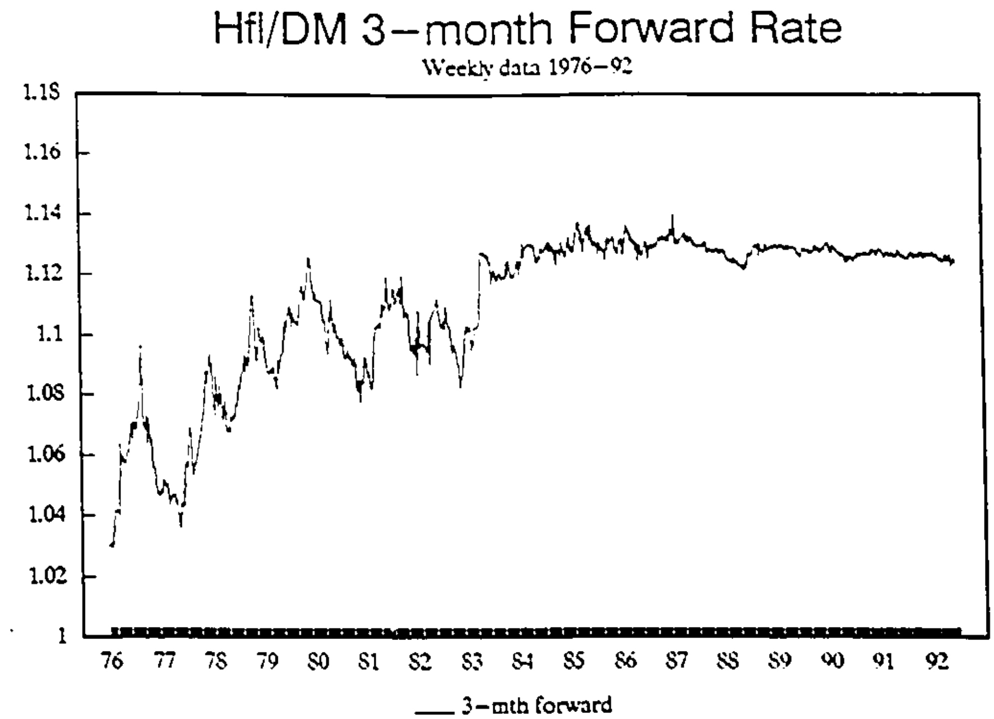

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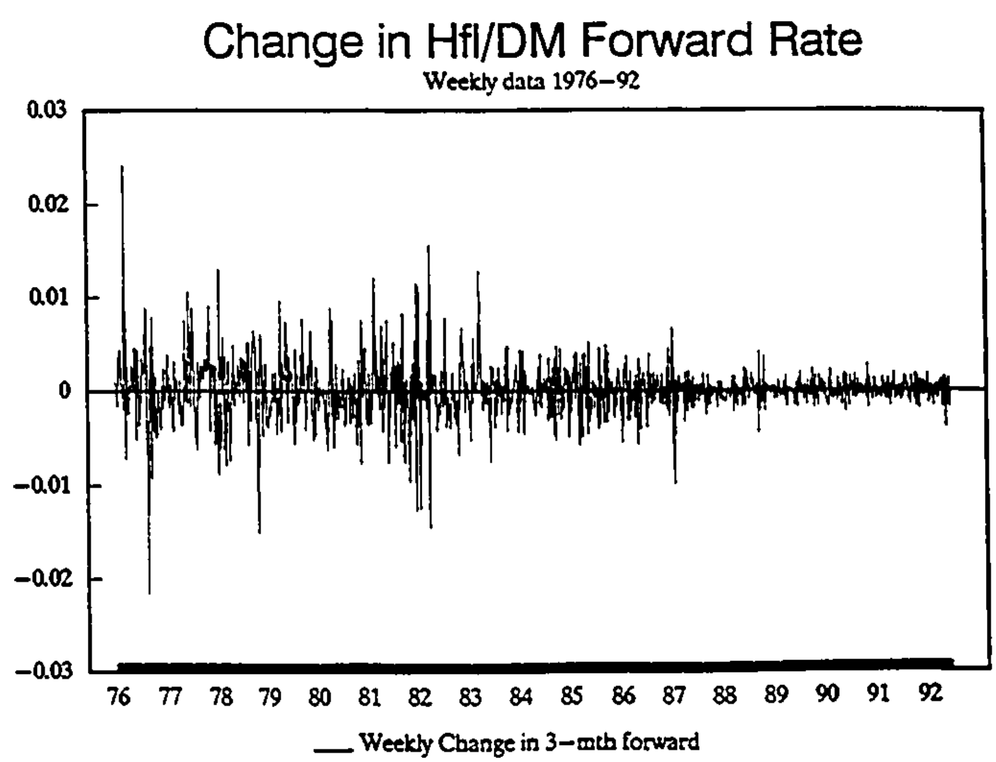

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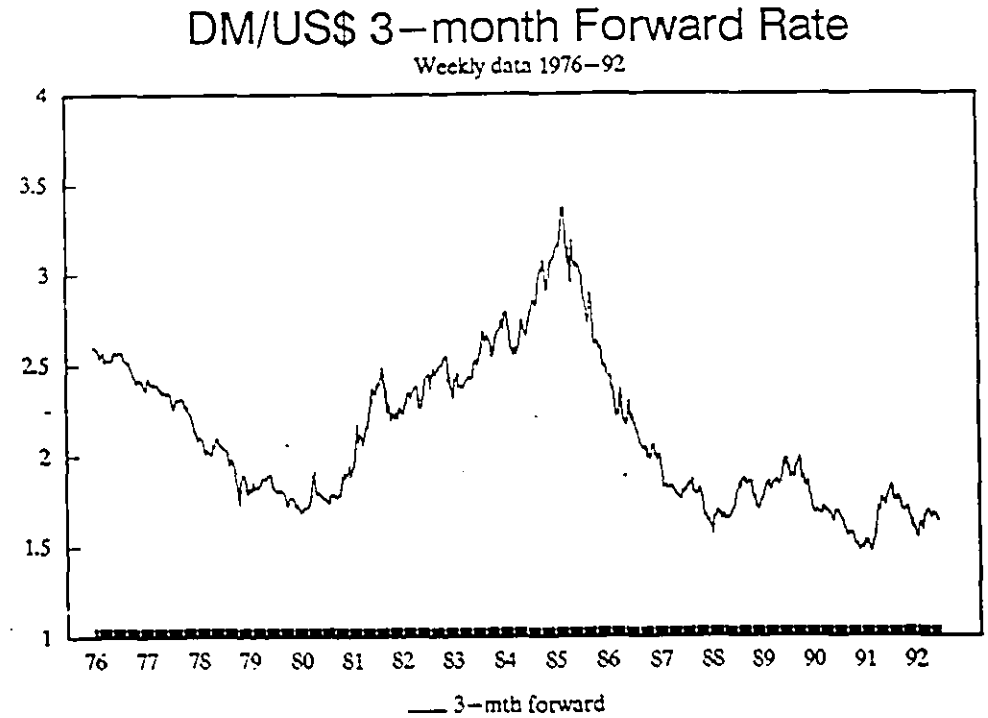

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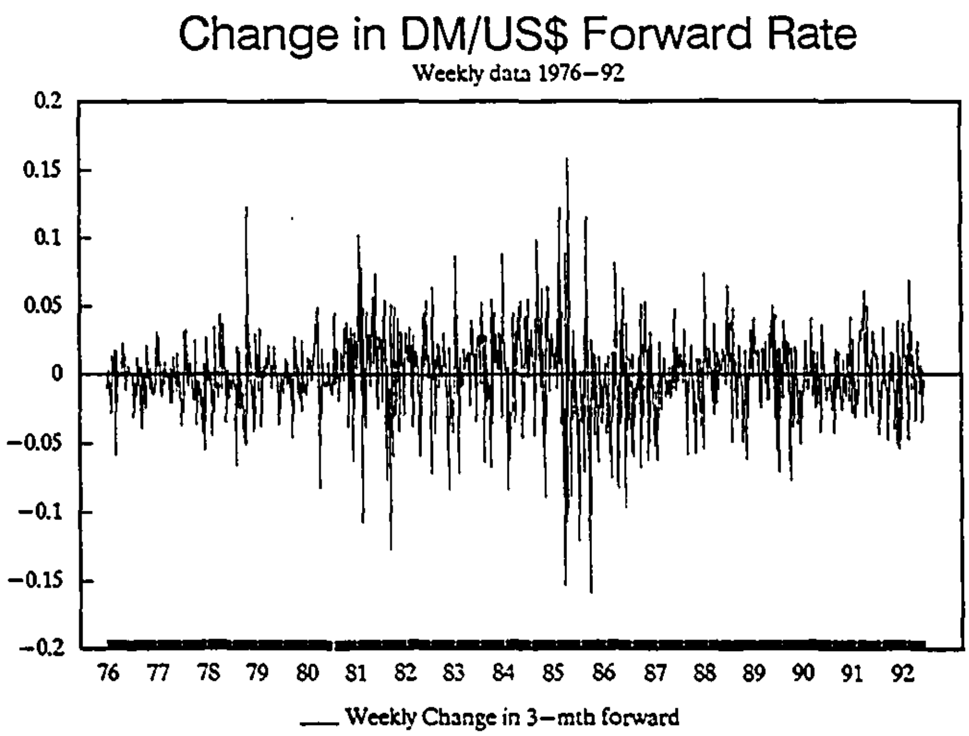

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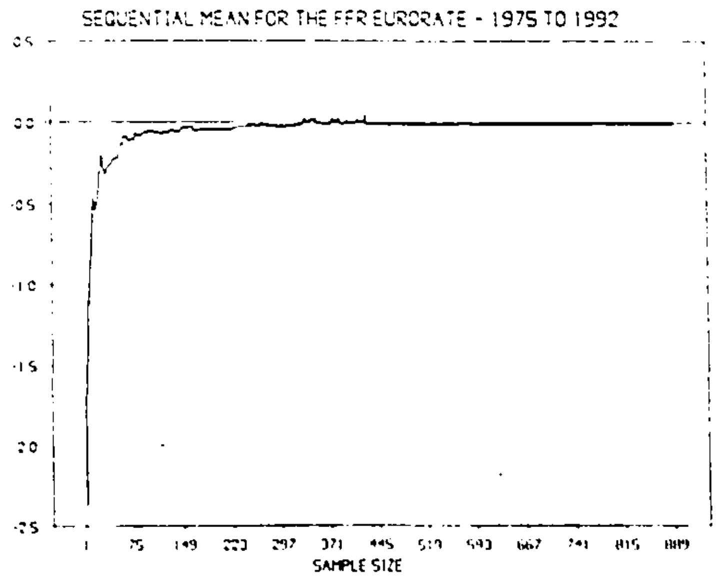

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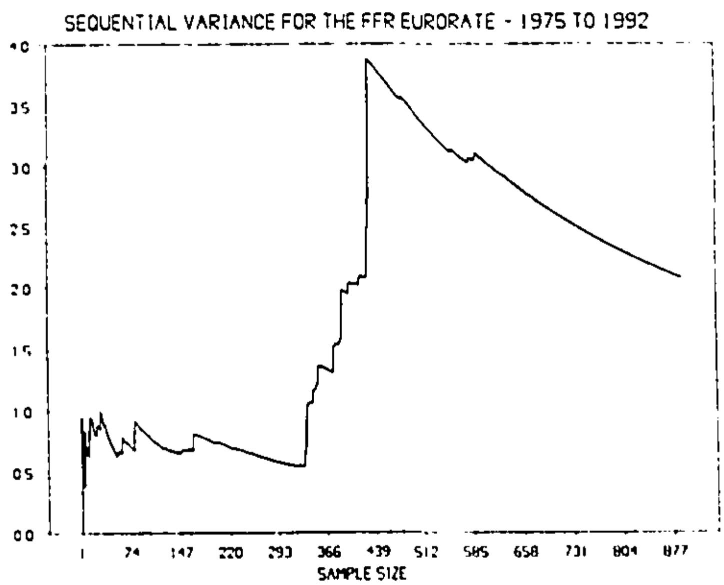

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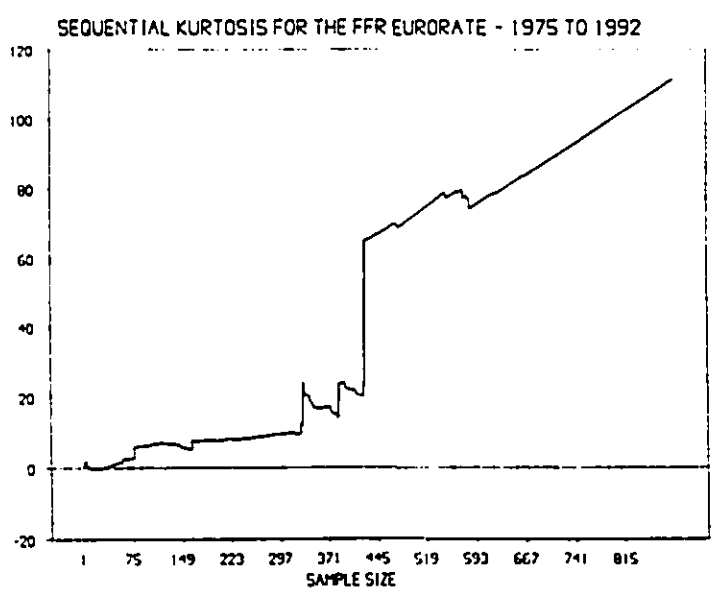

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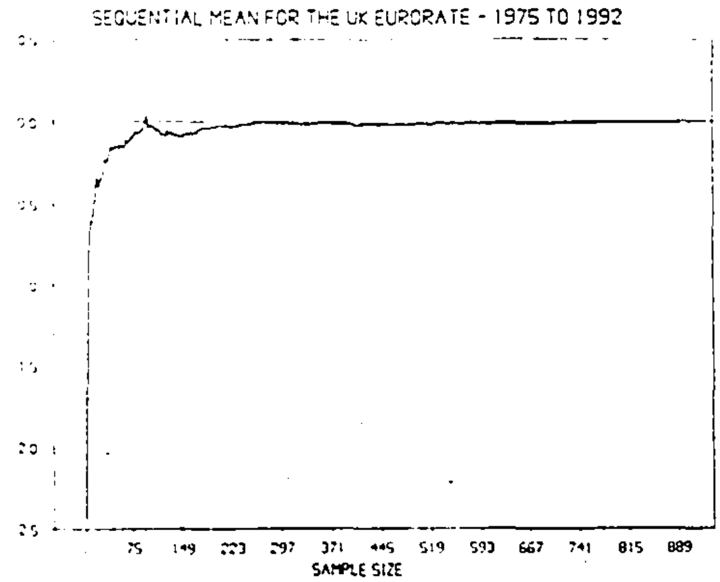

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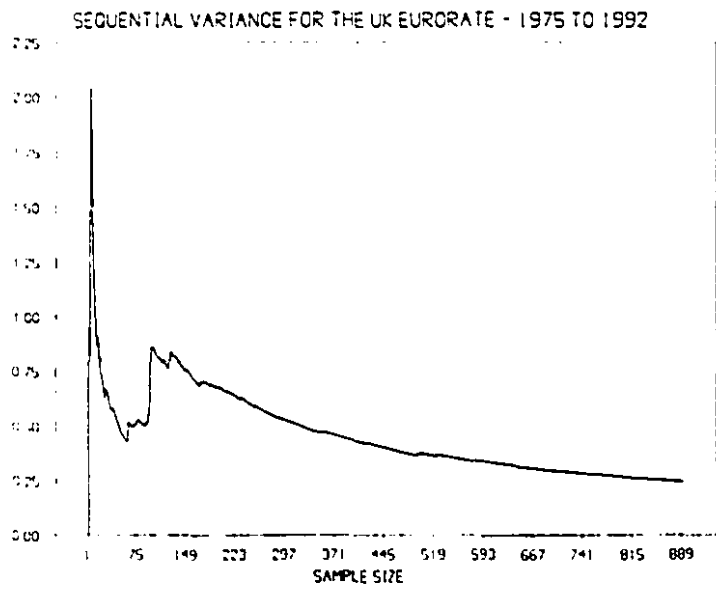

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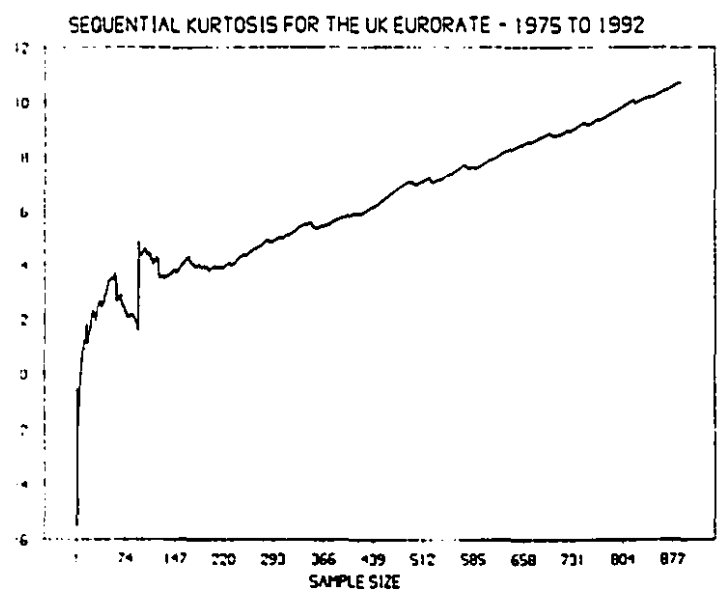

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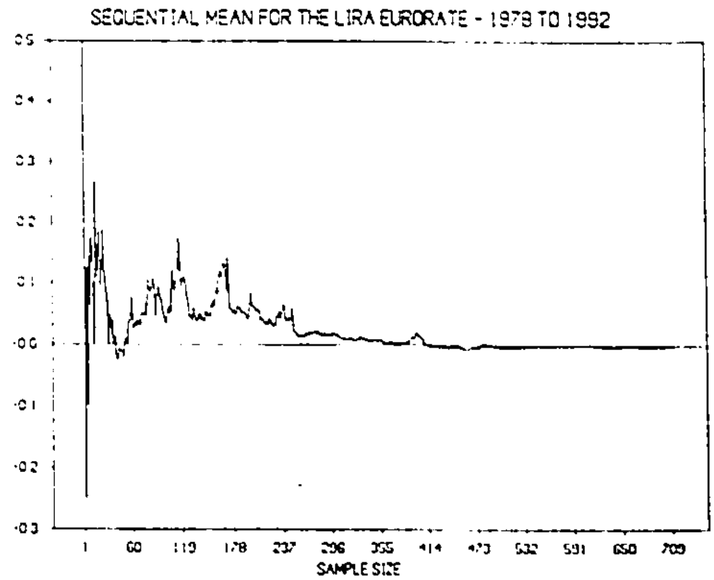

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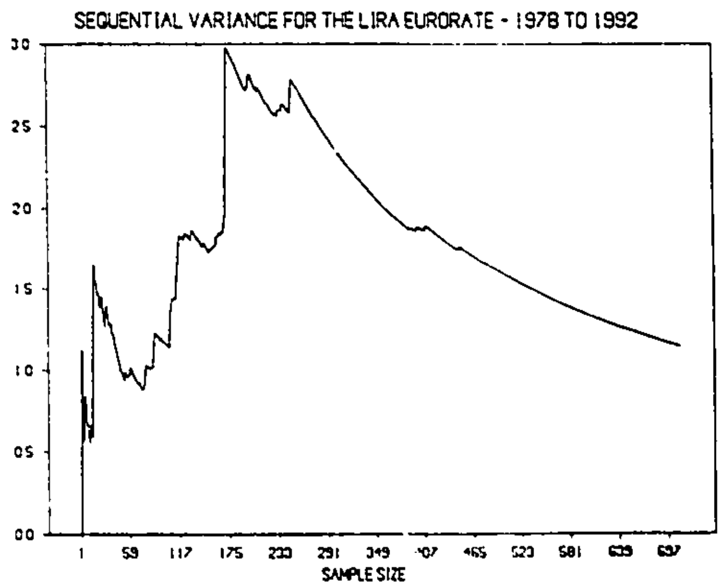

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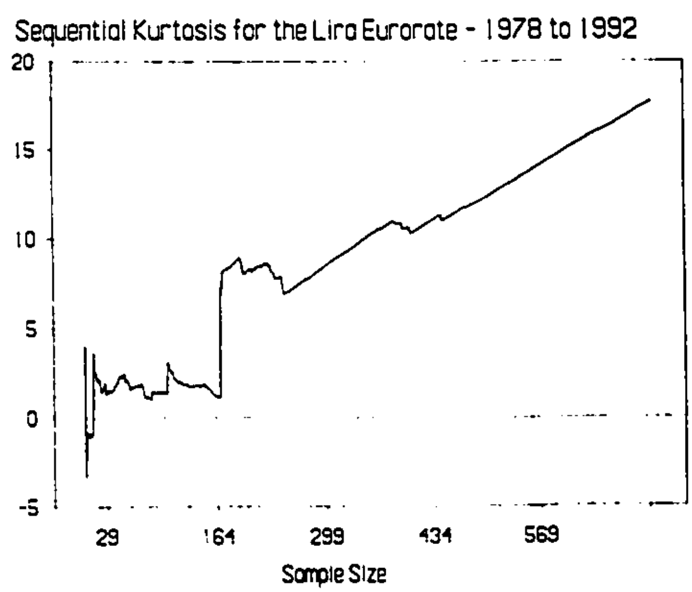

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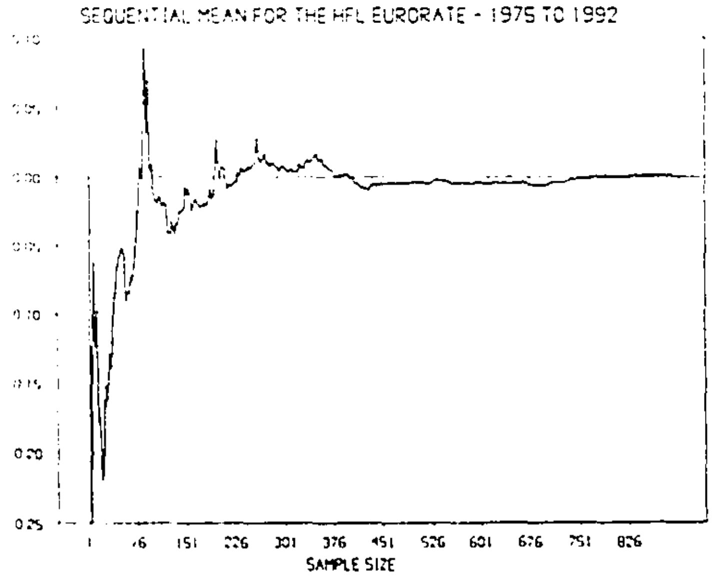

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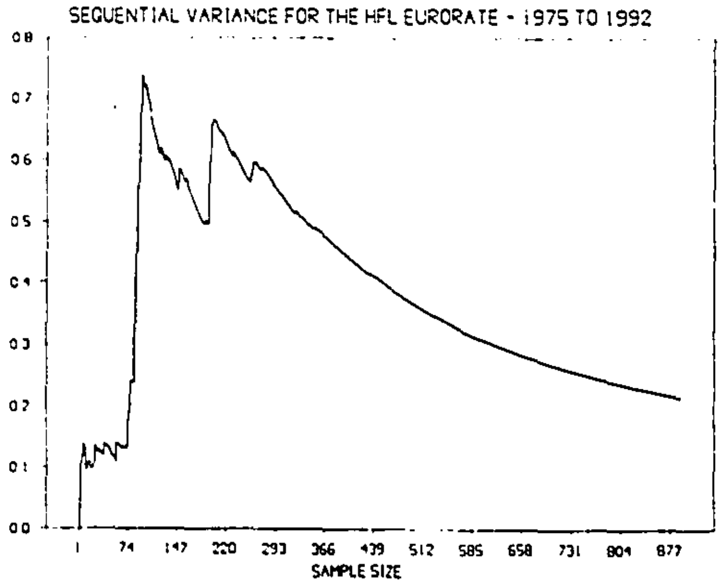

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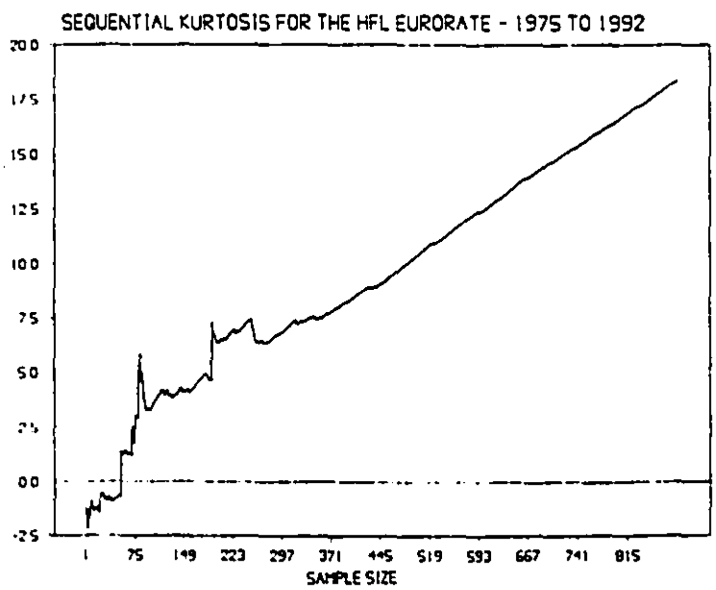

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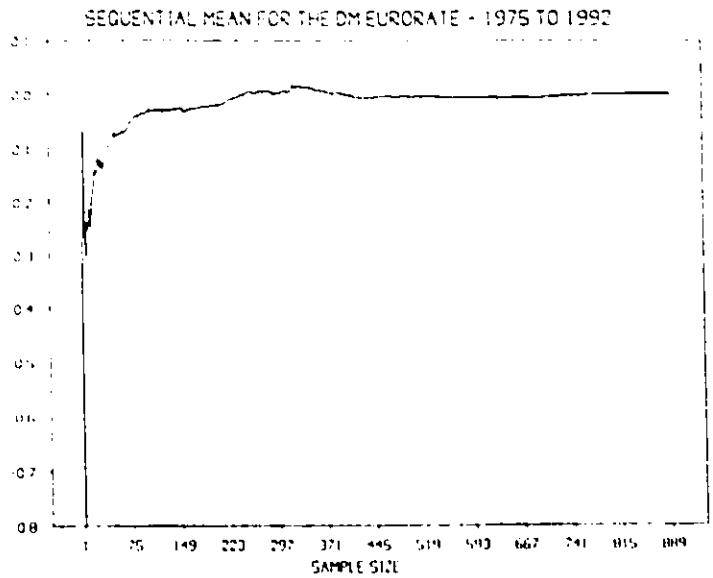

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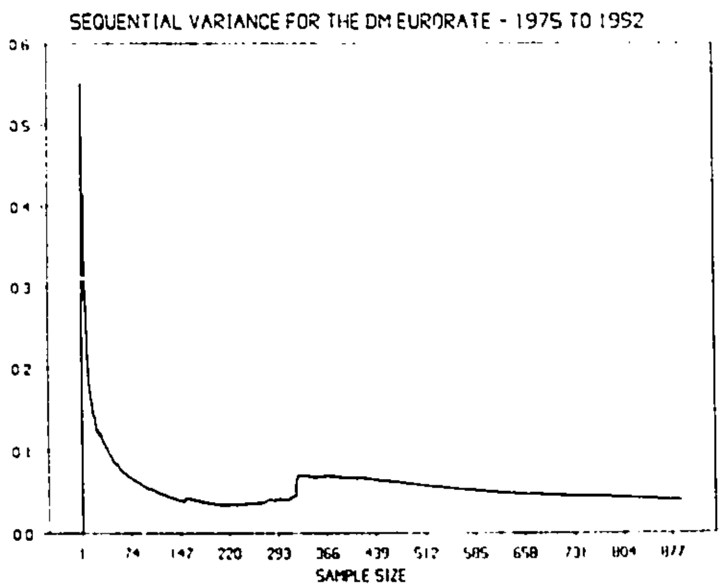

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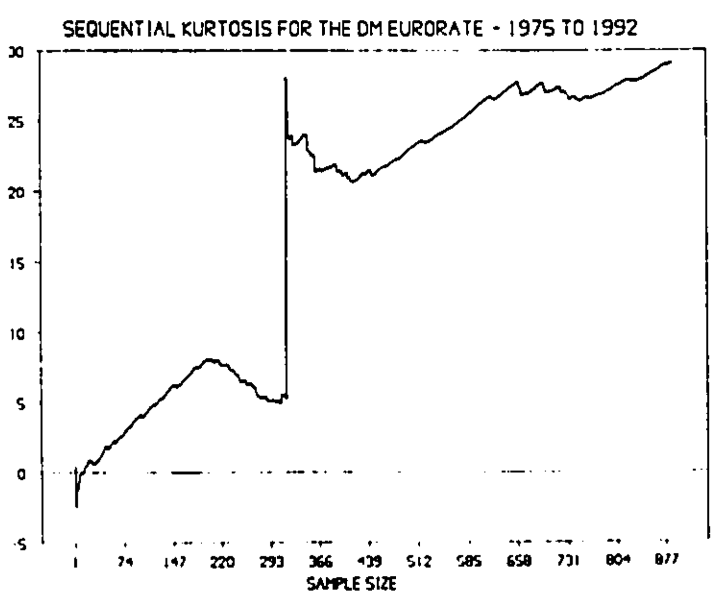


Figure 3.17a

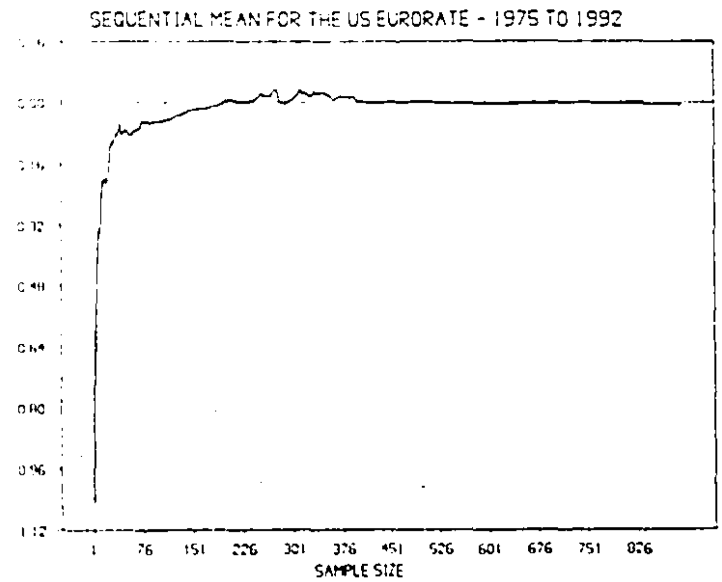


Figure 3.17b

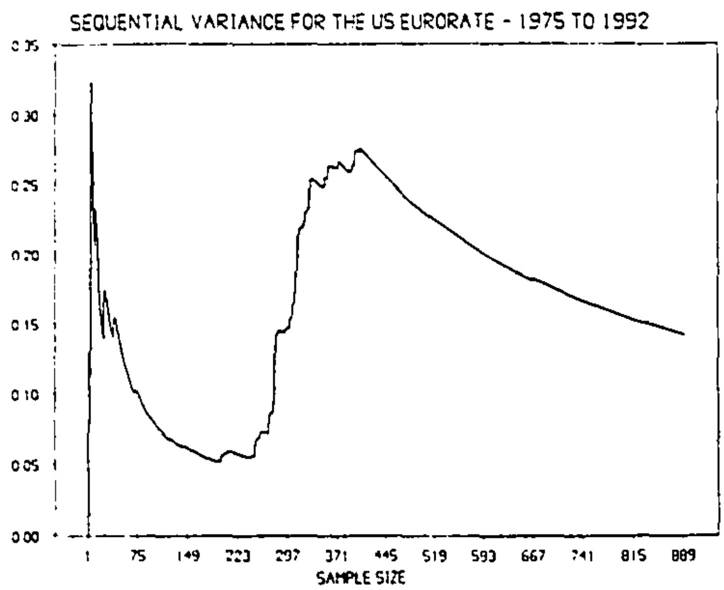


Figure 3.17c

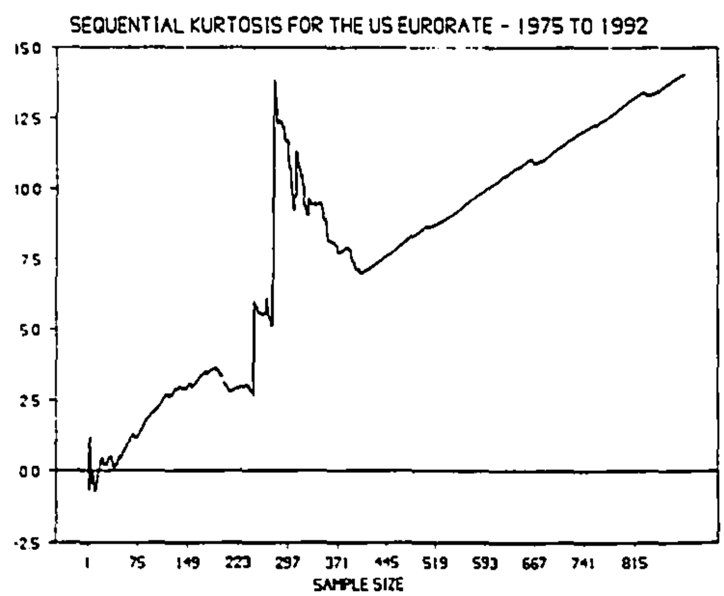


Figure 3.18a

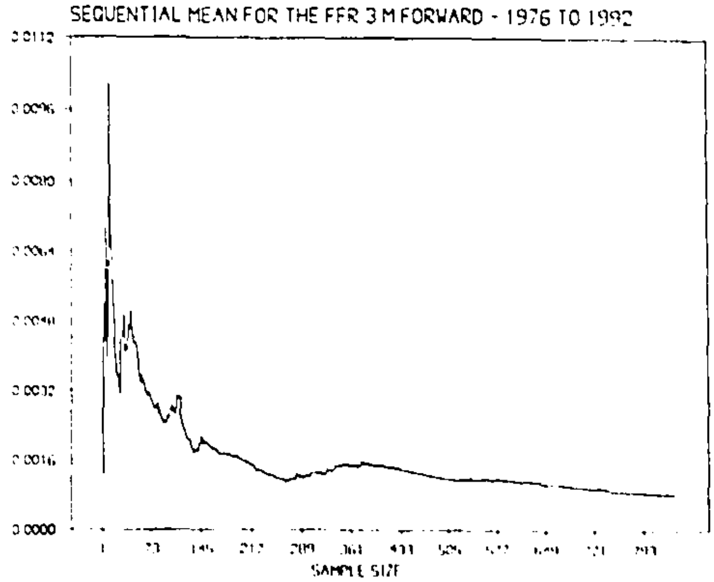
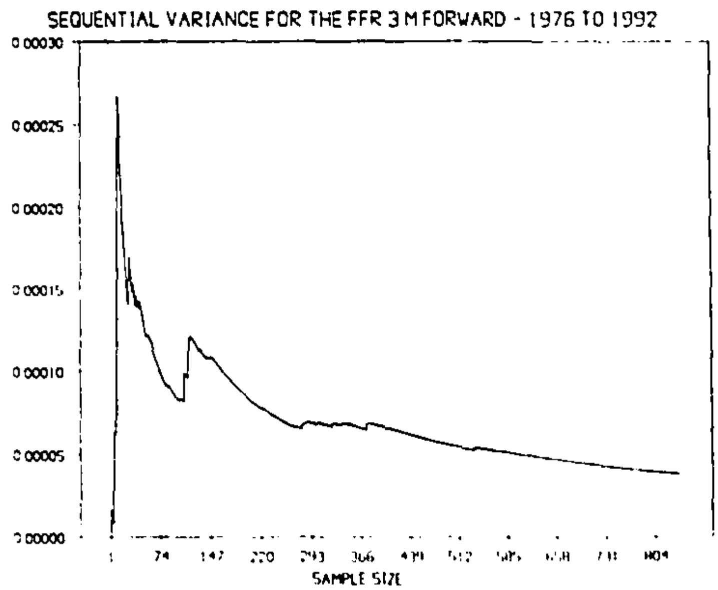


Figure 3.18b



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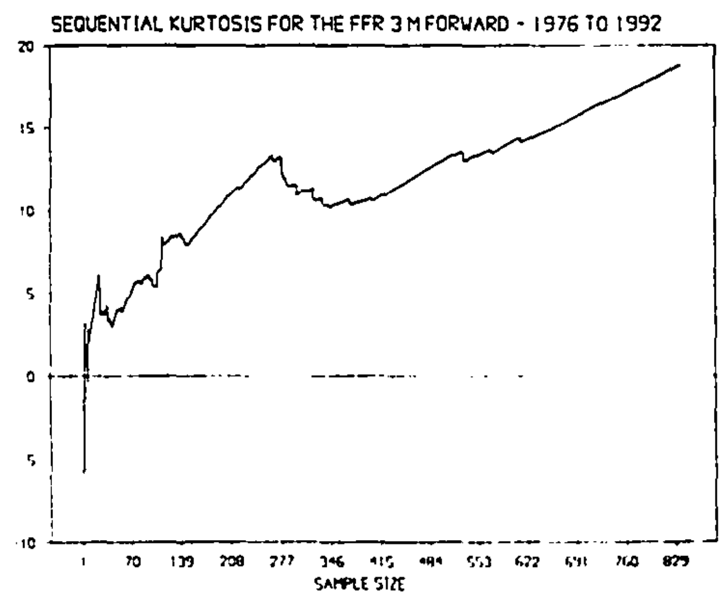

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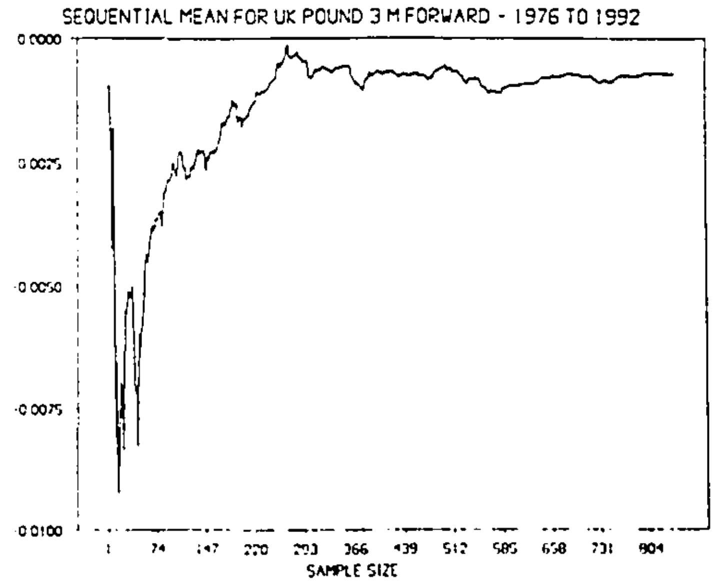

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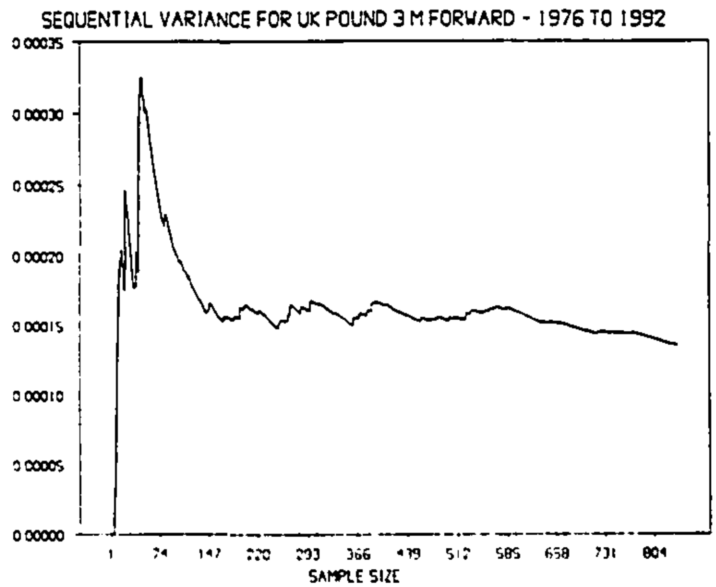

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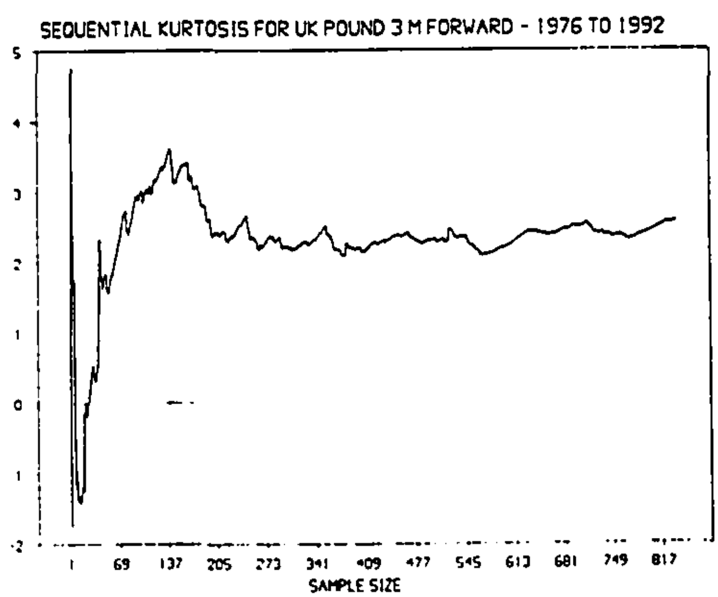

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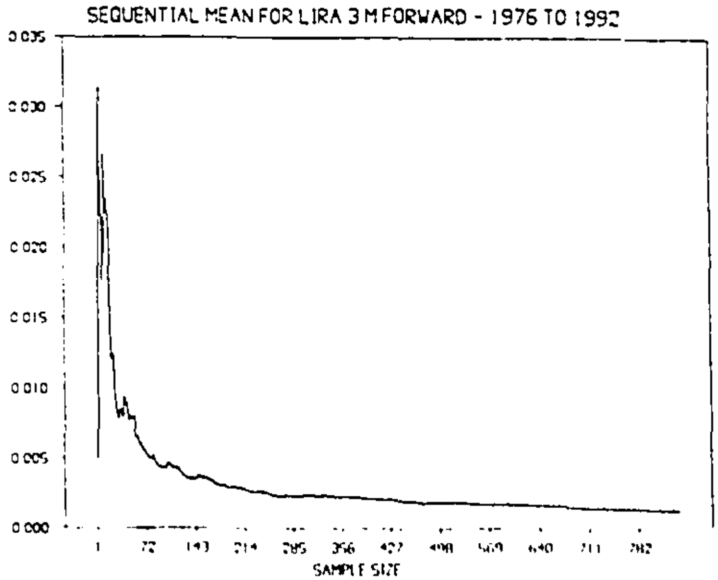

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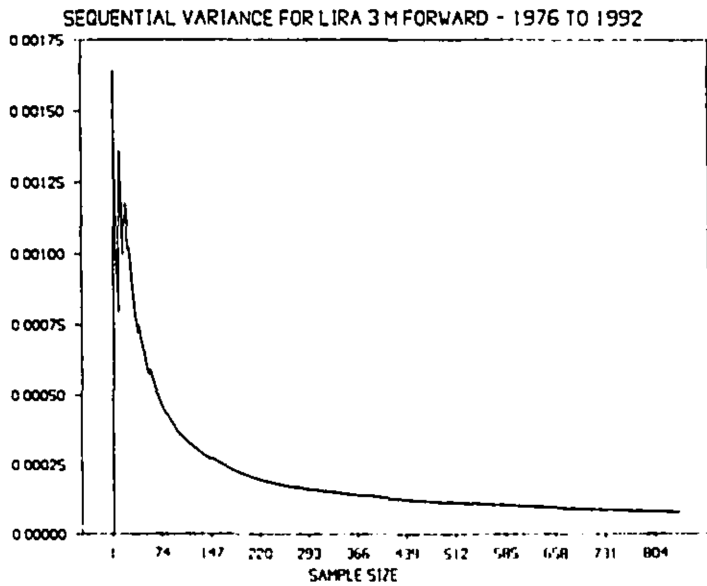

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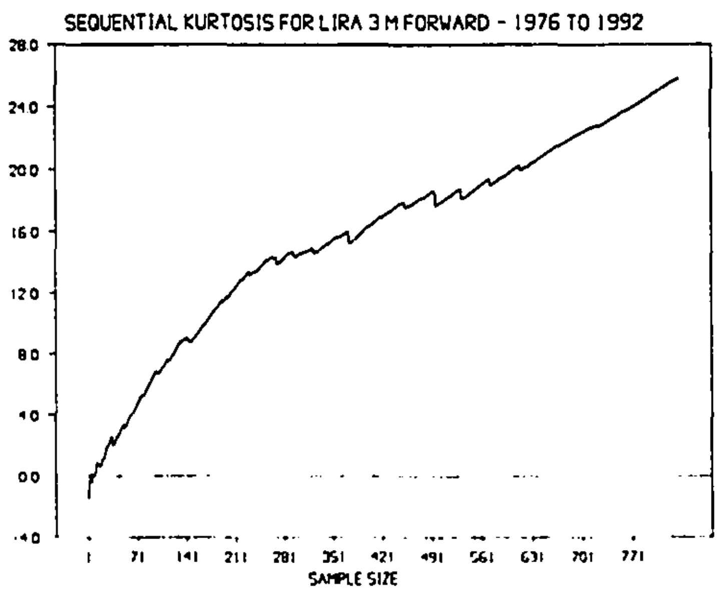

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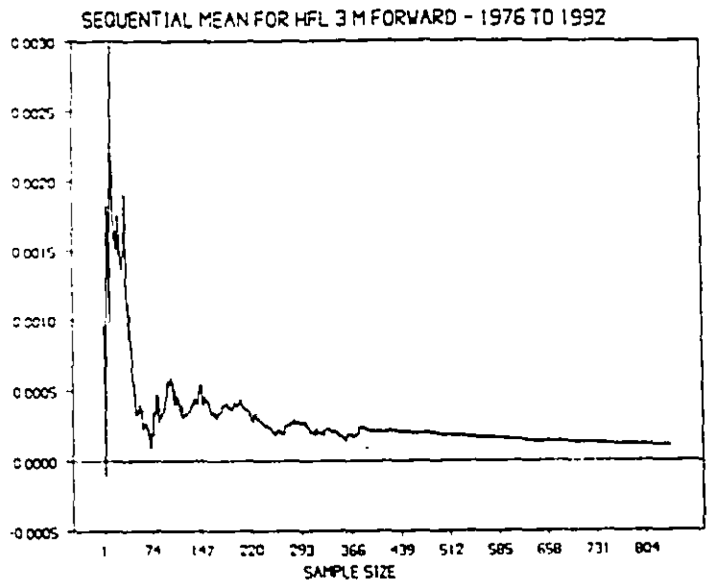
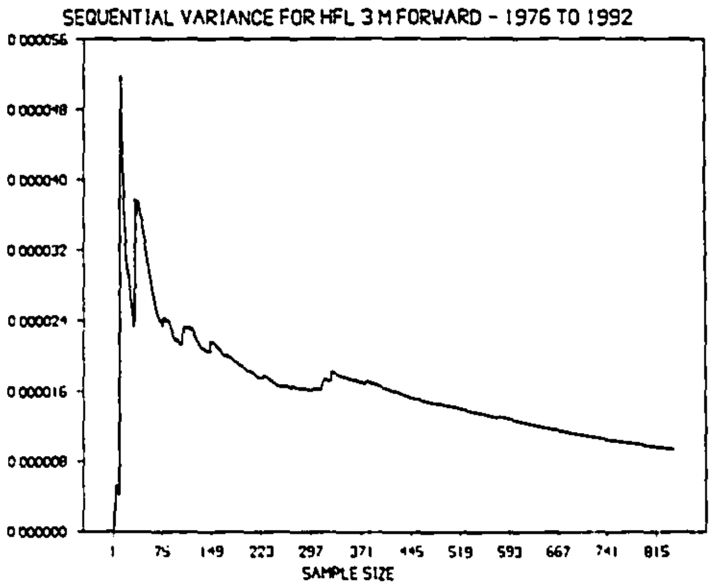


Figure 3.21b



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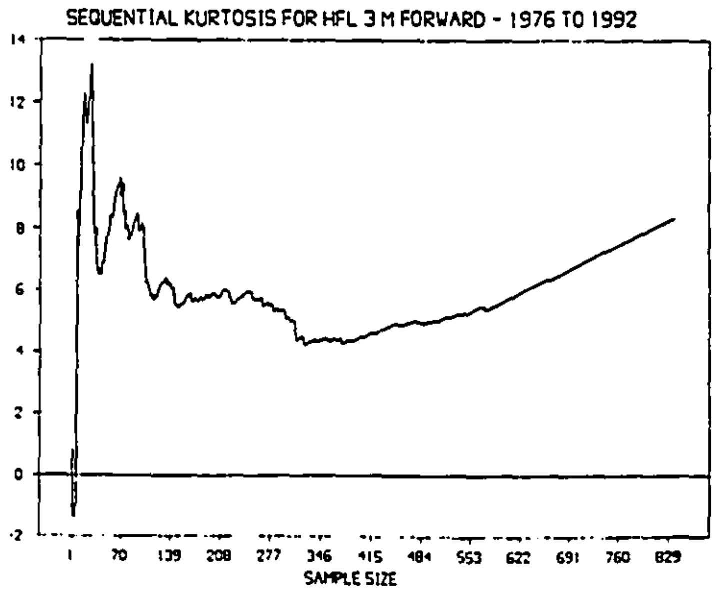

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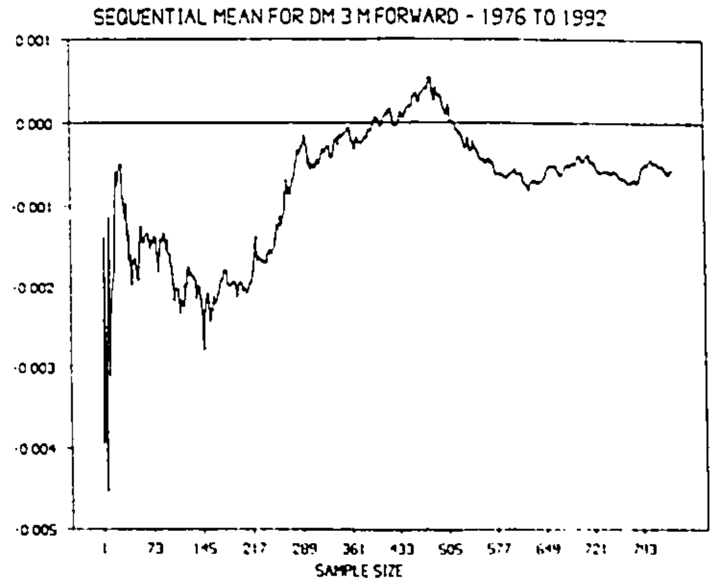

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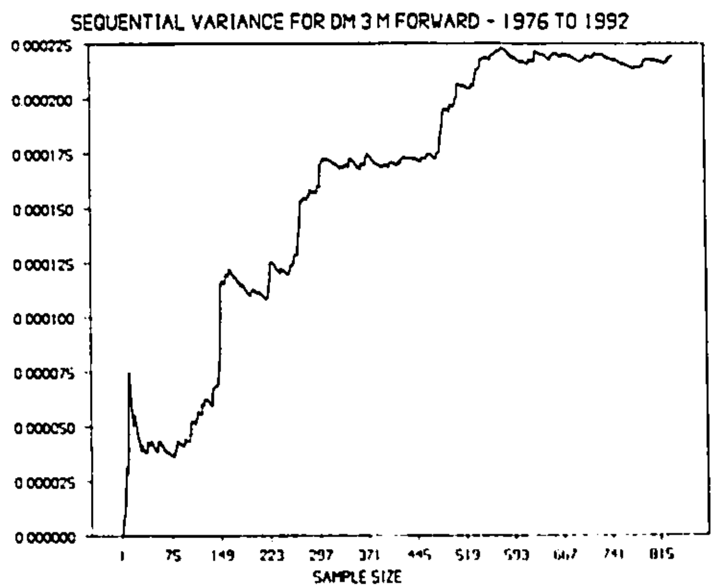

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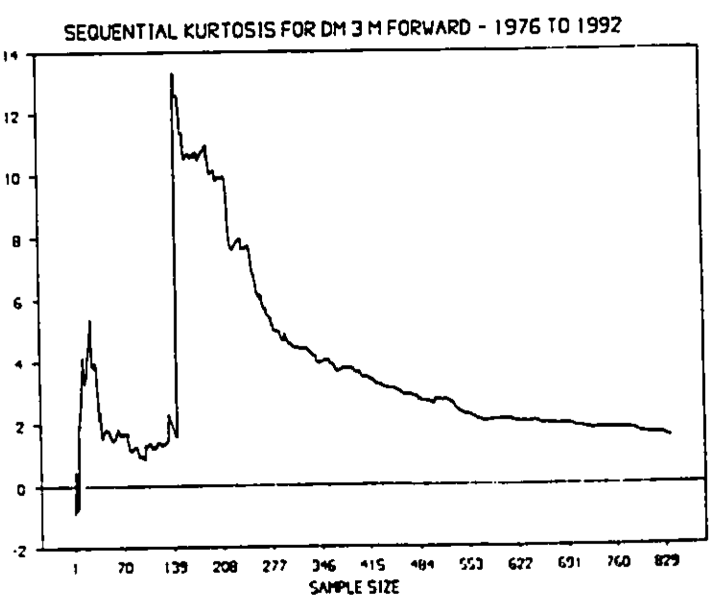

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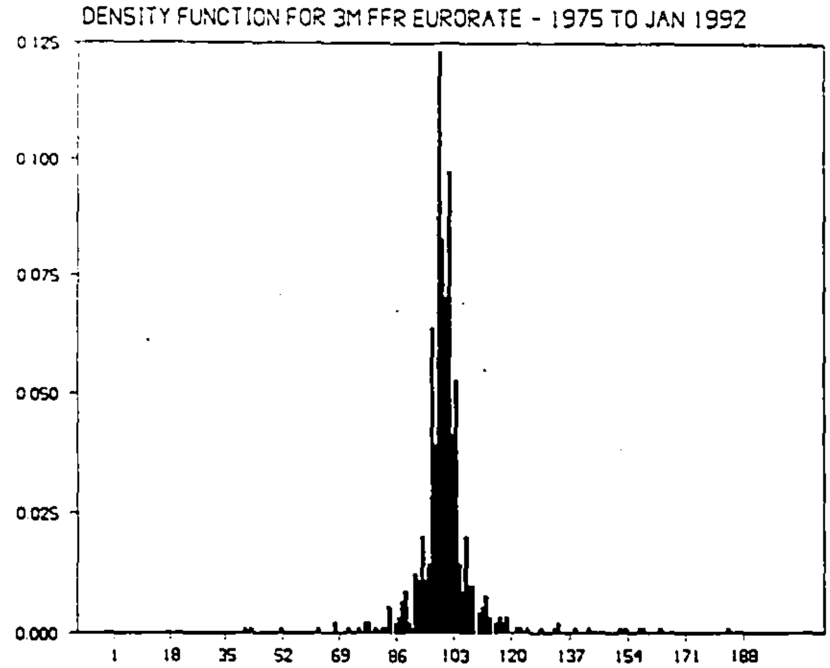

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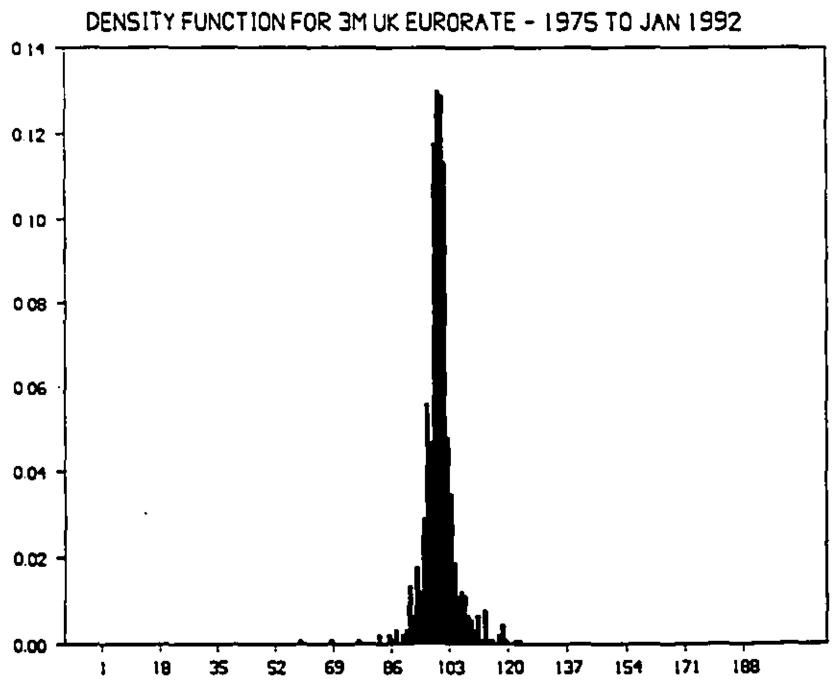

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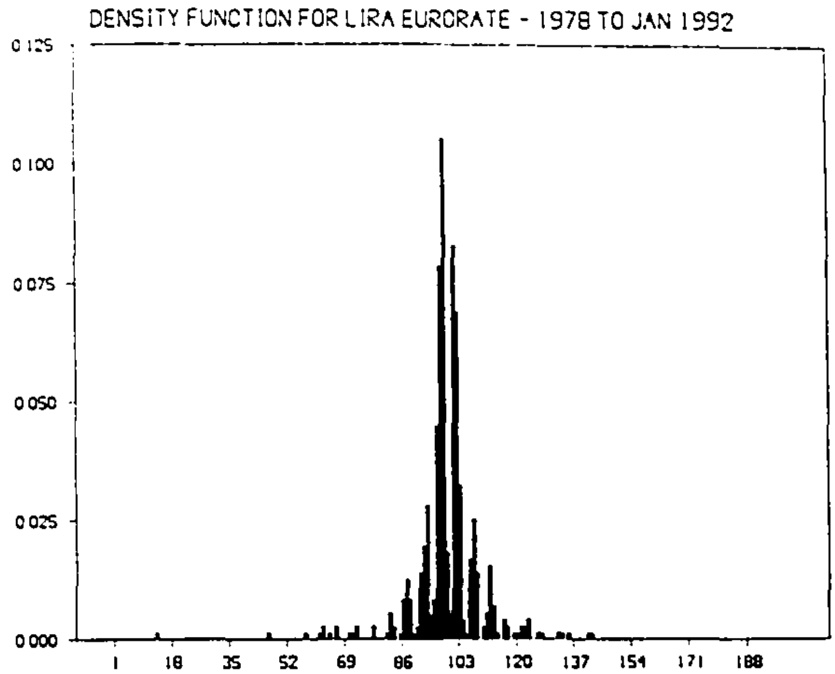
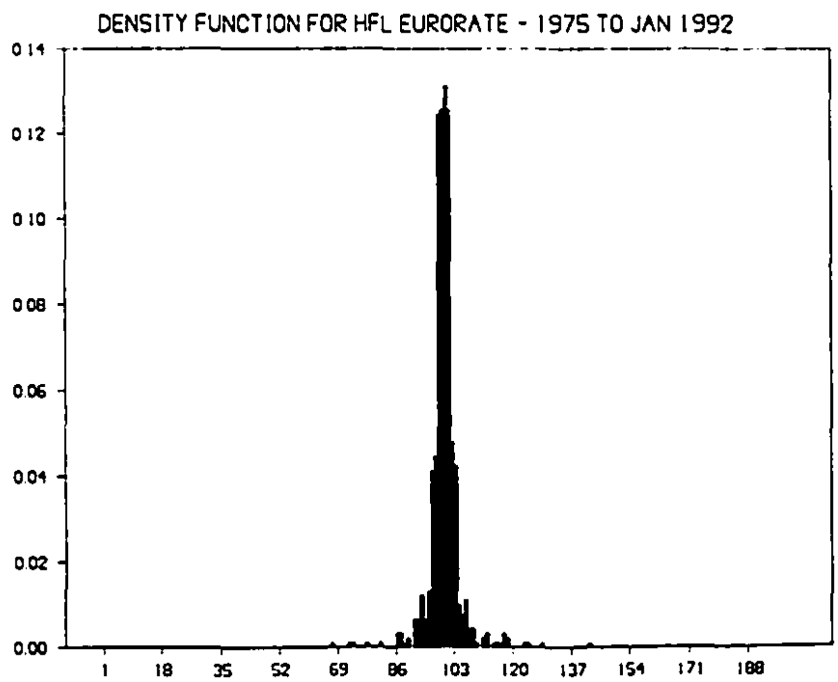


Figure 3.26



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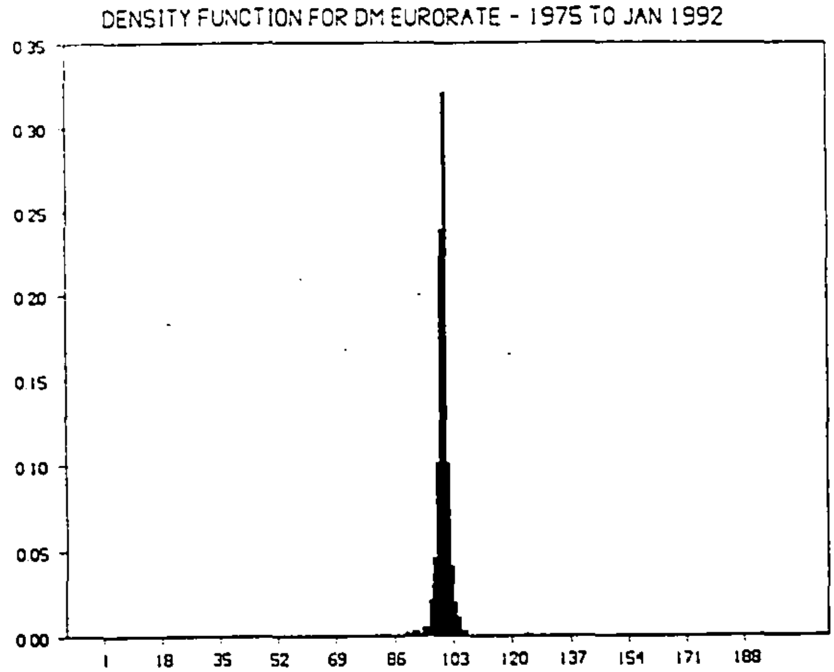


Figure 3.28

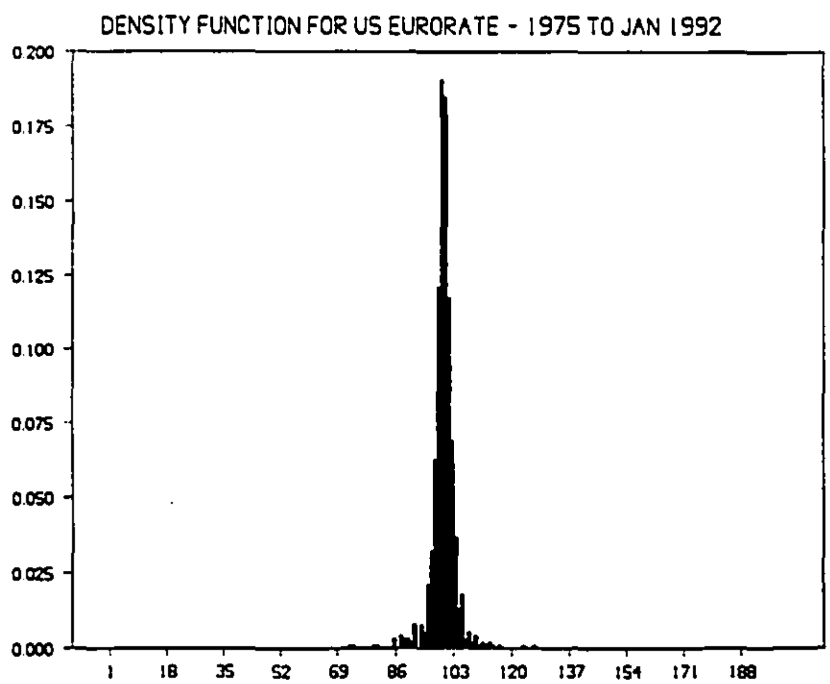


Figure 4.1

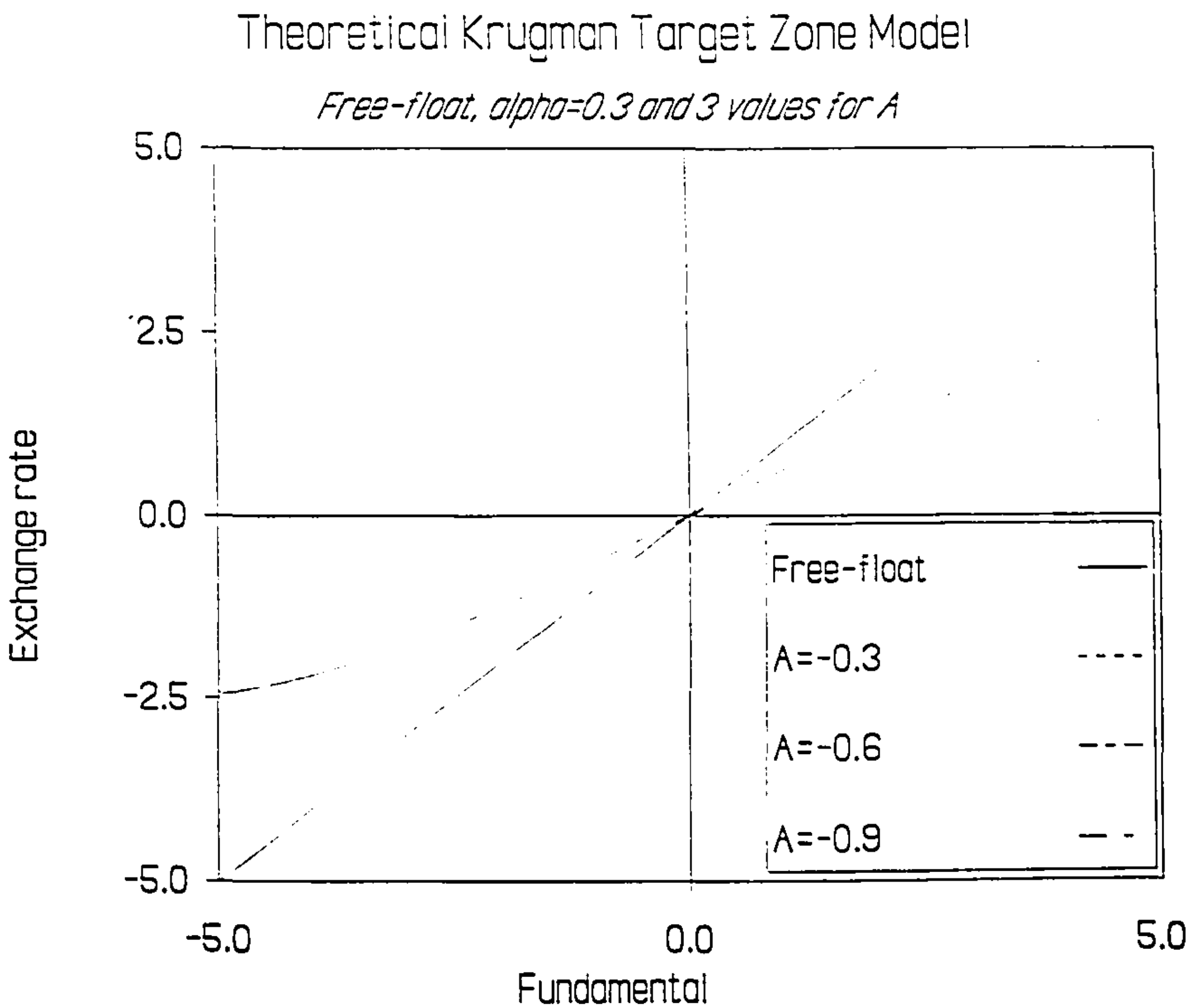

Theoretical Krugman Target Zone Model
Free-float, alpha=0.3 and 3 values for A
5.0
2.5
0.0
-2.5
-5.0
Exchange rate
-5.0
0.0
5.0
Fundamental
Free-float
A=-0.3
A=-0.6
A=-0.9

Figure 4.2

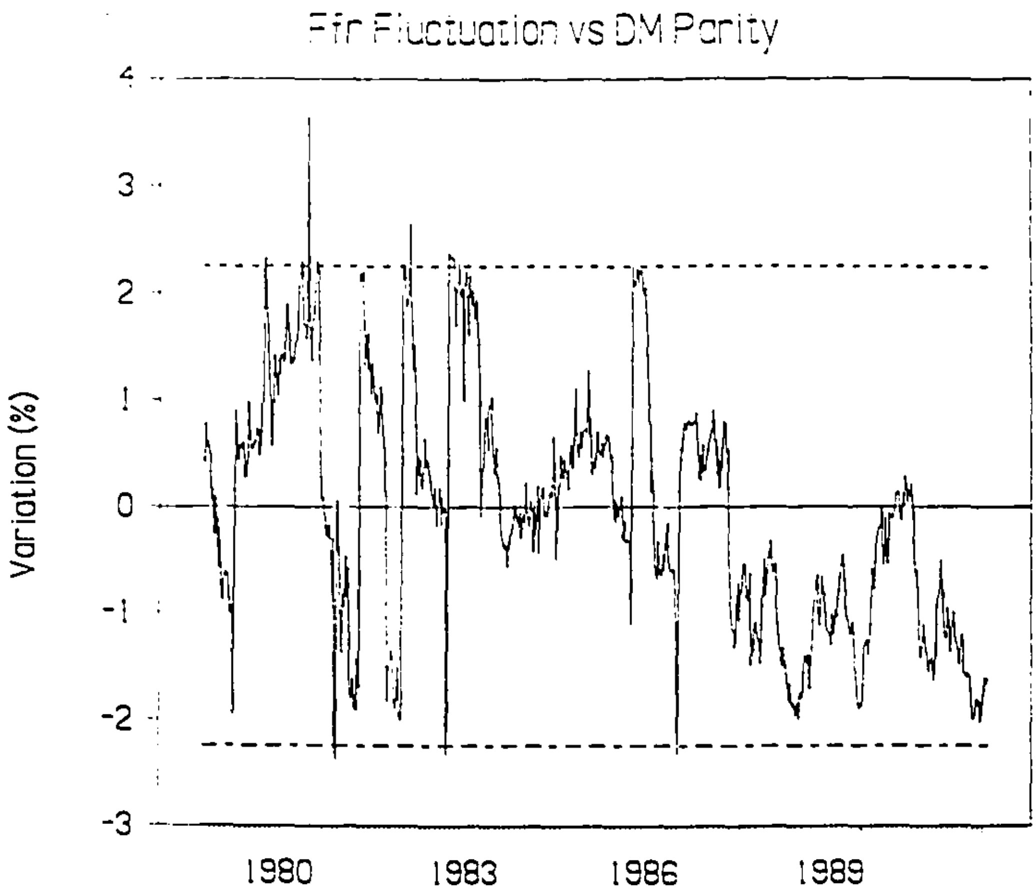


Figure 4.3

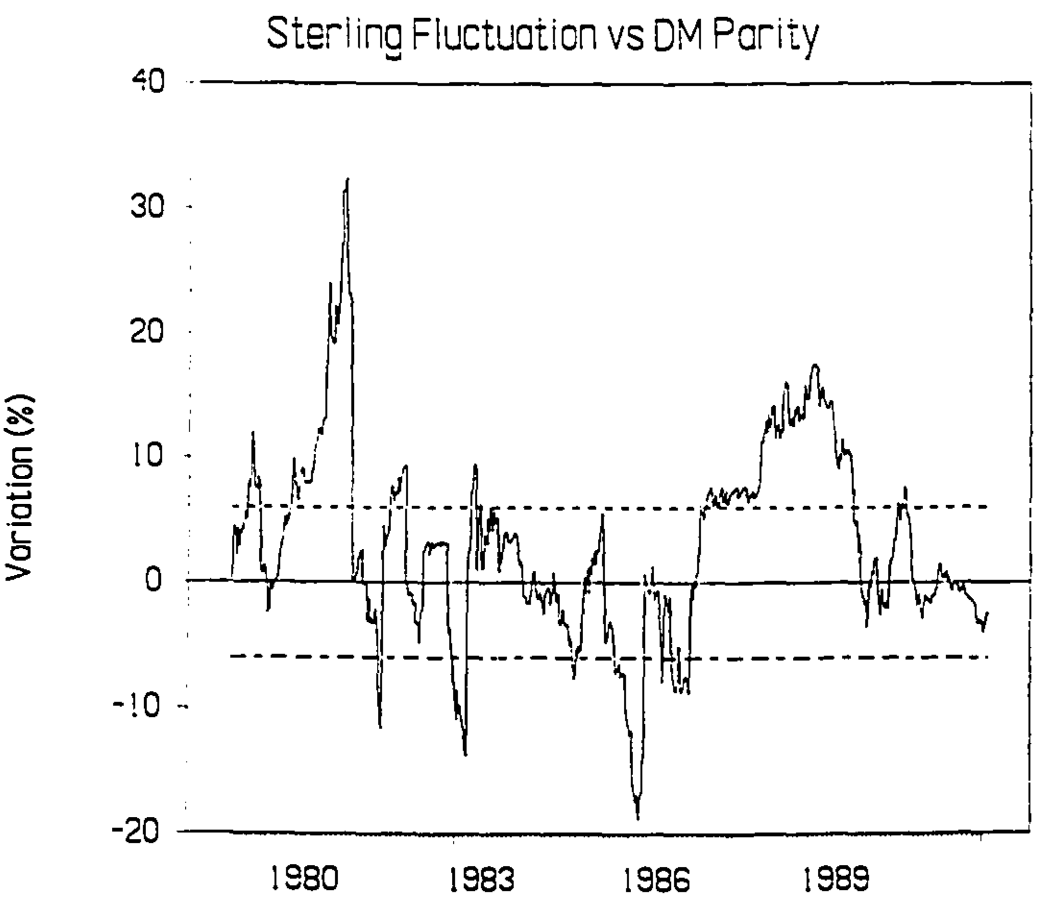


Figure 4.4

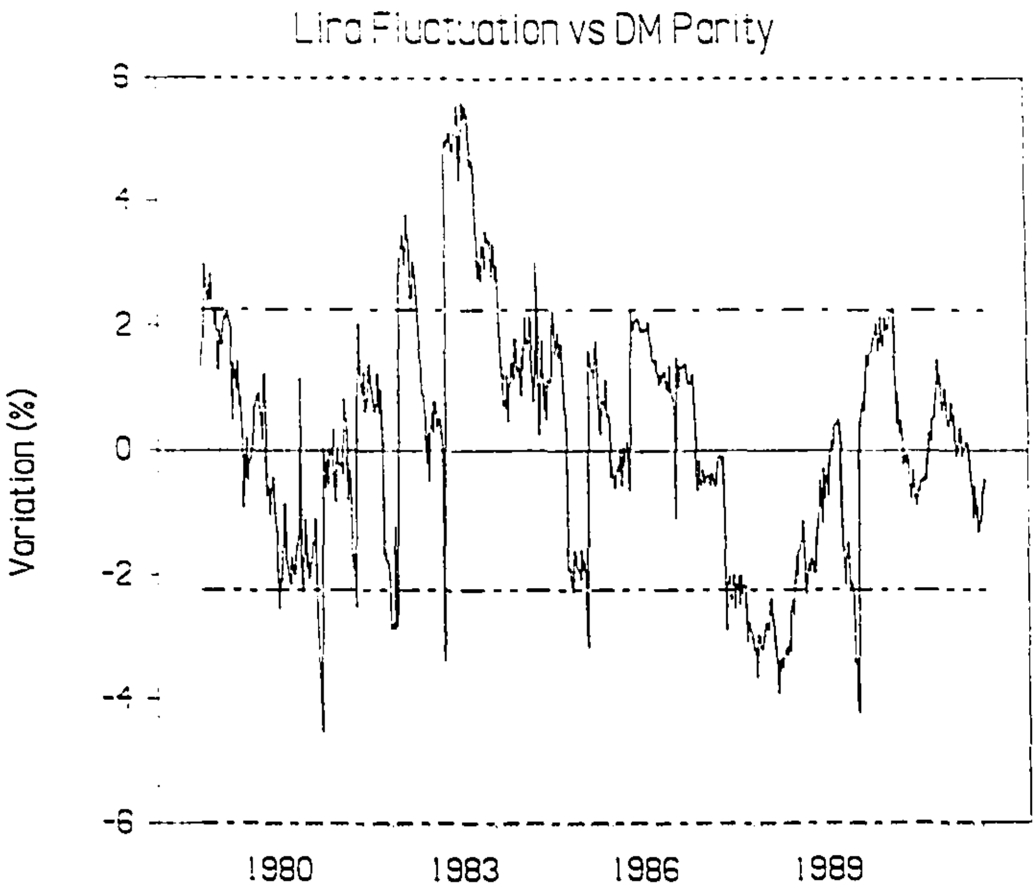


Figure 4.5

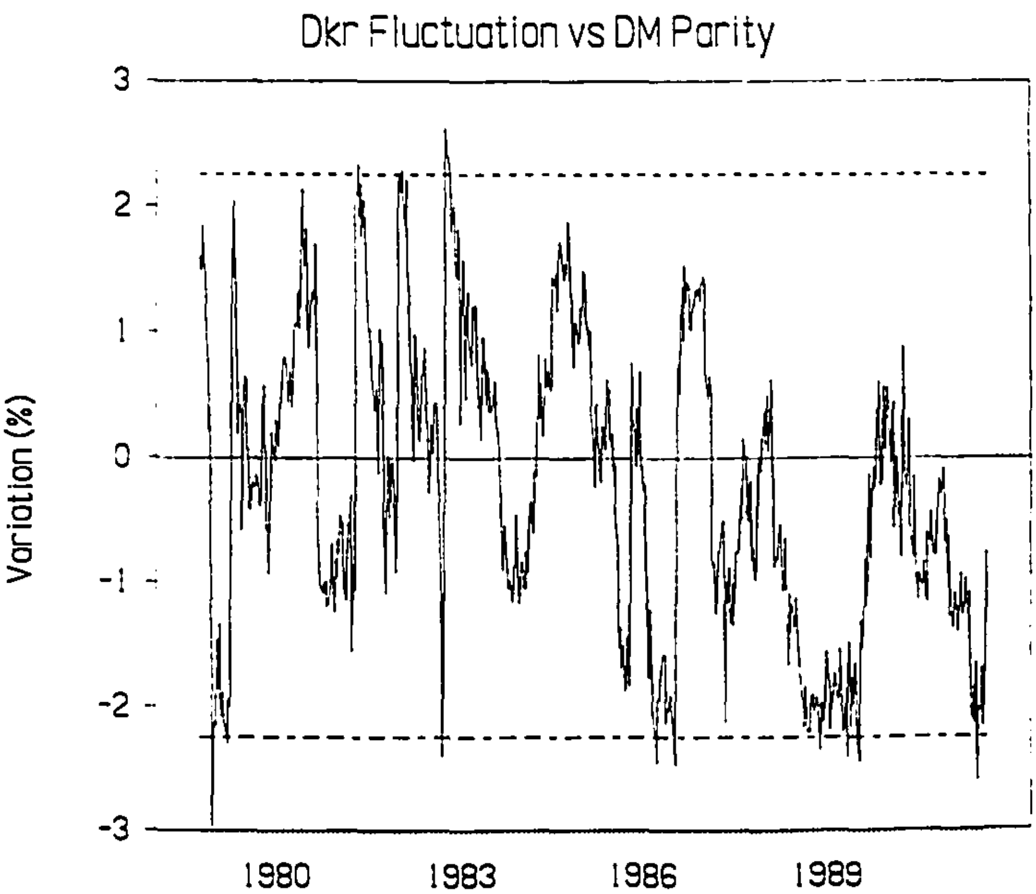


Figure 4.6

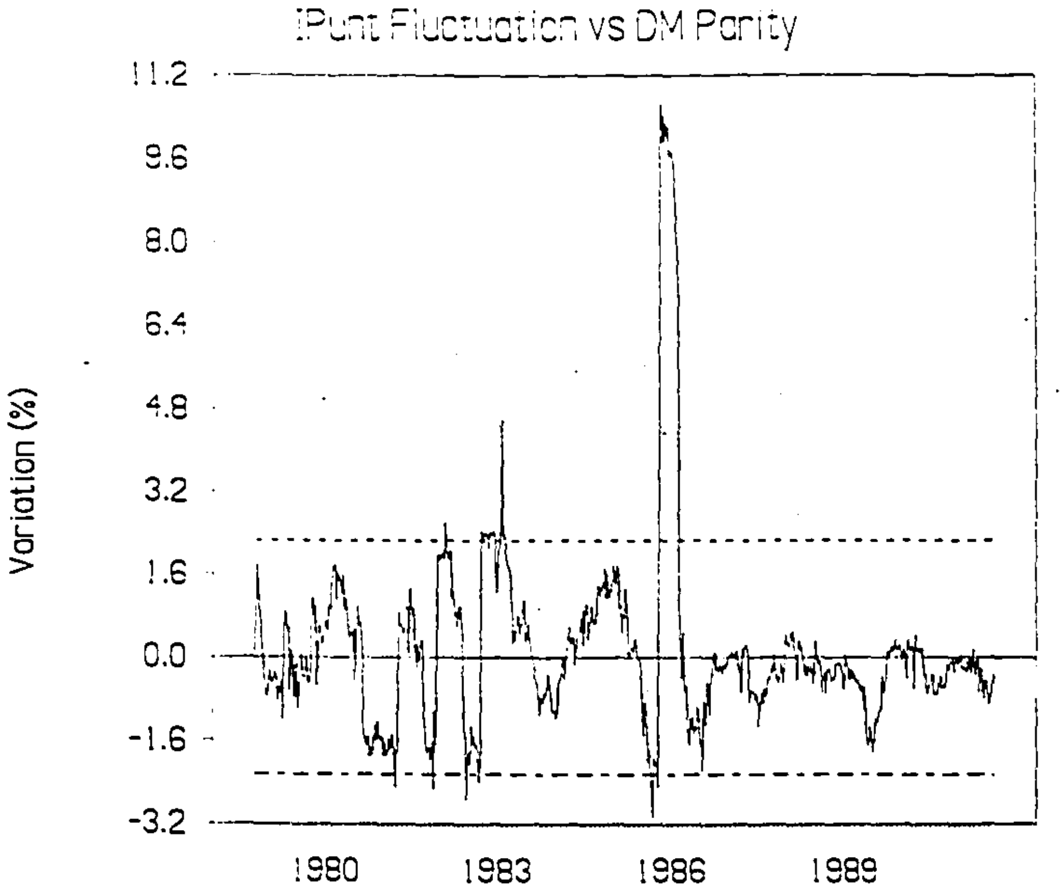


Figure 4.7

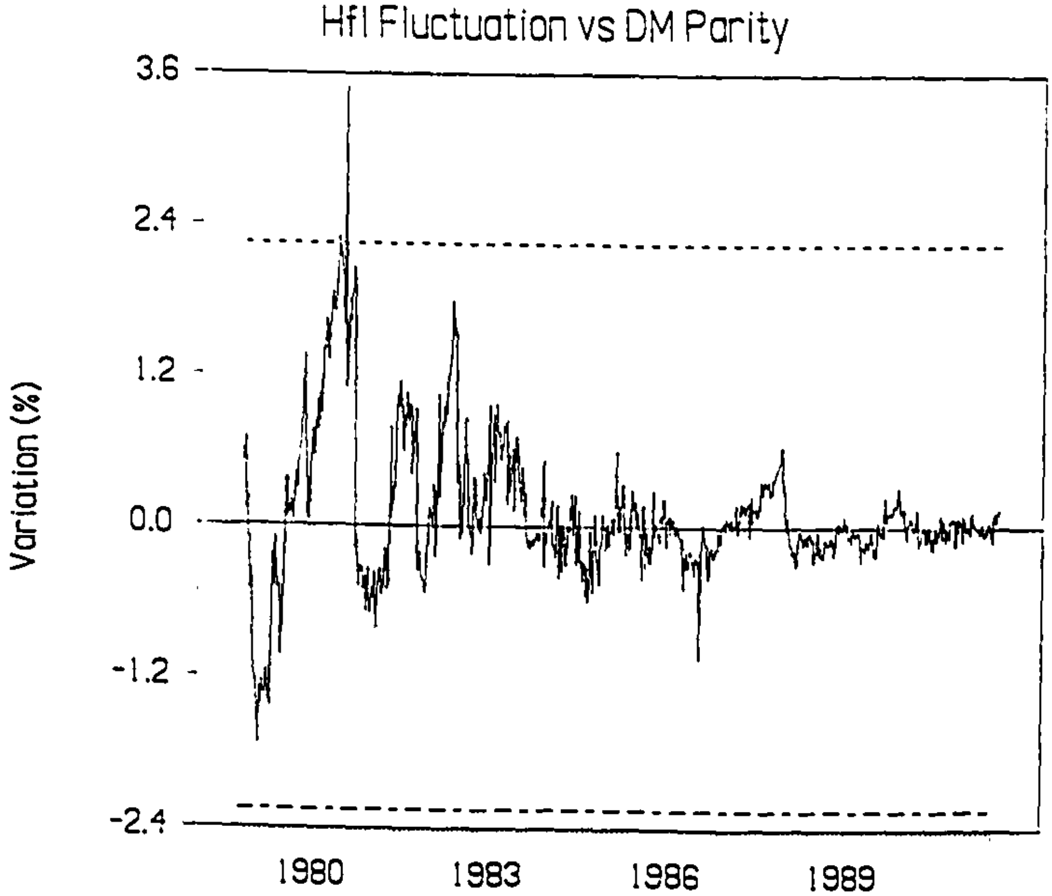


Figure 4.8

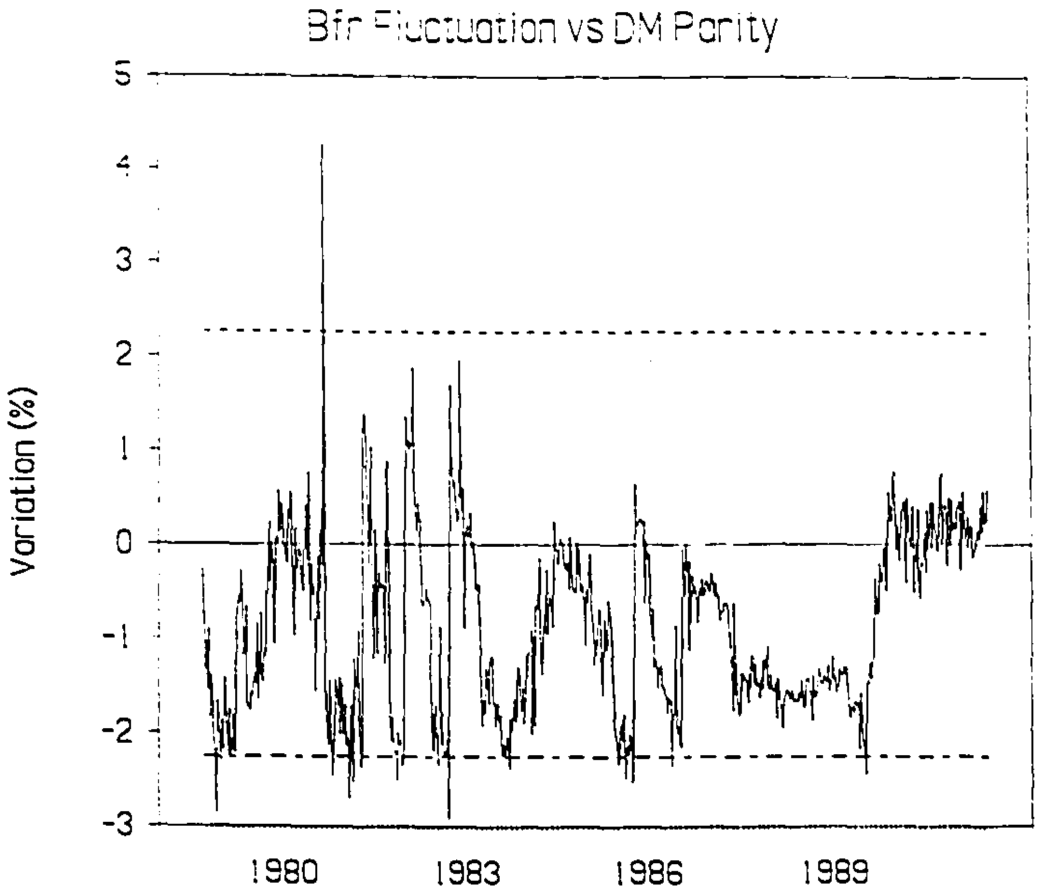


Figure 4.9

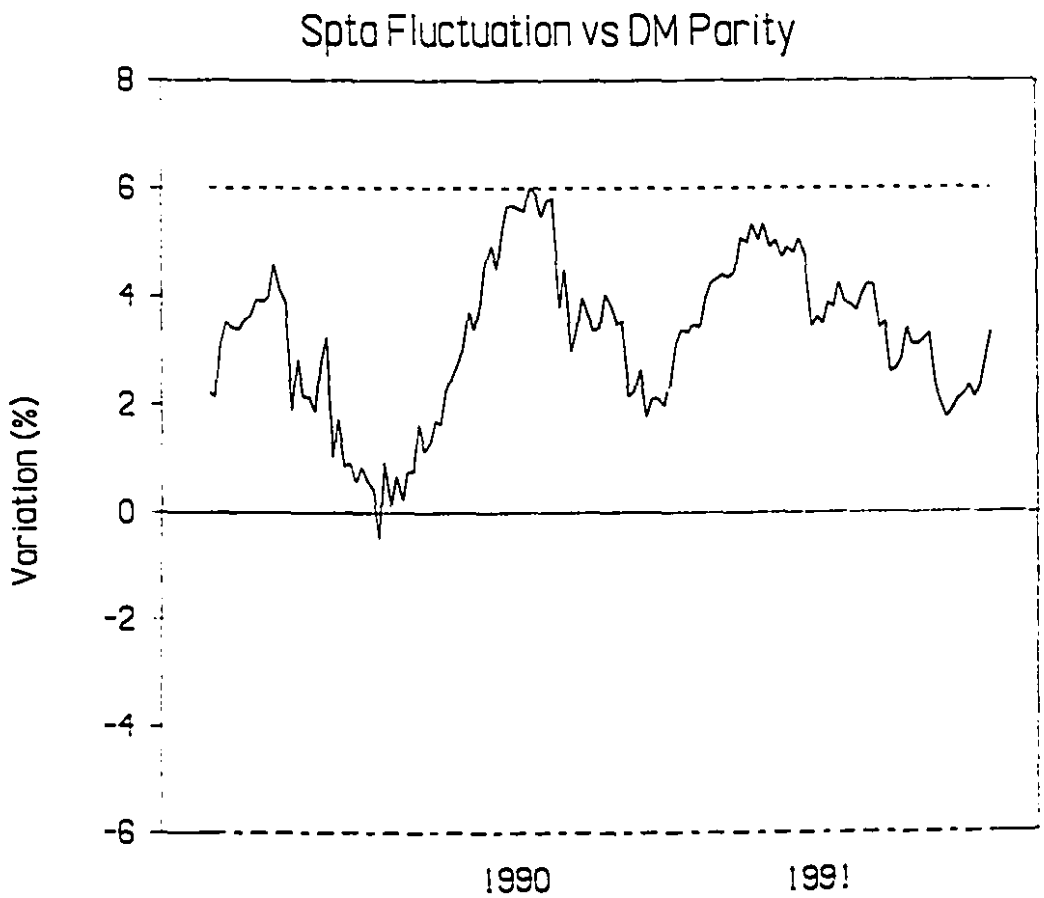


Figure 4.10

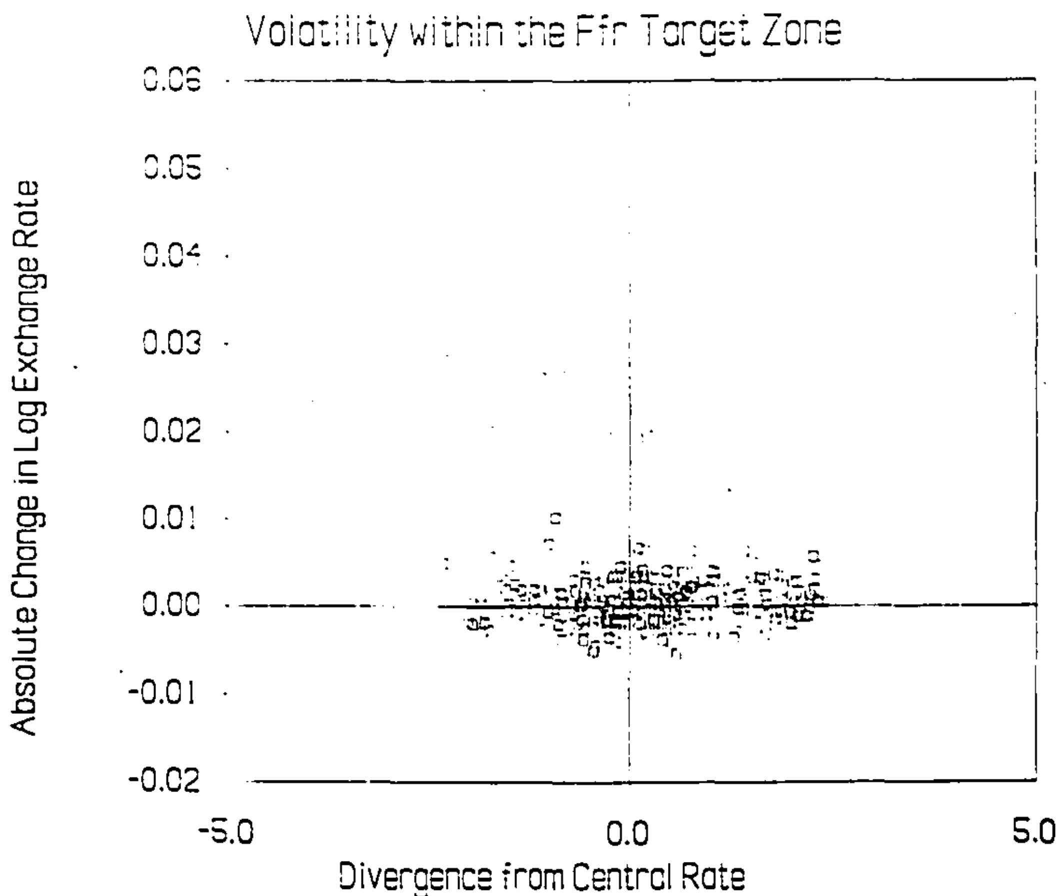


Figure 4.11

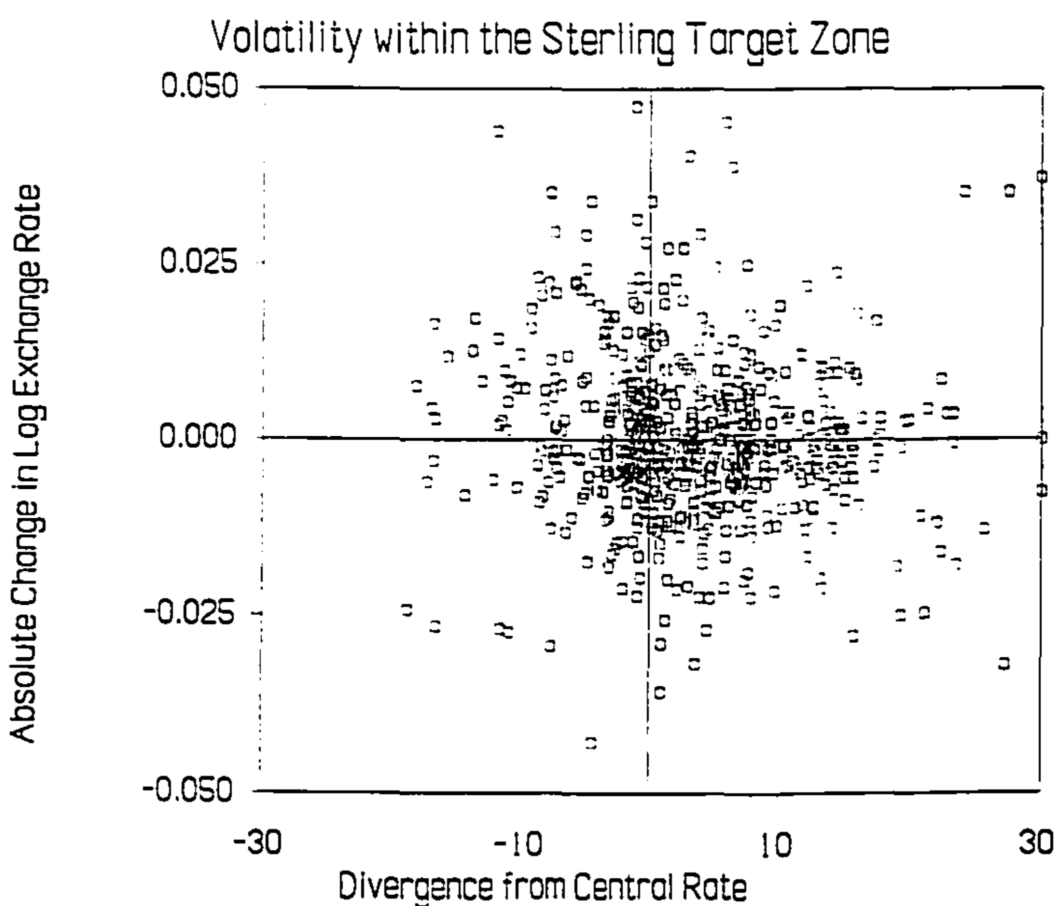
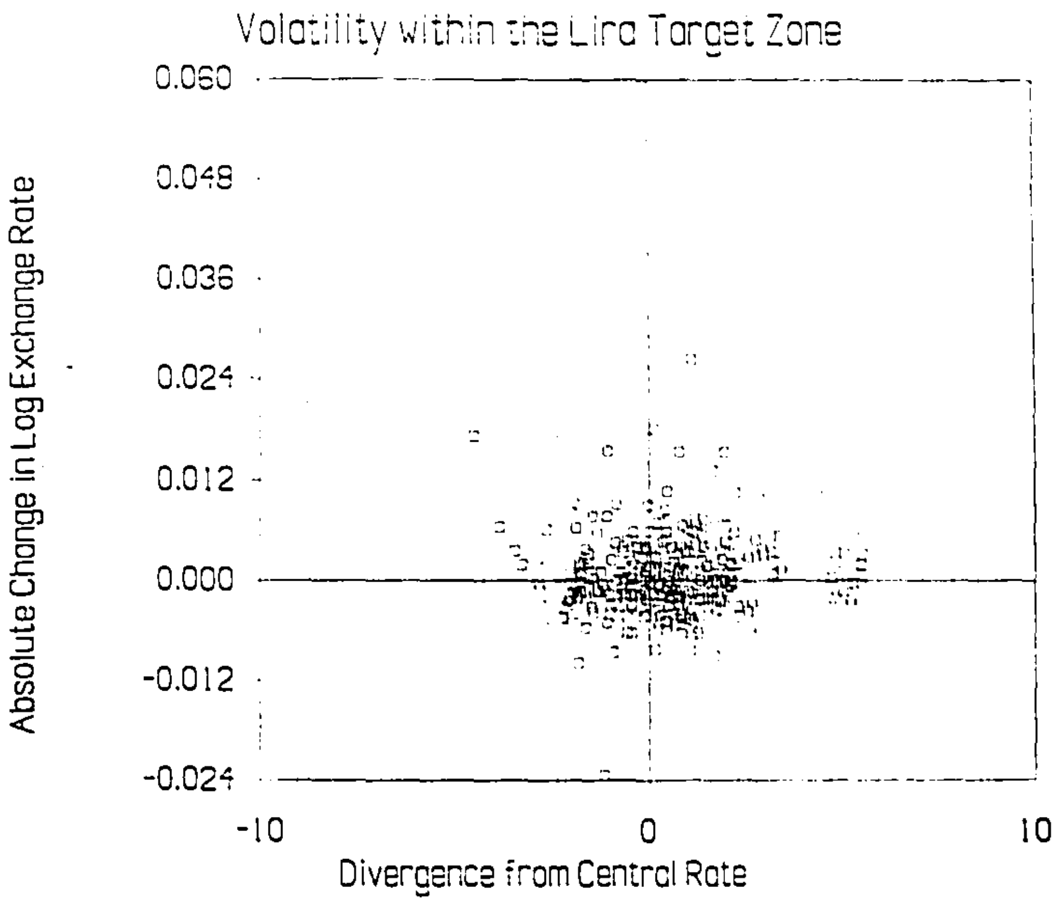


Figure 4.12



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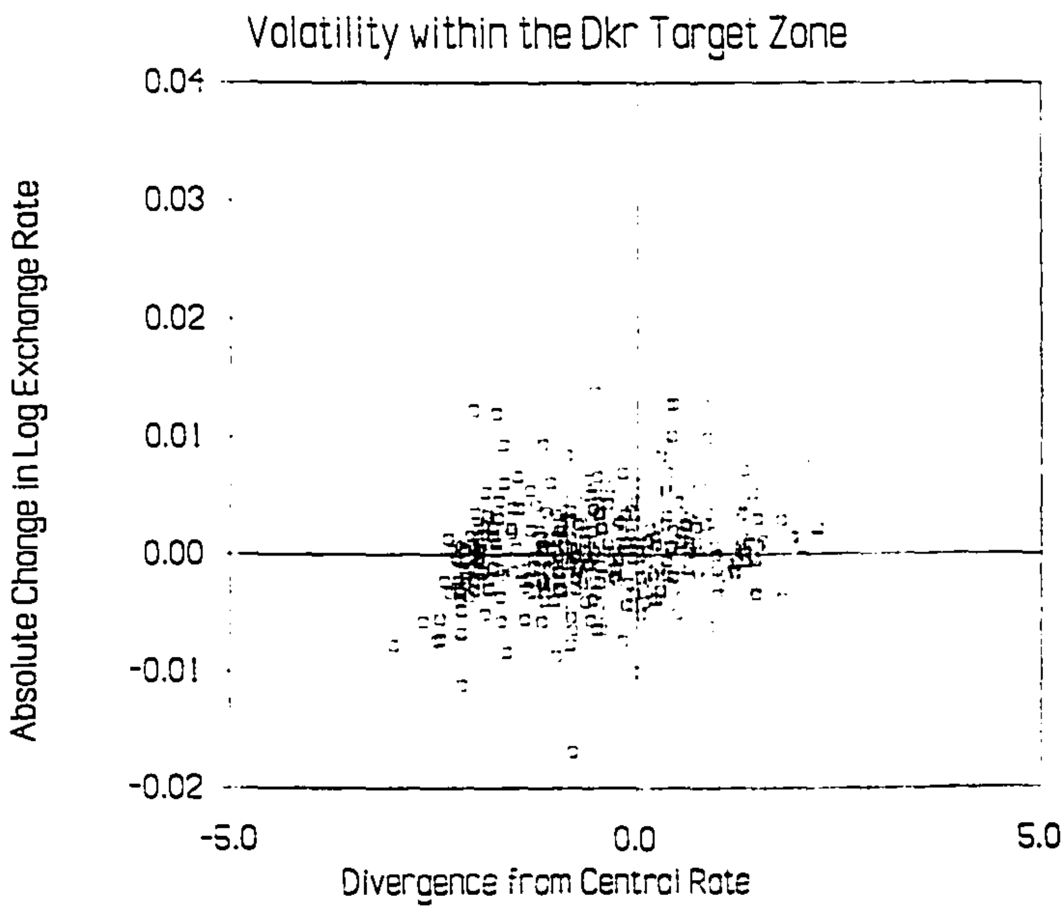
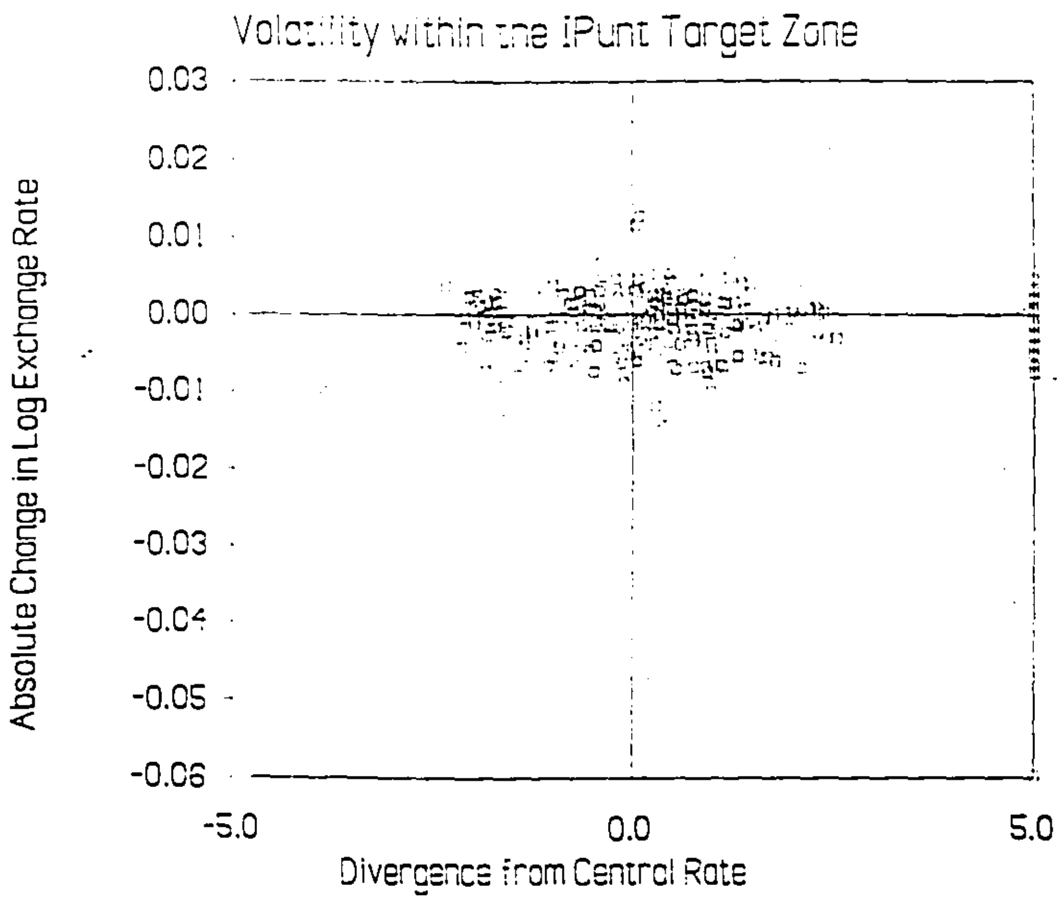


Figure 4.14



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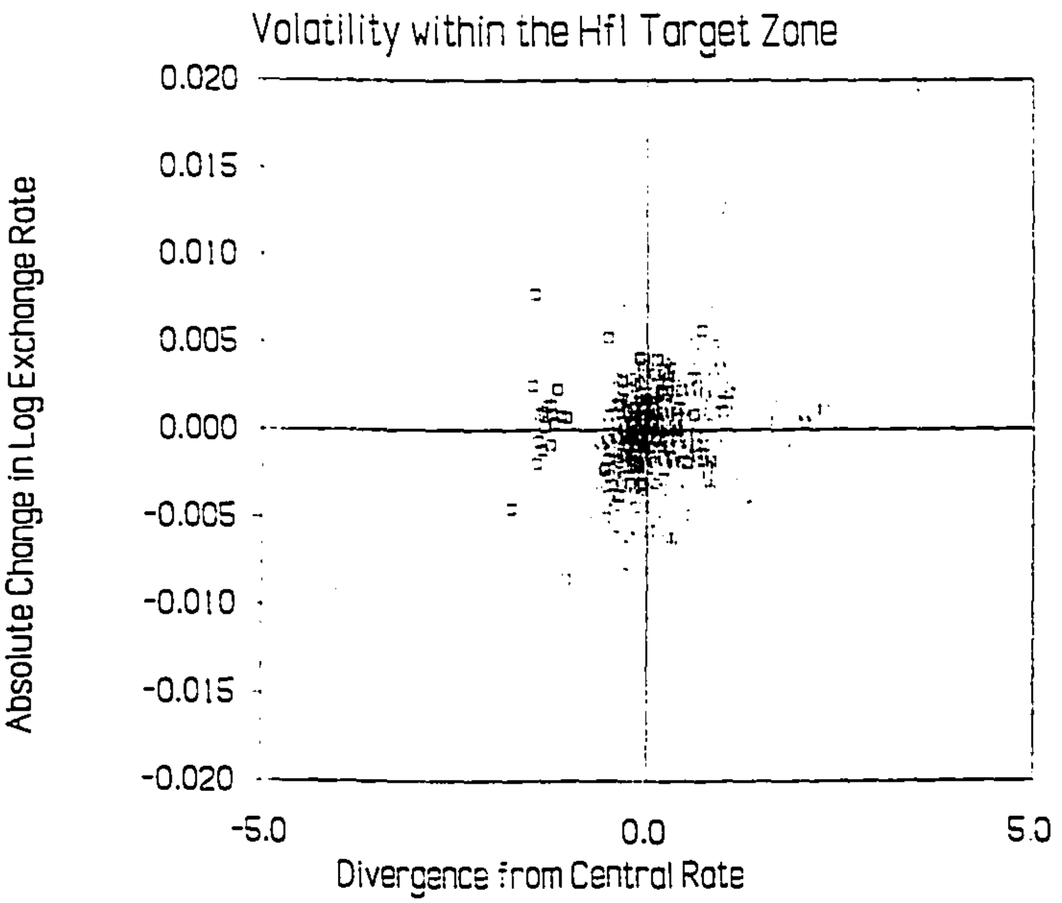

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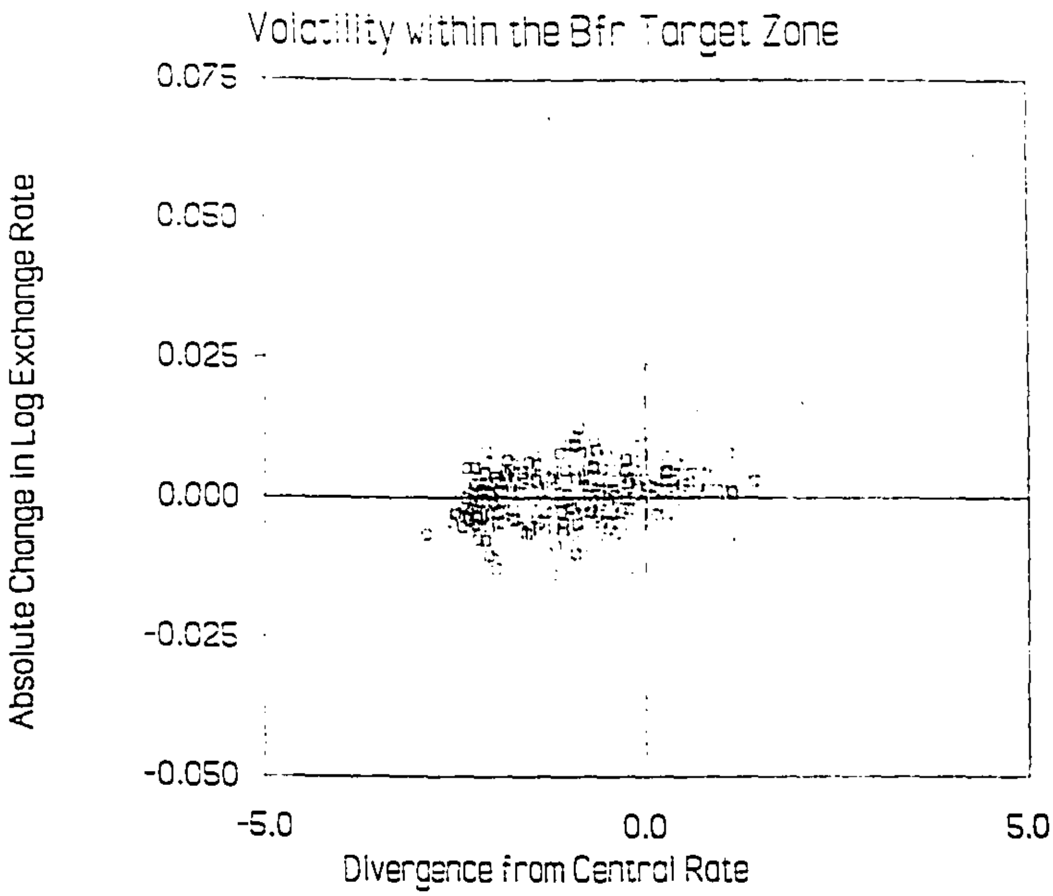

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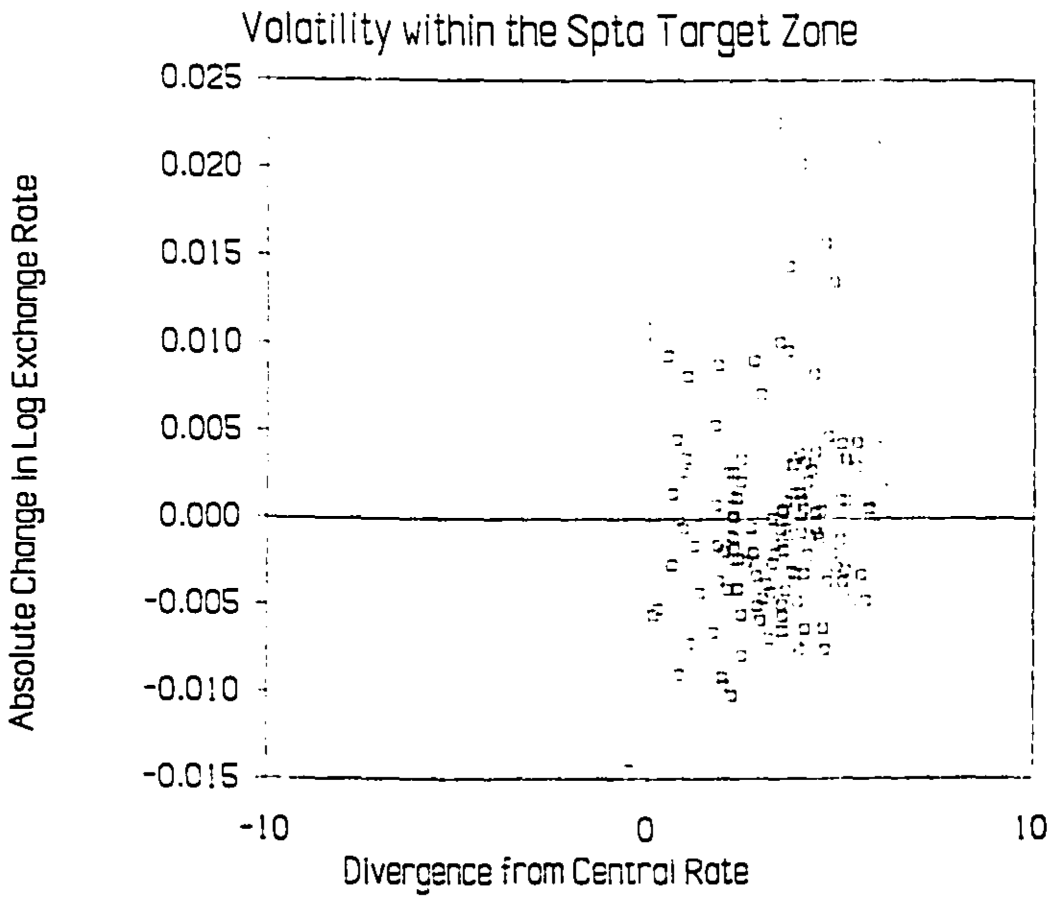

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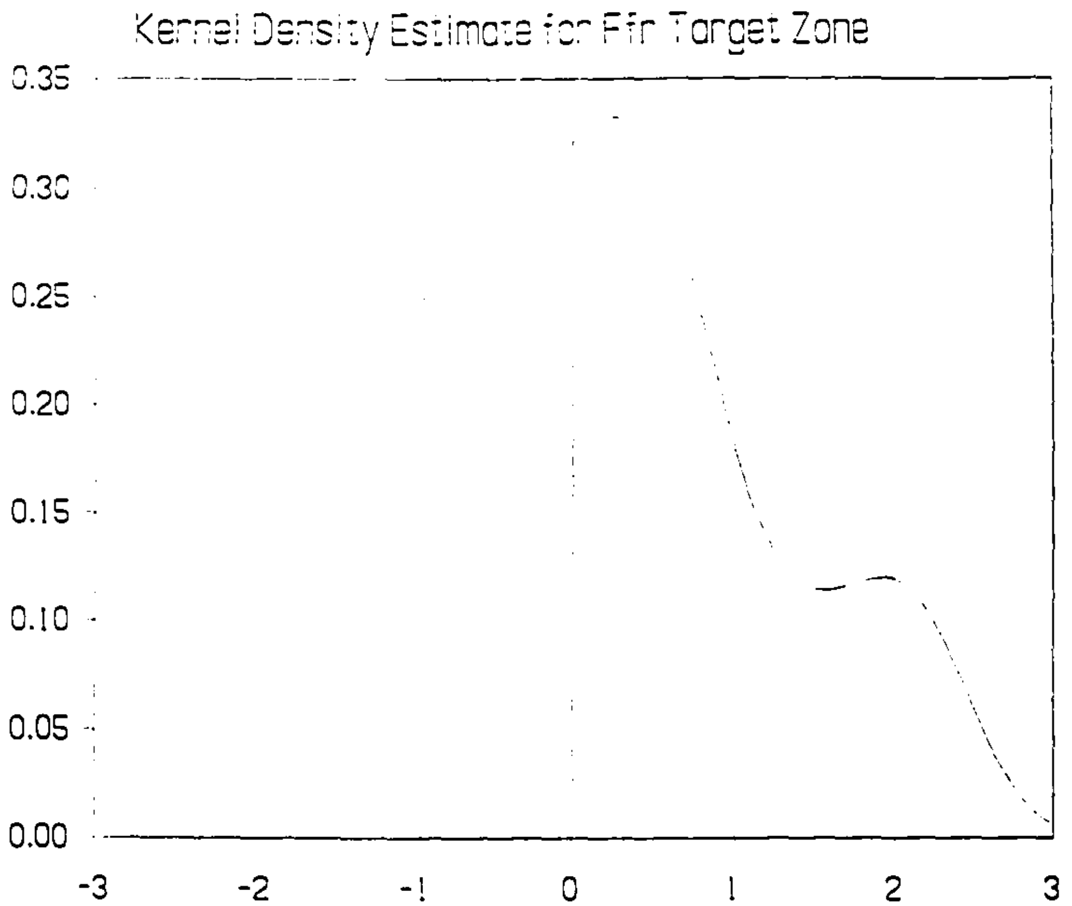


Figure 4.19

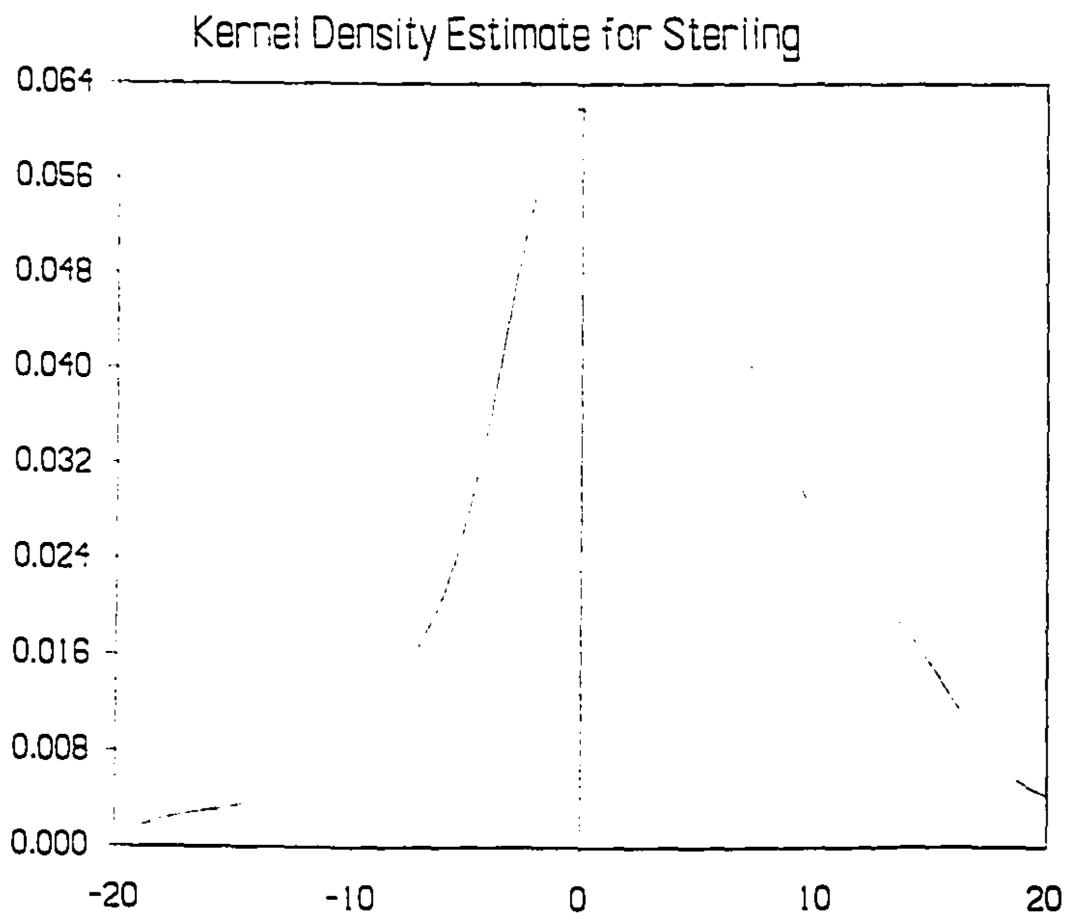


Figure 4.20

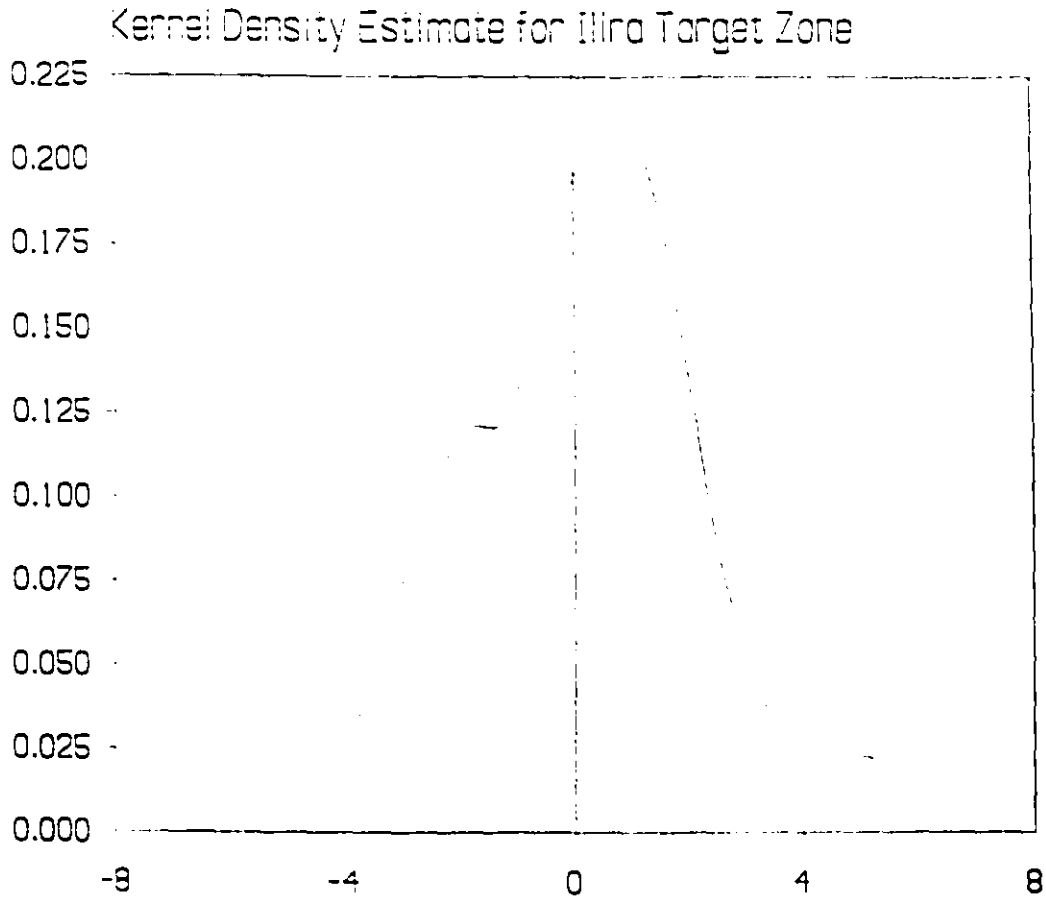


Figure 4.21

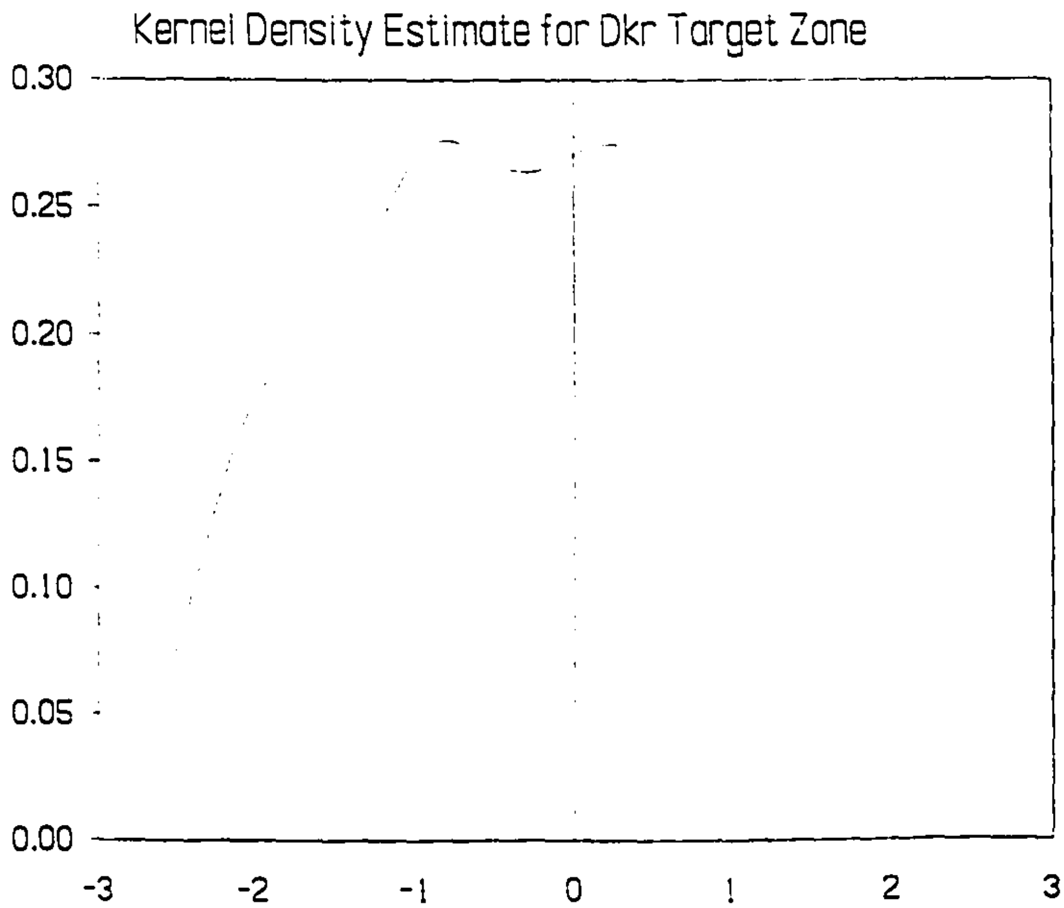


Figure 4.22

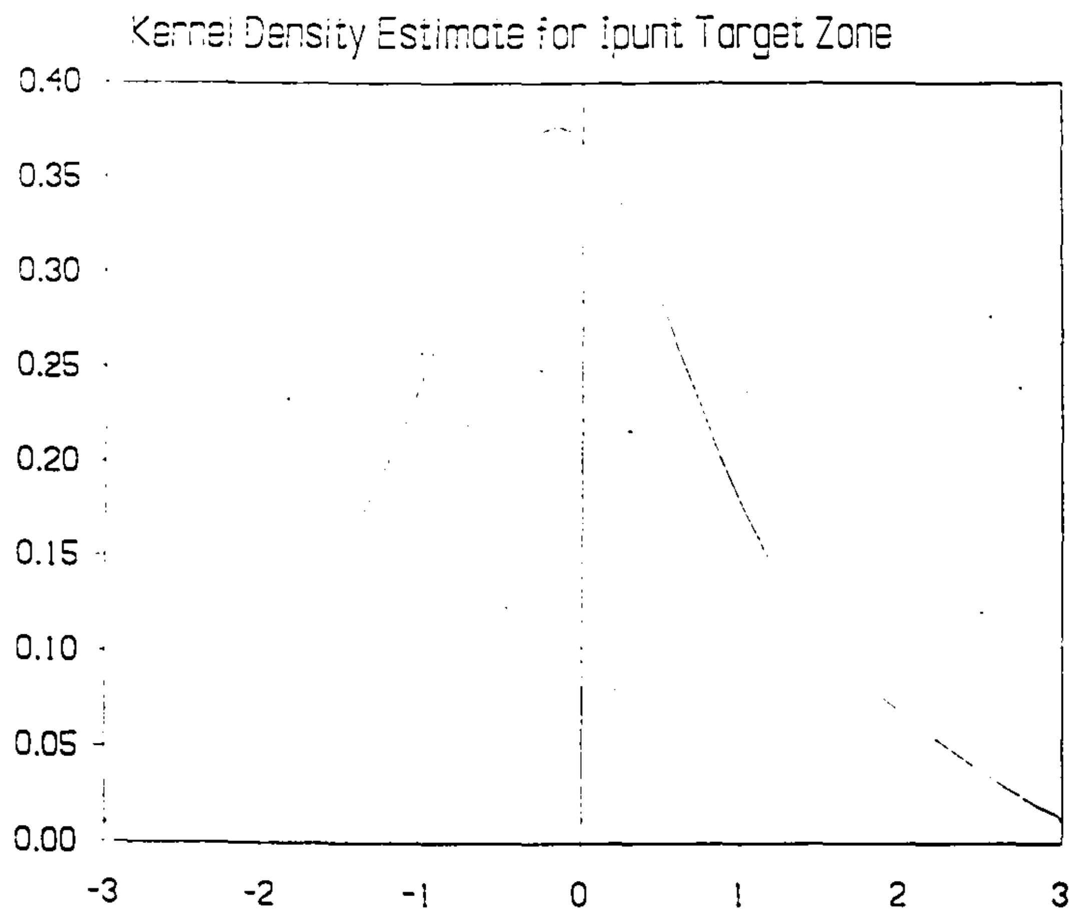
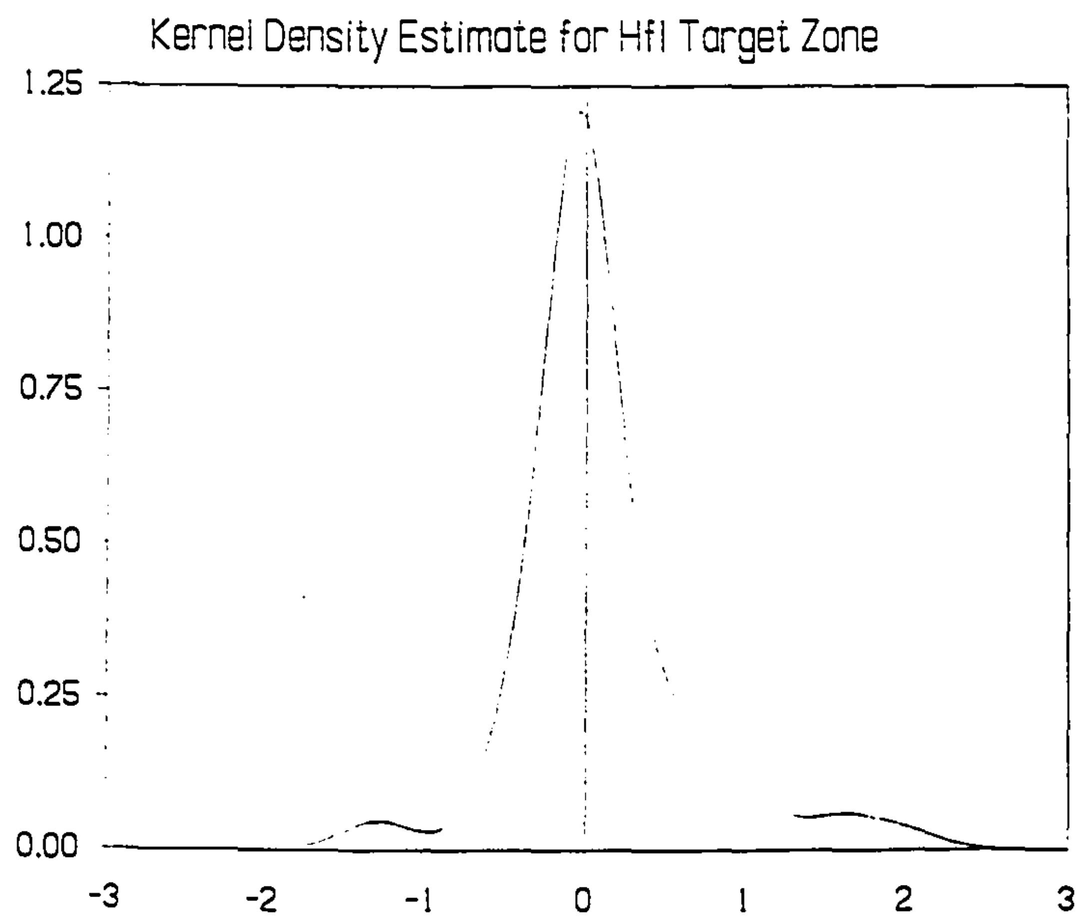


Figure 4.23



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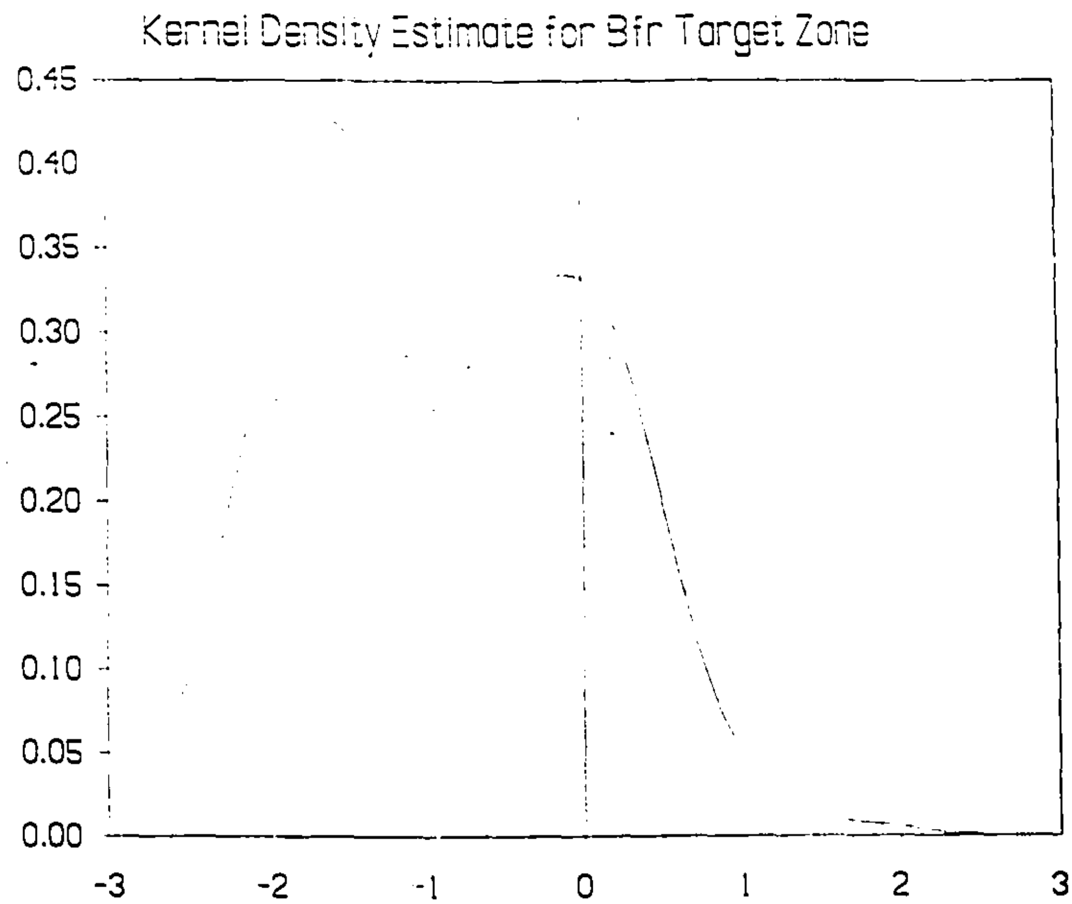


Figure 4.25

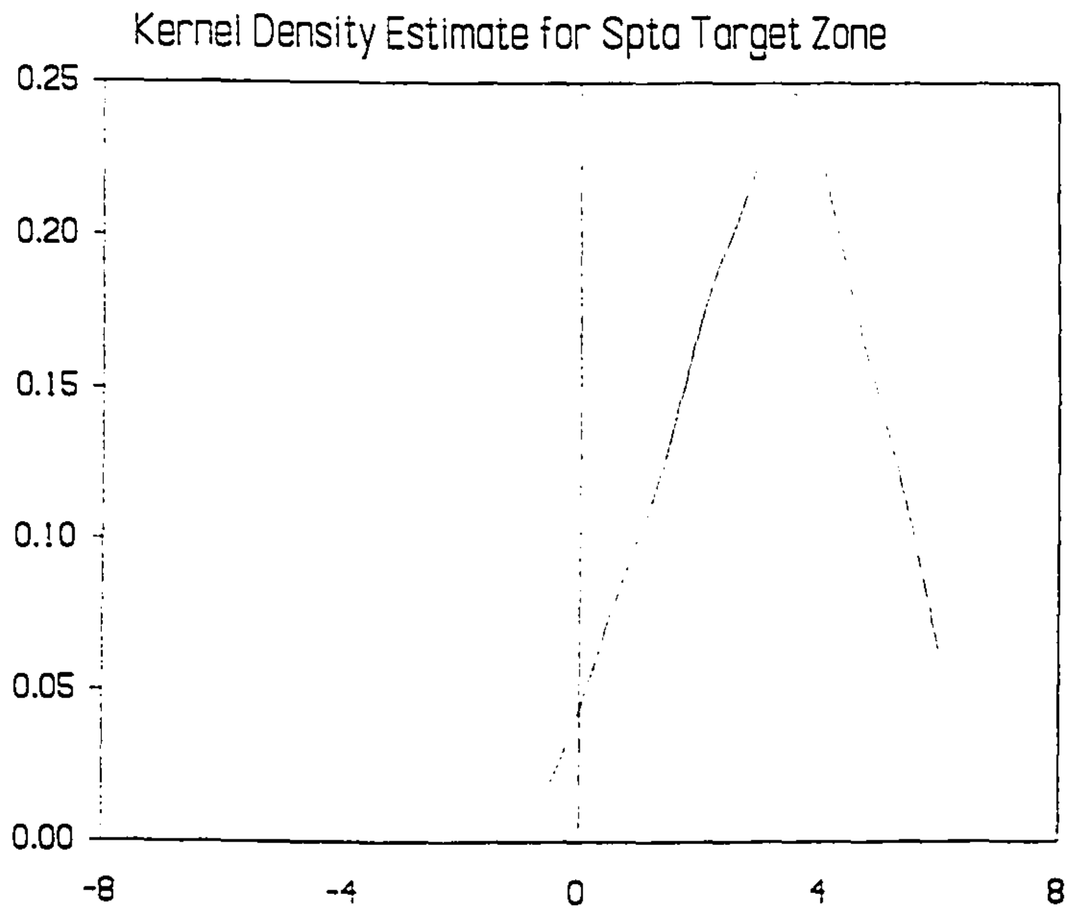


Figure 4.26a

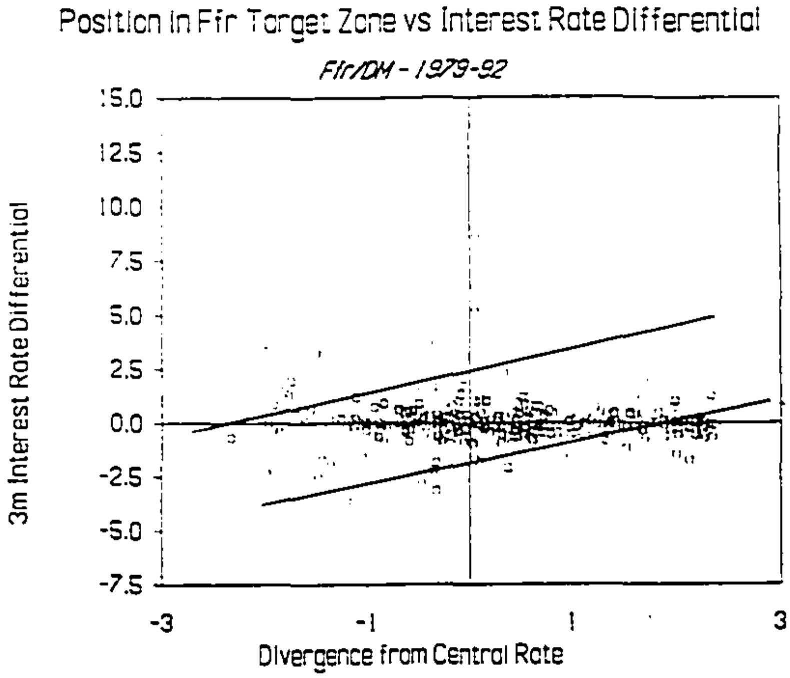
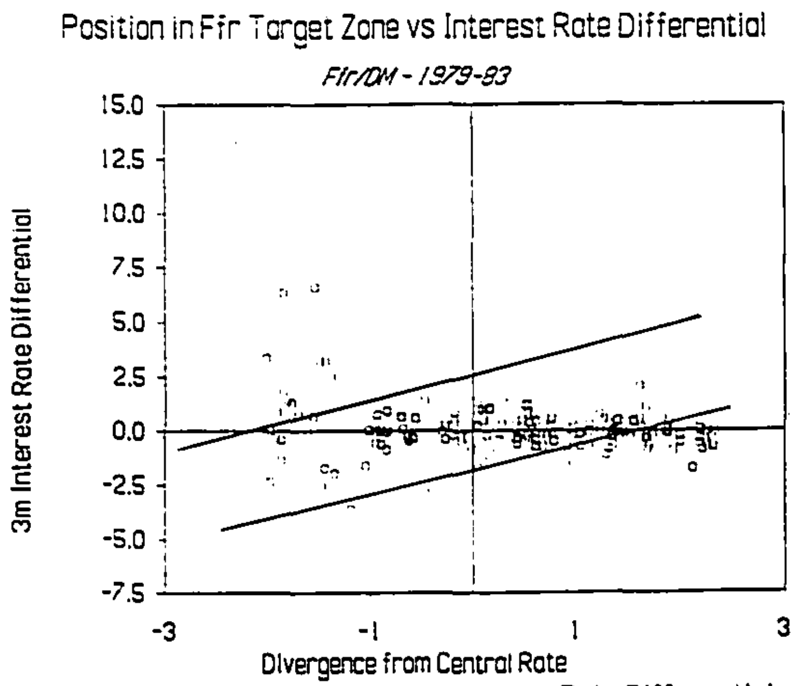


Figure 4.26b



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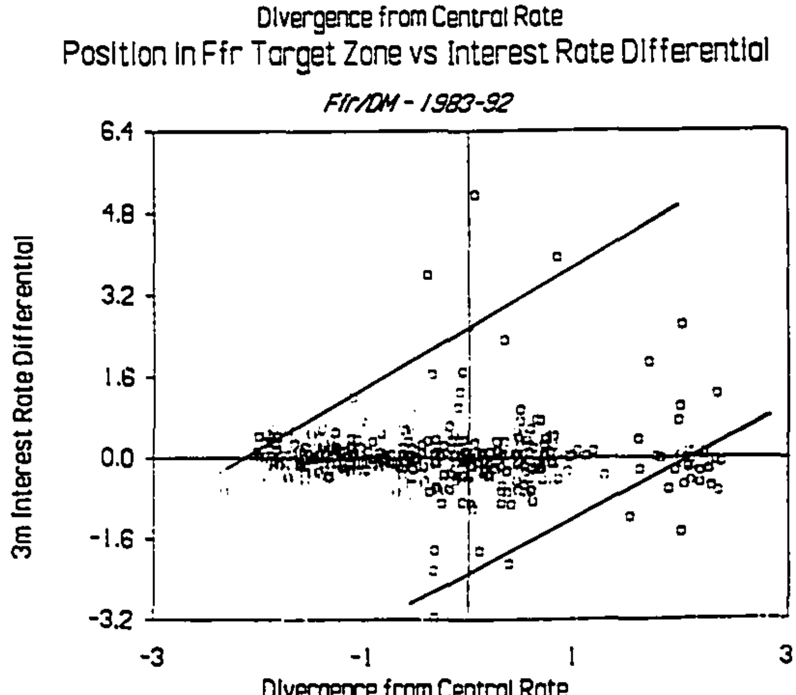

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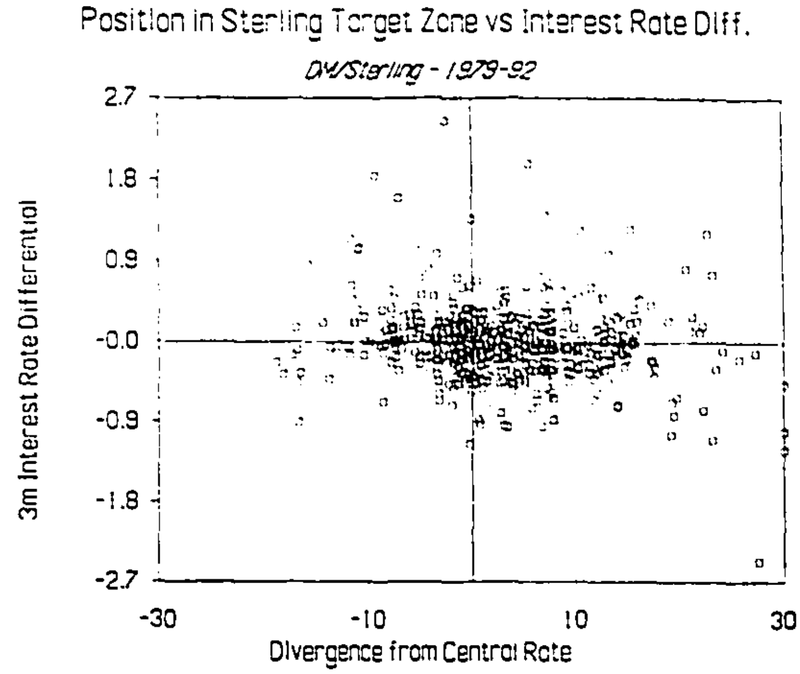

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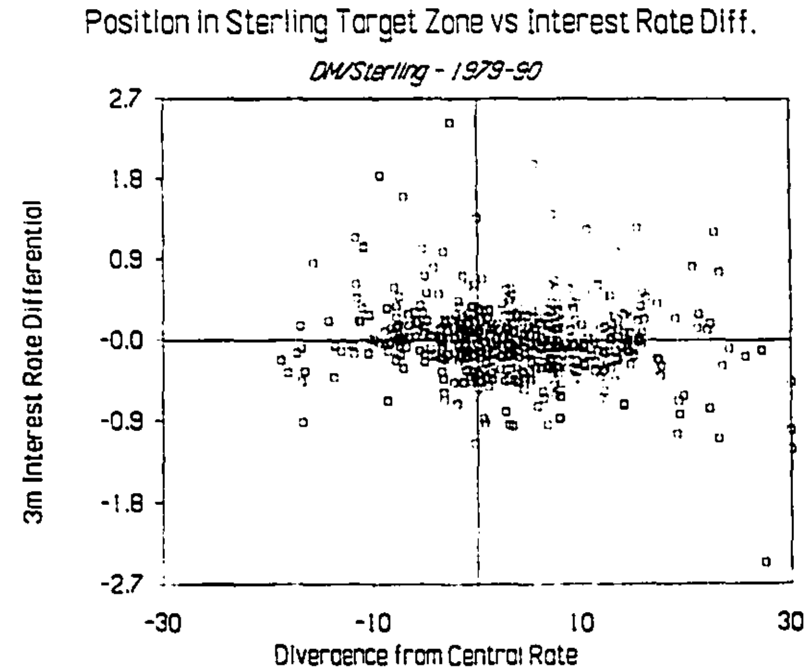

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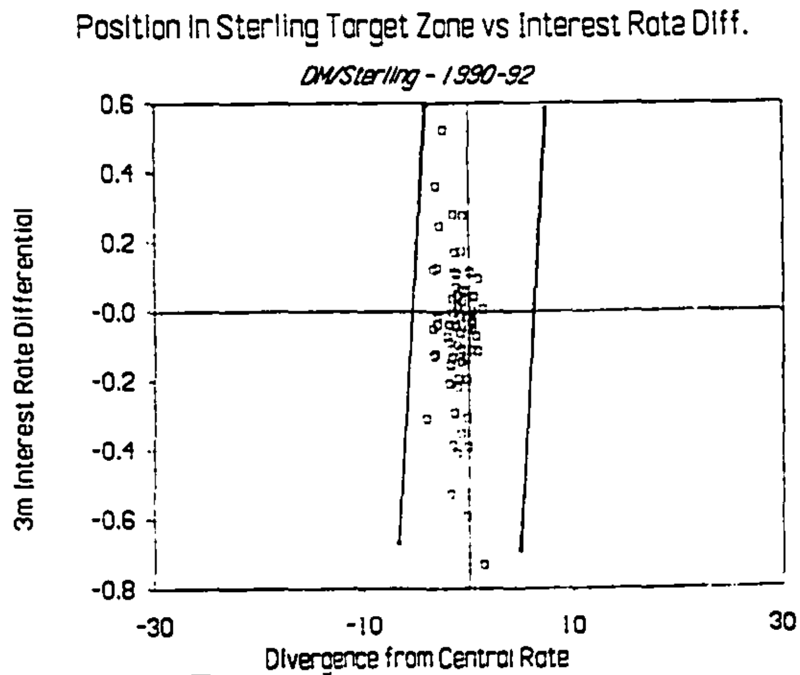

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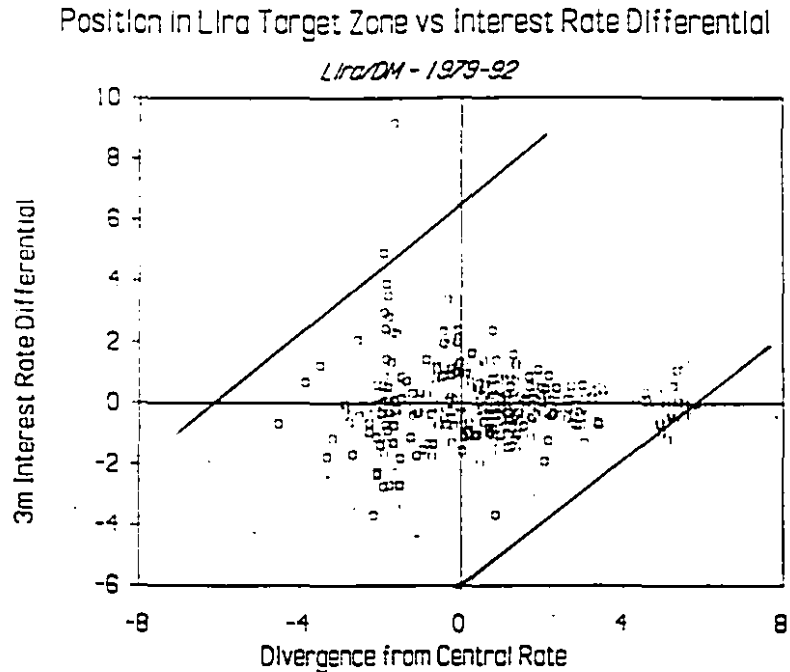

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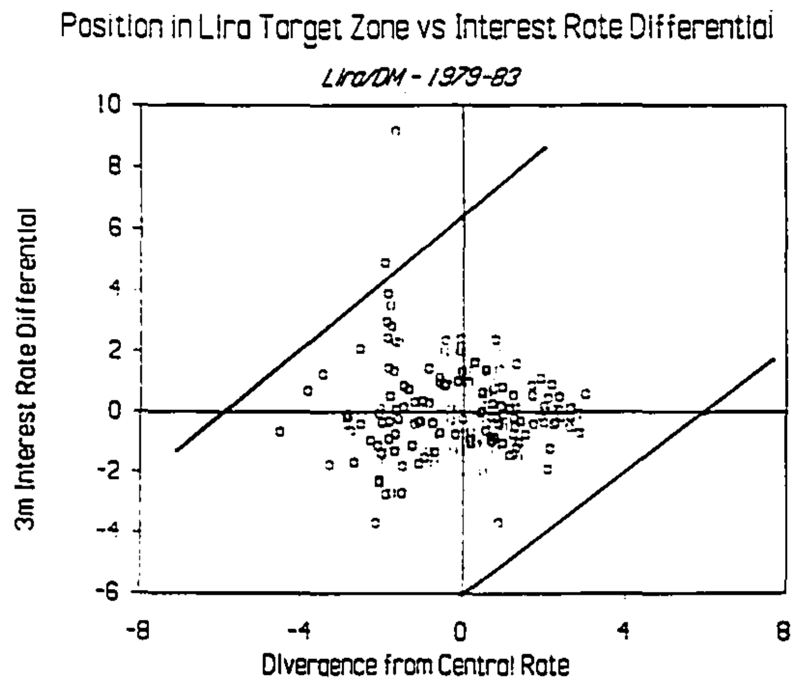

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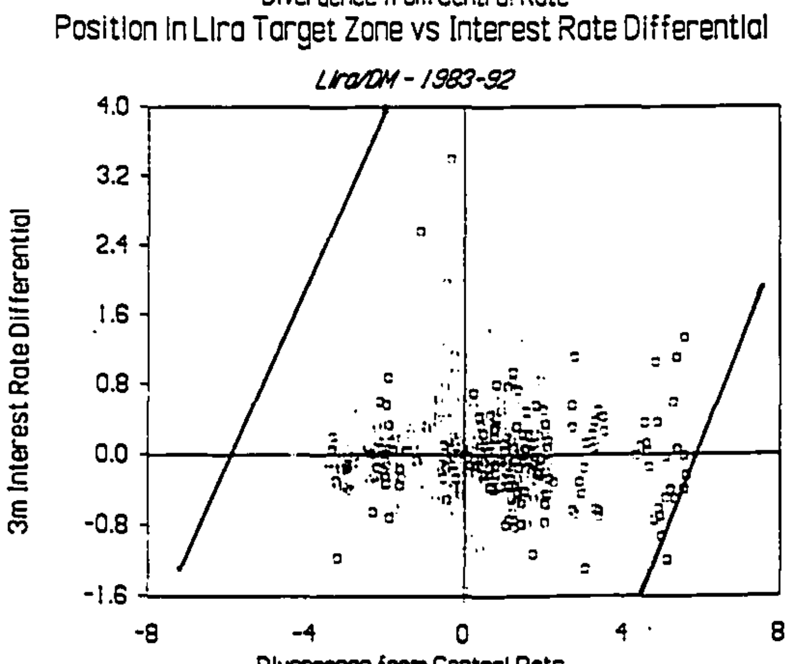

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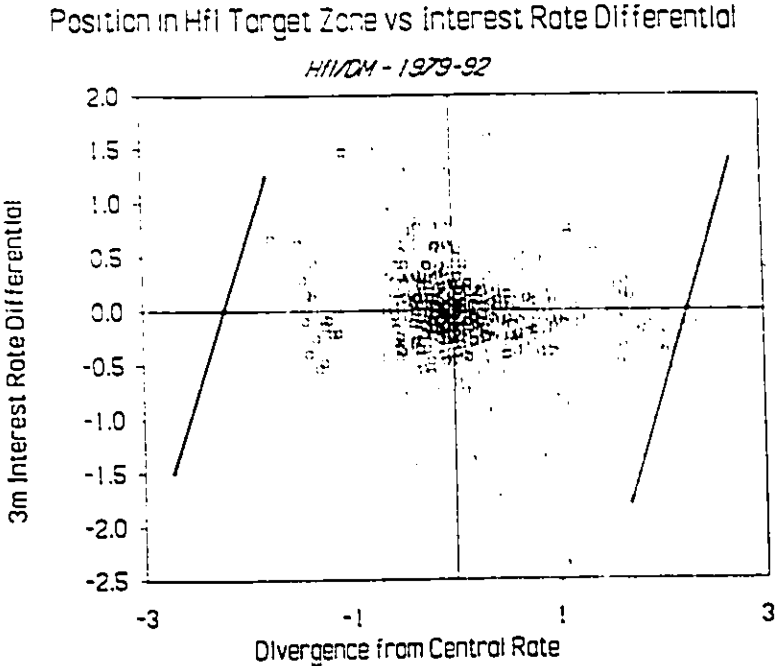

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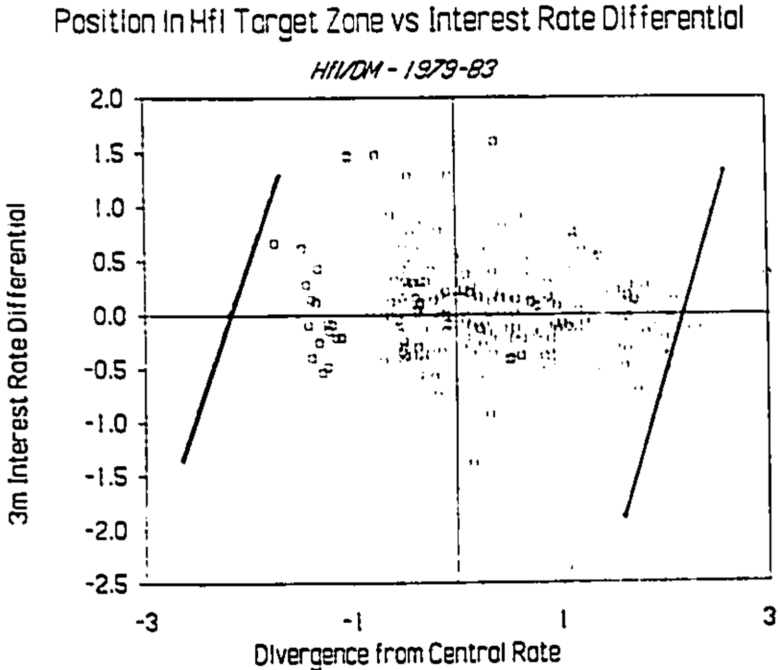

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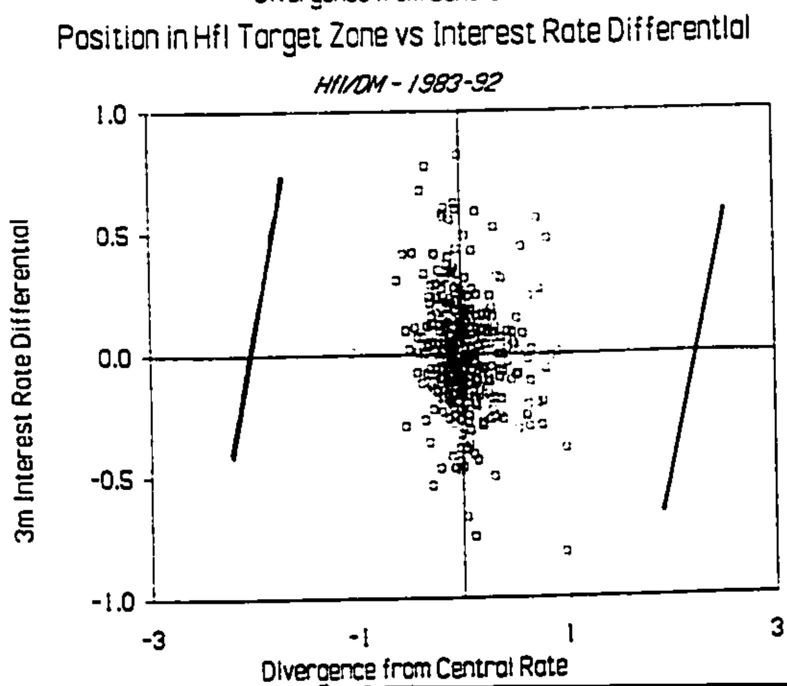

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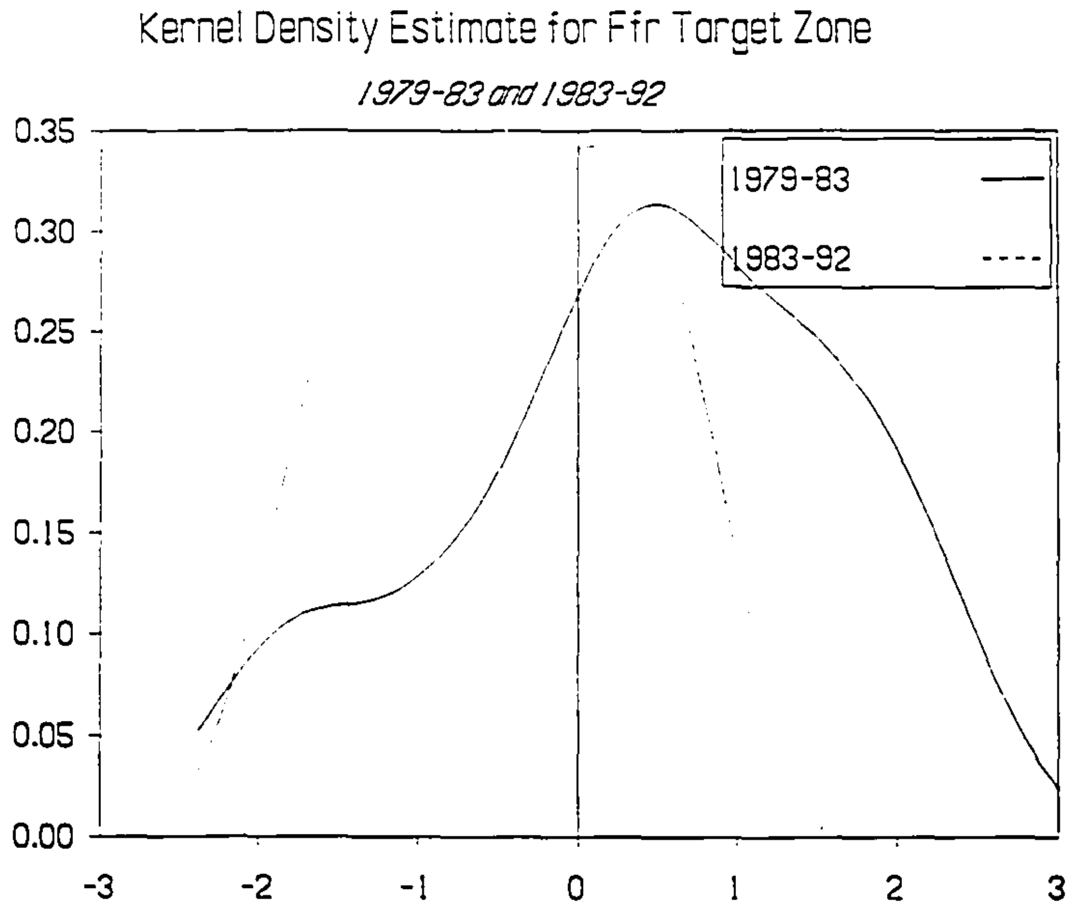
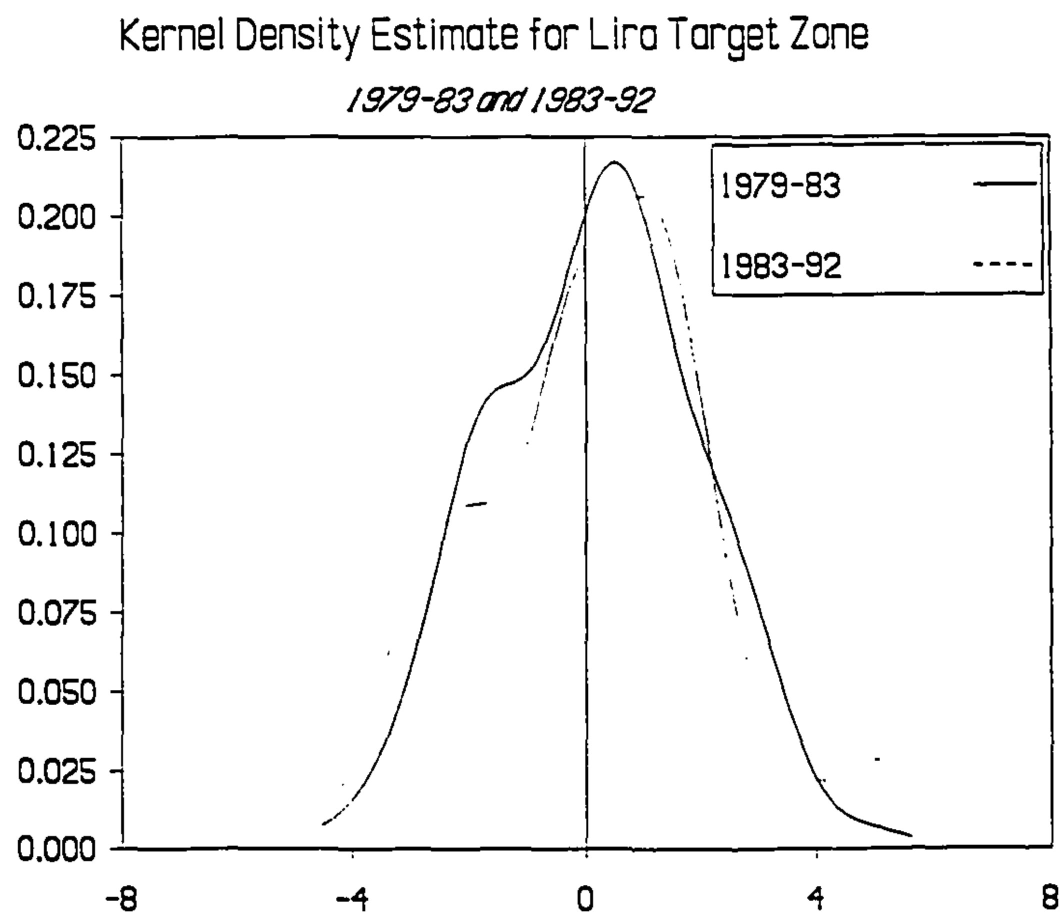


Figure 4.31



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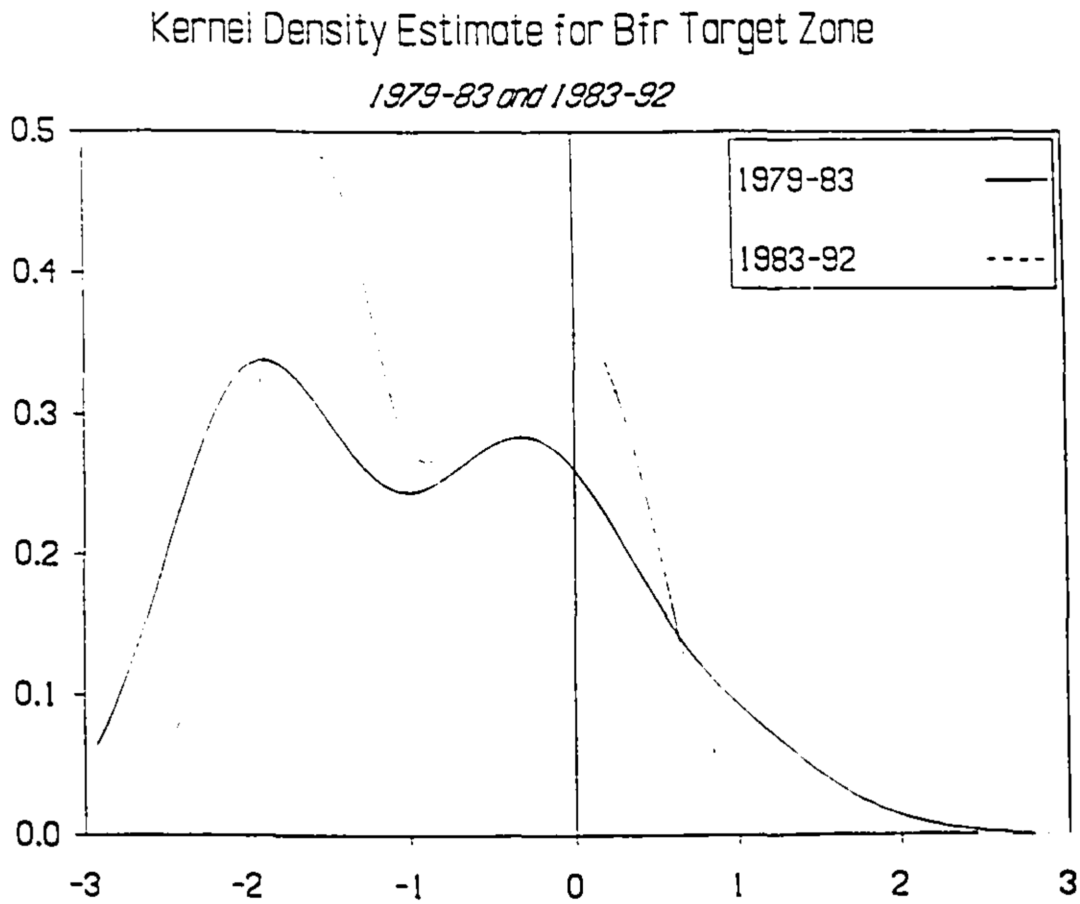

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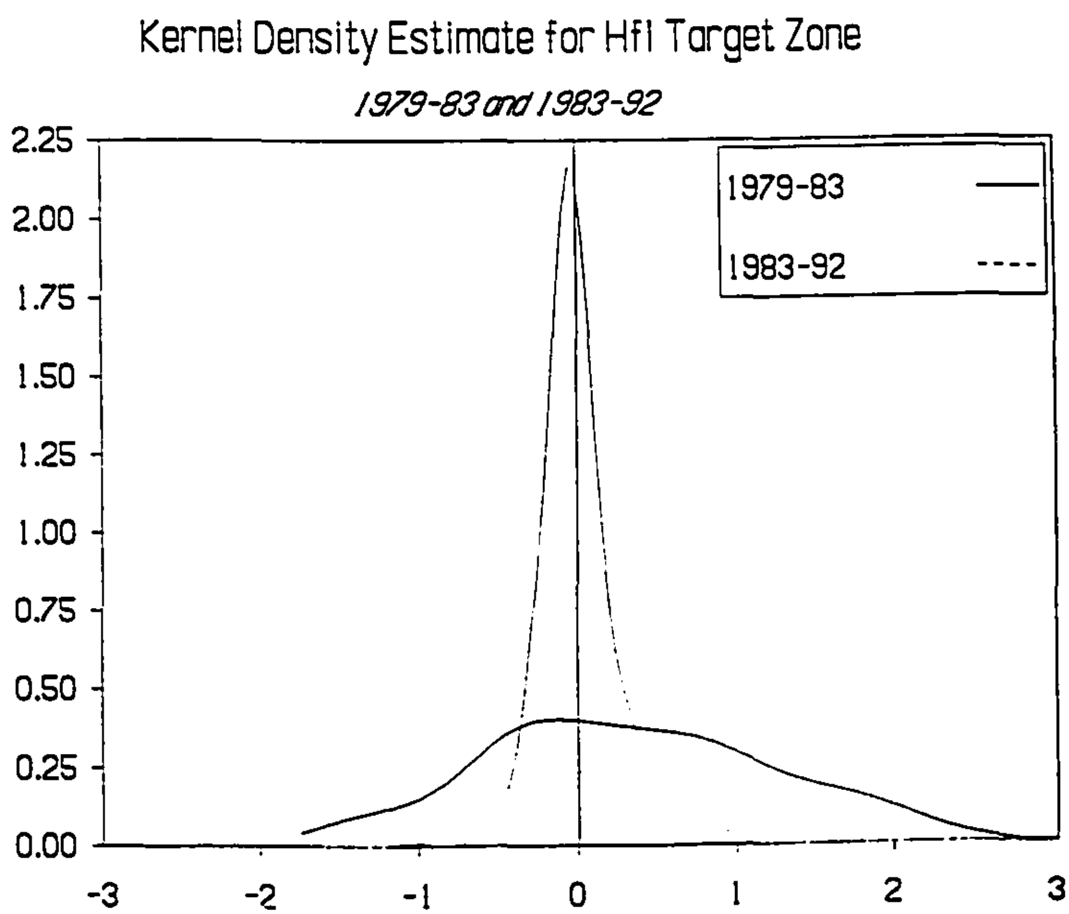
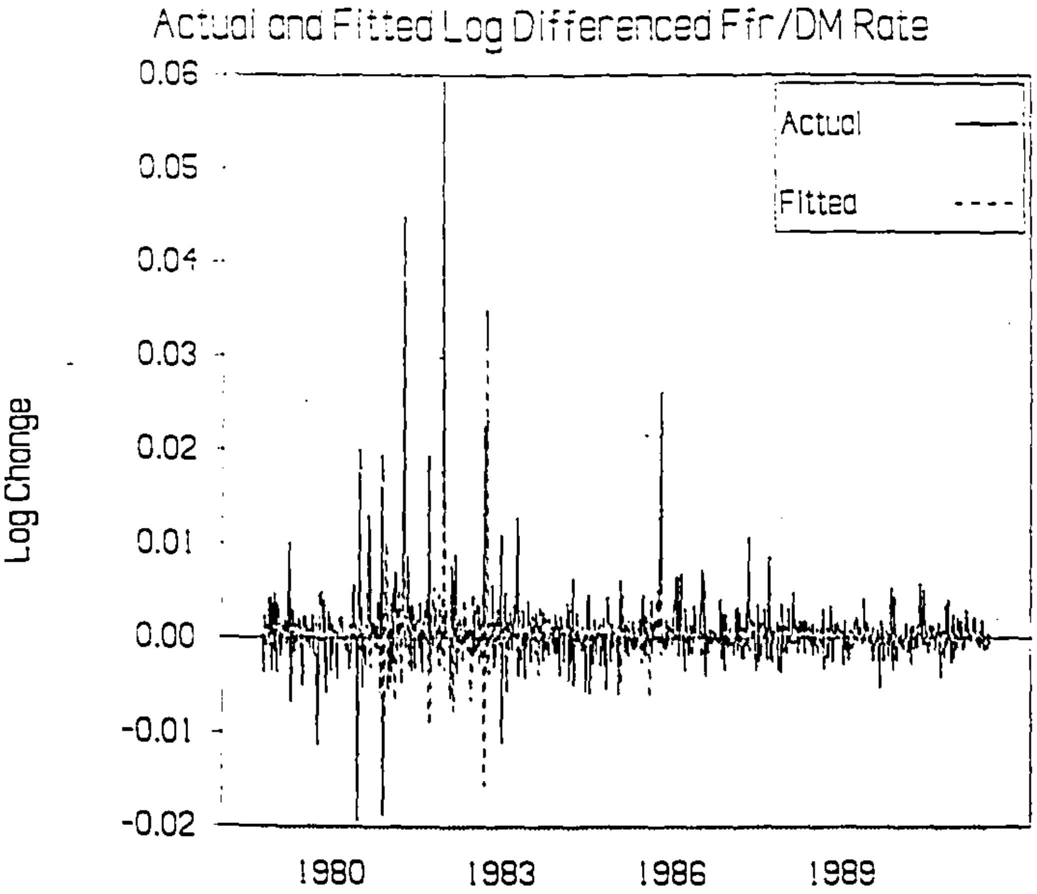


Figure 4.34



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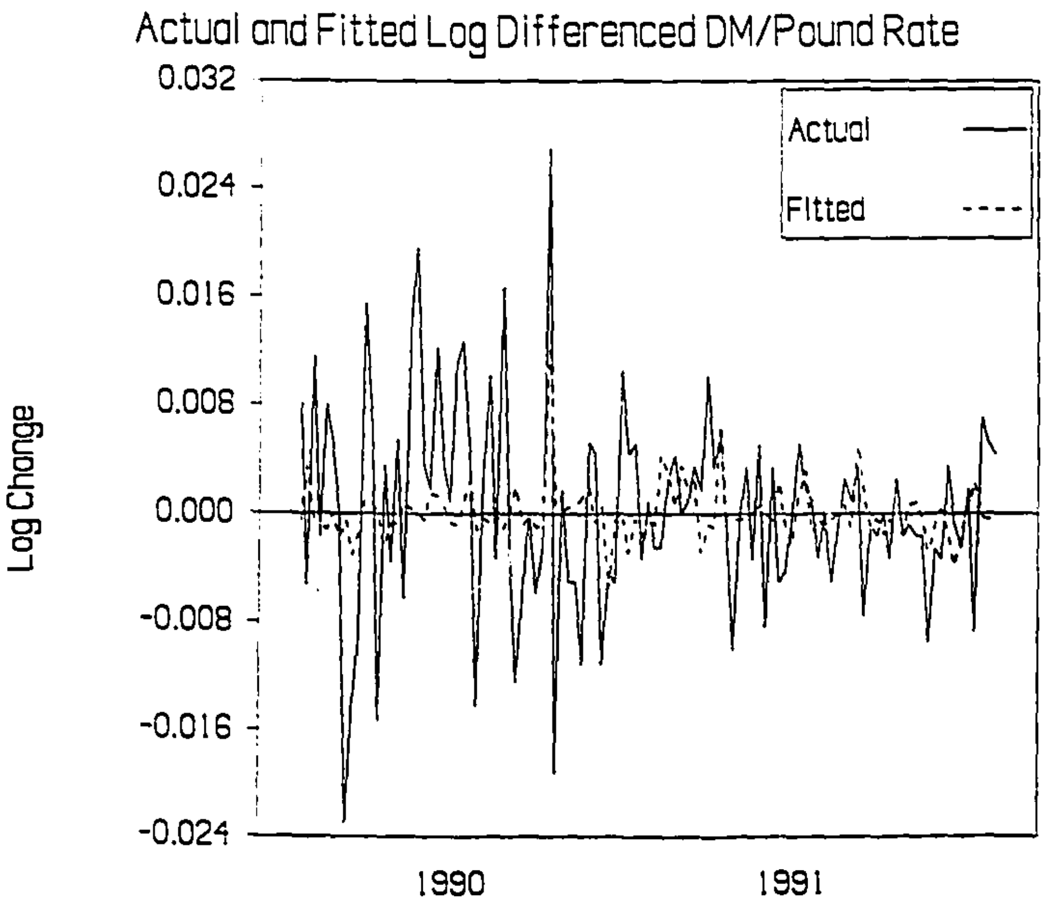

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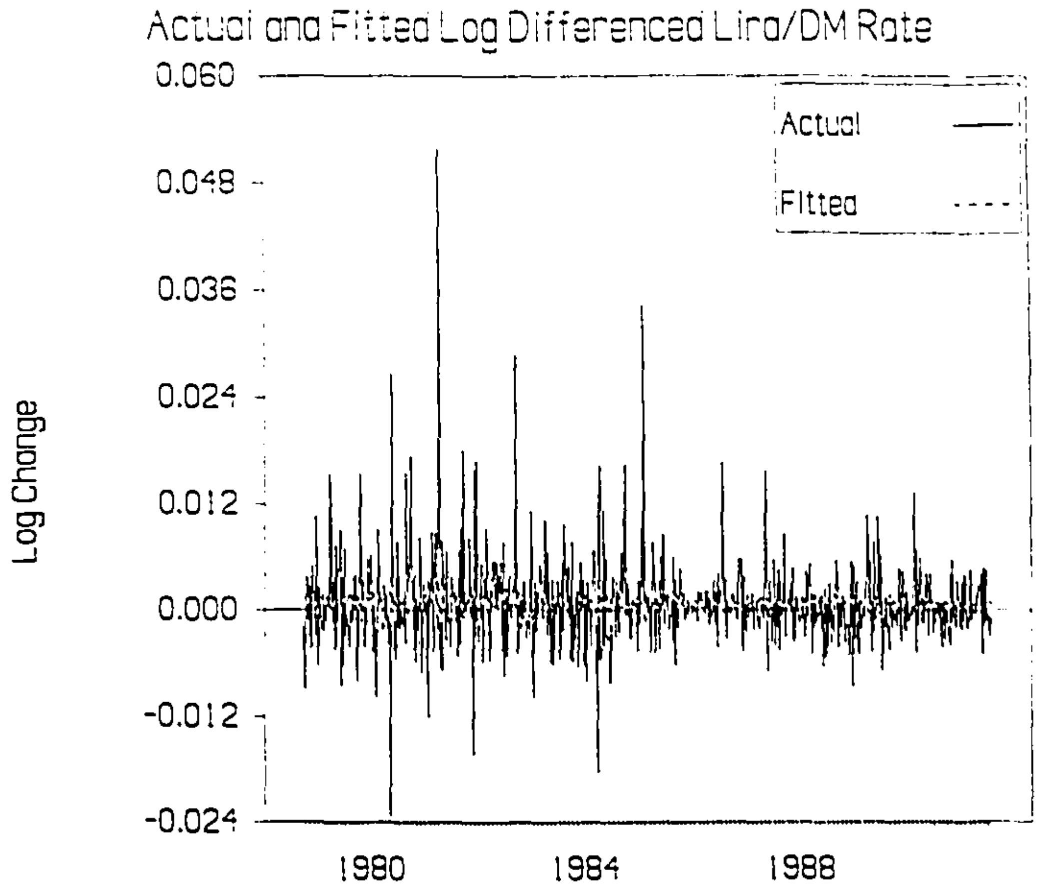

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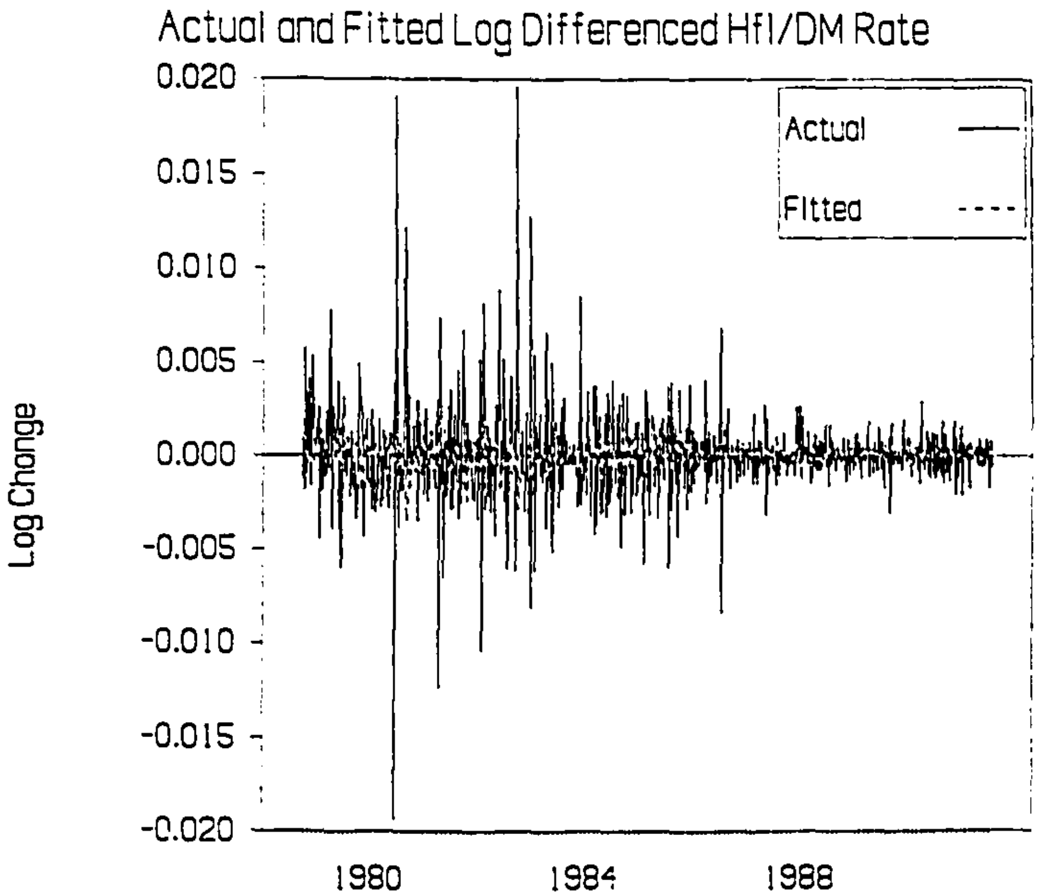

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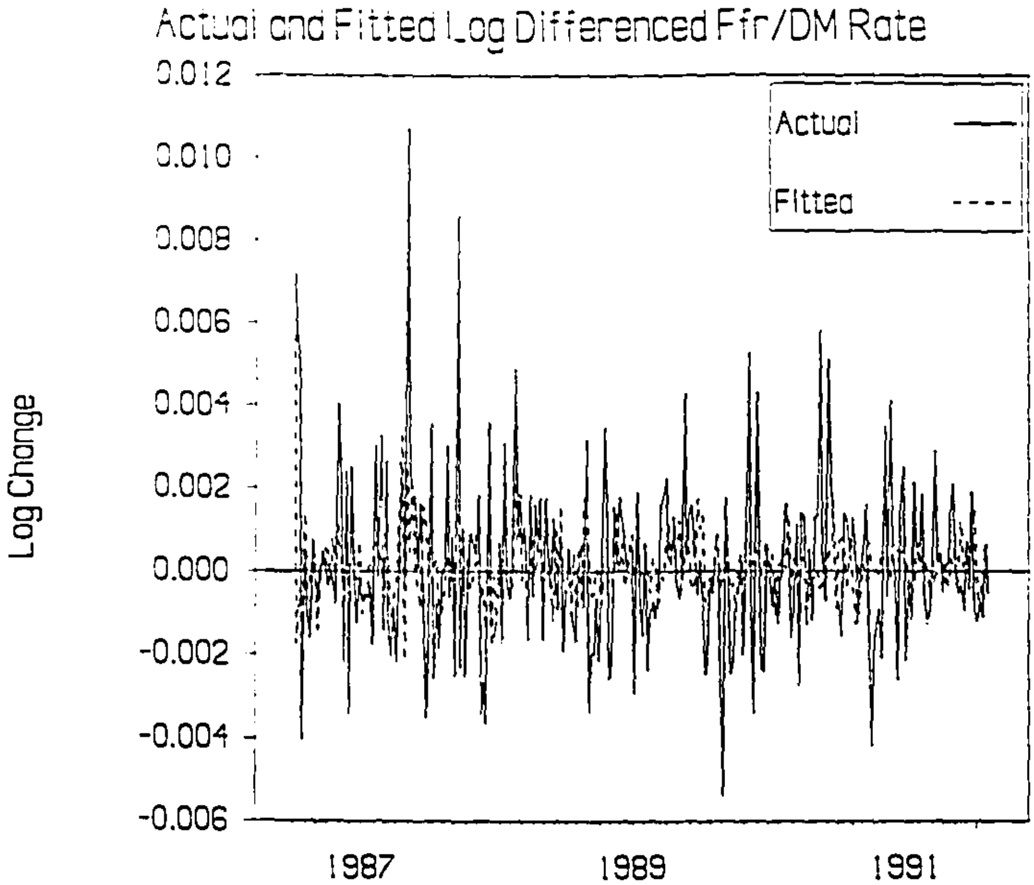

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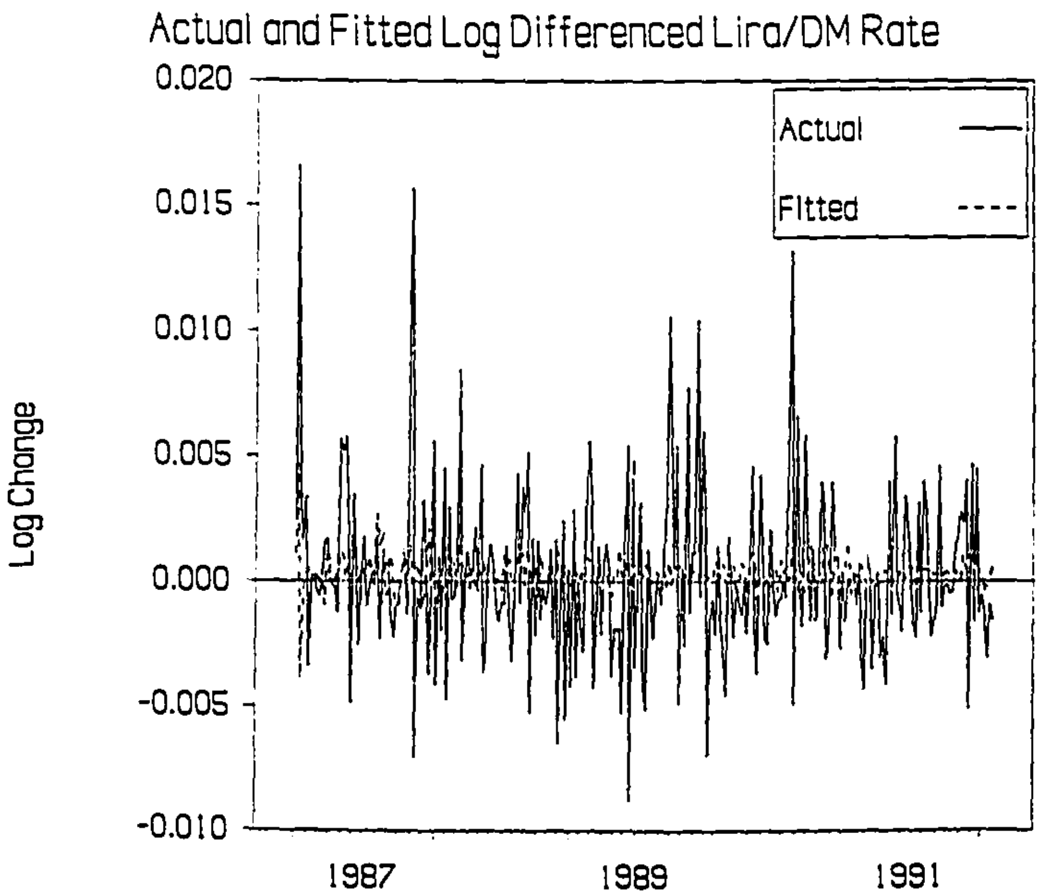

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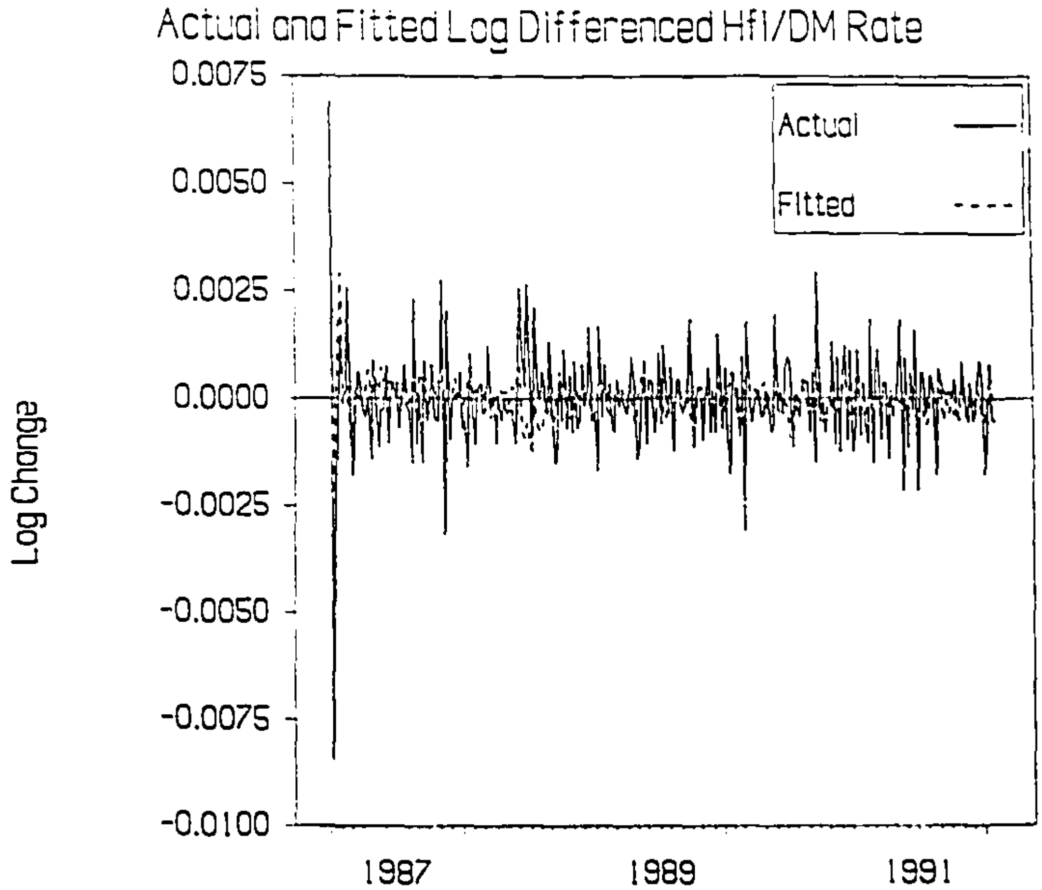

Actual and Fitted Log Differenced Hfl/DM Rate
Actual
Fitted
Log Change
0.0075
0.0050
0.0025
0.0000
-0.0025
-0.0050
-0.0075
-0.0100
1987
1989
1991