Volatility and the Euro: an Irish perspective

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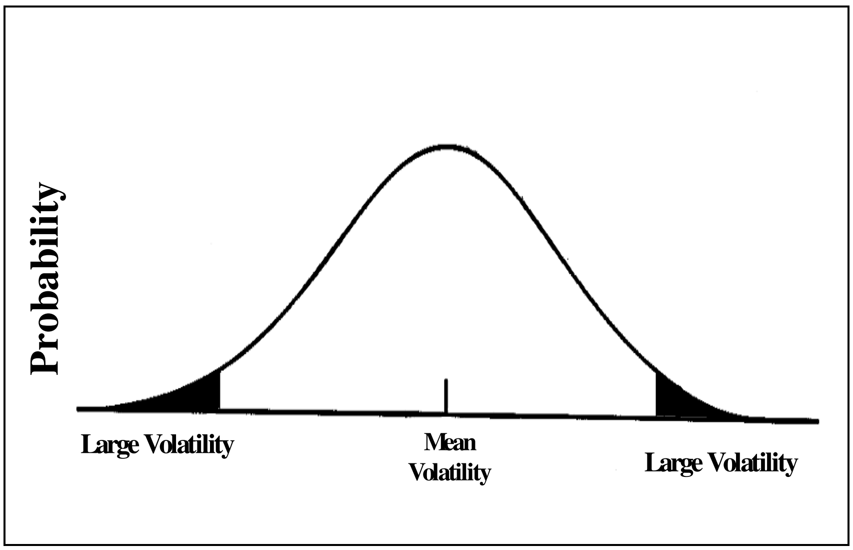
1. INTRODUCTION

With Ireland joining European Monetary Union (EMU) and adopting the euro, exchange rate risk between participating Member States is gone.[1] However, as is known, this new currency will continue to face exchange rate risk, and any general reduction of volatility on a day to day basis for Irish economic agents neglects to take account of possible extreme problems with the euro. In this paper we will see that even though the euro is a managed, or irrevocably fixed, system, trade between Ireland and non-members, most notably the UK and the US, involves two separate currencies. This trade will require currency trading, leading to the possibility of large downside exposure to exchange rate risk for Irish firms. In addition, dealings in capital markets may be inhibited thereby reducing the funds available for investment purposes.

The issue of currency volatility is important for policy-makers as high levels will generally reduce economic growth. Causes of an economic slowdown may be due to a reduction in investment, or firms setting prices too high in an attempt to satisfy their risk averseness. Two recent examples of exchange rate volatility show the downside implications of large currency changes. First is the experience of the Mexican peso disaster that reduced that country's real output by 6 percent in 1995 (Source).[2] Second, with more relevance to the Irish economy, is the 1992/93 crises of the EU Exchange Rate Mechanism (ERM) where failed attempts to avert forced devaluations cost all participating members between £100 billion and £150 billion (Source). These two examples show the power of speculators in exchange rate trading, and there is no reason to believe that the creation of a single currency will eliminate this type of activity in the foreign exchange markets.

The methodological approach relied on in this paper is two-fold. First, conditional volatility is measured using a *Generalised AutoRegressive Conditional Heteroskedasticity* (GARCH) model. This will demonstrate the extent to which exchange rate movements have varied over time, with periods of low and high volatility. Second, exchange rate fluctuations are examined using *Extreme Value Theory* (EVT). This in essence determines exchange rate fluctuations allowing for the true data characteristics to be imbedded in the calculations. With EVT the more common, or average levels of volatility are not primarily of concern to economic agents as they are reasonably small in nature, and only have minor policy implications. Rather, it is large exchange rate movements that are of concern, as these can impact economic activity to a large degree.[3] A graphical example will illustrate what is being calculated, and its importance. In Figure 1 nominal exchange rates increase or decrease, and these changes can be large or small, with the relative frequency of any fluctuation measured by probability levels. As we can see, the large fluctuations do not occur frequently, but they do have a major impact on an economy, and it is the shaded areas that are of interest to us.

Figure 1: Volatility and a Distribution of Exchange Rate Changes



Volatility levels are analysed for different exchange rate regimes using bilateral nominal exchange rate data involving the Irish pound. As Ireland's main trading partner is the UK, considerable attention is placed on analysing the pound/sterling relationship since 1979. This period of analysis covers both countries being part of the managed ERM (1990-92) as well as two separate periods surrounding this time frame where the currency control between these economies was less structured. This examination can be compared to fluctuations in the euro by analysing future rates that are available since 1997. This analysis is introduced by a presentation of the stylised facts and a description of the general distributional properties of nominal exchange rates. Previous analysis of this type using a related methodology for Irish financial time series has been completed for the equity market (Cotter, 1998 and 1999).

This paper proceeds as follows. Section 2 gives a chronological description of the major events affecting the Irish pound since it formally broke the sterling link in 1979. This is followed in section 3 by a discussion of the problems that may occur from large levels of exchange rate volatility. Section 4 details the empirical characteristics of exchange rate series and how this paper addresses these issues. In particular, the lack of normality and the fat-tailed characteristic are discussed in conjunction with GARCH models and Extreme Value Theory. A basic description of the exchange rate series analysed is given in section 5. This is followed by a presentation of the empirical evidence where three sets of findings are discussed. In section 6 some preliminary statistics for a wide range of exchange rate series are given. Following this, the conditional volatility measures are presented in section 7, and finally the Extreme Value measure detailing the very larger exchange rate fluctuations are discussed in section 8.

2. A BRIEF HISTORY OF THE IRISH POUND

Up until 1979 when Ireland joined the European Monetary System (EMS), the Irish Pound had inextricable connections with sterling. For instance, there was a common currency between 1826 and 1928, and thereafter both currencies traded at parity (Leddin and O' Leary, 1995). Thus, fluctuations in sterling were completely mirrored in the Irish case. As a result, Ireland was part of the Gold Standard between 1924 and 1931 which exhibited low volatility through fixed exchange rates, in contrast to the period of relatively high volatility between 1931 and 1944 when this system was abandoned. After this, the Bretton Woods system induced some calm into exchange rate price movements until this collapsed in 1971, thereafter resulting in more volatile markets. Thus whilst it is clear that these systems were initially set up to be permanent in nature, this cannot be taken for granted regardless of how irrevocable the system appears on its introduction.

Discussing the break of the link from sterling in more depth, it was decided to join the EMS in order to anchor the pound to the German mark. From this, it was envisaged that by tracking the German currency, the economic fundamentals enjoyed by Germany such as low inflation could also be tracked by the Irish economy. Previous fundamental disasters affecting the UK, such as high inflation; high interest rates; and most importantly, an unstable currency, had pointed to the advantages of adopting closer ties with the more stable German economy.

Characteristically, the EMS was an example of a managed exchange rate system that mixed floating market conditions with a stringent fixed mechanism. The system relied on the ability of a currency to float within a predestined band, for example ± 2.25 percent, and movement beyond these rate changes were to be restricted through government intervention. Rules that had to be followed within the EMS were laid out in the ERM, which described the initial exchange rate each member economy got through its value in terms of a central currency, the European Currency Unit (ECU)[4]. Each Member State's respective central bank, through the buying and selling of currency reserves, were the agents responsible for ensuring that the currency would not exceed the limits predefined by the ERM.

Initially, joining the EMS did not offer the Irish economy the benefits envisaged. This was due to the Irish authorities trying to stay within the ERM bands while retaining parity with sterling. This policy was short-lived ending within three weeks of its introduction.[5] Thereafter, the pound's tracking of the mark suffered a credibility problem with Irish economic agents, including employers and unions, recognising that the strongest trading partner were not EMS countries, but rather, the UK (Power, 1999). This lack of credibility is demonstrated by Ireland's four realignments during the 1980's. As a consequence, the Irish economy suffered detrimentally during much of the decade with high unemployment, and relatively high interest rates and inflation vis-à-vis Germany. These empirical features go against the arguments that are usually presented in favour of low exchange rate volatility arrangements, namely that it induces economic growth. As we will see, the volatility in currency markets is greater for floating regimes in comparison to their managed counterparts, although the extreme values are actually greater for the latter system.

Between 1987 and 1992, exchange rate stability for the pound was ensured. Thereafter, the bands of the ERM widened to ± 15 percent, allowing for large levels of exchange rate fluctuations without the intervention of a country's monetary authority. In practice, central banks allowed currencies to be part of a 'soft' exchange rate zone with wide fluctuations being allowed over the short run, and stability being provided by narrow fluctuations in the long run (Bartoline and Prati, 1999). For example, this policy was applied during the peso crises in 1995 where the Irish pound was allowed to depreciate against the mark. After Ireland agreed to join EMU, much of the analysis over the last few years has concentrated on advantages and disadvantages of this decision. Turbulence facing the pound has been moderate and on December 31, 1998 the Irish currency was confined to history, and the euro took its place.

What actually caused the band to be widened was the collapse of the EMS in August 1993 brought about through intense speculative activity on currency markets. Ireland unfortunately suffered extensively during the 1992/93 crises that preceded the collapse and it is worth detailing the events surrounding it as a demonstration of how exchange rates can go through periods of heavy turbulence even when there is a system that is set up to eliminate this feature. A description of the events surrounding the EMS crises is given in Table 1.

Table 1: A Chronology of the EMS Crises, 1992-1993

Date	Event
1992	
June 2	Denmark referendum rejects Maastricht Treaty.
July 16	German discount rate increases to 8.75 percent leaving a differential of 6.75 percent over US rate,
August 20	Sterling rate falls to floor of ERM band.
September 5-6	After a lack of intervention by the Bundesbank, an EC meeting ends with no sign of German appeasement to strong demands for action by UK.
September 16	UK suspends sterling's participation in EMS after numerous attempts to maintain the currency's value within ERM bands.
September 17	Irish pound falls to floor of allowable ERM bands while Italy suspends the lira's participation.
September 24	Ireland imposes capital controls, which has no impact on the pound's value.
November 23	Central Bank of Ireland, amongst others, raises interest rates.
December 3-28	Intensive speculative pressure put on pound and other currencies.
1993	
January 6	Central Bank of Ireland raises official interest rate to 50 percent.
January 7	Central Bank of Ireland raises official interest rate to 100 percent.
January 28	Central Bank of Ireland again raised official interest rate to 100 percent after it was cut in mid-January.
January 30	Irish Pound devalued by 20 percent.
July 31-August 1	After EC finance ministers meet, the EMS band is widened to ± 15 percent.

Source: IMF (1993).

This shows up two important considerations when thinking about the history of Irish exchange rate policies. First, the divergence between sterling and the mark was central to the currency problems and their impact on the Irish economy. Ireland's attempt to track the mark to attain macro stability, and sterling to remain competitive with their main trading partner, was unfeasible anytime that sterling became unstable. The fact that sterling was part of the EMS should have implied that the Irish authorities were now within a formal system that allowed them to achieve their goal of importing the positive macro fundamentals experienced by Germany, while remaining competitive in trading with the UK. However, the actions of the Bundesbank in trying to support the unification of Germany were unacceptable to the UK government, and they abandoned the system in 1992.

Second, and more importantly in the context of this paper, Table 1 indicates that while exchange rate volatility can sometimes be controlled, it can never be totally eliminated. The EMS, which had the support of the central European economies, was unable to defend individual currencies against speculative attacks. Within a time frame of almost a year, involving major government intervention trying to maintain exchange rate stability, the speculators successfully targeted currency after currency, and through sheer trading volume were able to defeat any policy initiative or trading stance that was put up against them. In the case of the pound, belligerent statements against the speculators by government, unions and employers alike, the use of extensive currency reserves in open market operations, and major adjustments to its key monetary variables together were not enough in their goal of defeating the currency traders. The exchange rate movements resulting from this speculation had a detrimental affect on the Irish economy and led to the view by many commentators that this type of closely managed system led to opportunities for intense speculative activity which could not be withstood.

3. PROBLEMS OF LARGE LEVELS OF EXCHANGE RATE VOLATILITY

A number of disadvantages result from large fluctuations in exchange rates. These normally come under the heading of microeconomic factors dealing with trade including a reduction in investment; risk averse firms setting too high a price; poor price signalling leading to expensive search costs; and a reduction in foreign investment for domestic capital markets (Honohan and Lane, 1999). It is necessary to discuss these at more length and see the extent to which they occur. To set the importance of exchange rate volatility in context, Table 2 shows the importance of external, non-euro trade for individual members of EMU. As we can see, Ireland's reputation of being an open economy is very much focused on trading relationships with non-euro partners, and this activity as both a percentage of GDP and total trade outweighs that of the other single currency participants. Ireland's booming economy is very much driven by our external trading activity. This implies that Ireland is very much exposed to fluctuations in the euro with the currencies of its trading partners. Any problems with the euro currency will have major implications for Ireland's external trade balance. However, if the UK joins EMU this would very much reduce this concern given the very strong trading relationship there is between the two economies.

Table 2: Non Euro Area (NEA) Trade 1998

	NEA Trade/GDP %	NEA Trade/Total Trade %
Ireland	85	64
Belgium/Luxembourg	50	39
Netherlands	48	45
Finland	39	65
Germany	26	55
Austria	22	29
Italy	20	52
France	20	47
Portugal	19	33
Spain	17	41

Source: Eurostat (1999).

Concentrating more fully on the problems encountered by large levels of exchange rate volatility raises a number of issues. A simple example can illustrate the costs incurred by consumers in exchange rate transactions. The European political establishment in favour of a single currency, suggested that the transaction costs of exchanging currencies within the EMS countries was worth 0.5 percent of EU GDP (European Economy, 1990). Intra-EU exchange rate volatility was the cause of this loss. Now these costs are eliminated within EMU, they still occur between euro zone members and non-members, for example between Ireland and the UK.[6]

However, there are two commonly used arguments that negate against this hypothesis. First, hedging products are available that diversify against or eliminate exchange rate risk.[7] Whilst these are not costless assets, their popularity would suggest that they are perceived to be successful in reducing exchange rate risk. At the very least, an upper limit of risk effects is set in place, similar in purpose to the bands of the ERM. Countering this, we are still dealing with imposing expenses, however small these may be, to counteract currency fluctuations. Second, volatility in exchange rates between two economies does not imply volatility for all bilateral rates. Thus an economic agent can shift their consumption choice away from markets involving volatile currency movements that result in blurred pricing policies, to suppliers in other economies. However, whilst this may imply that world consumption is not affected by specific cases of bilateral currency fluctuations, trade between the economies with volatile exchange rates is affected. Assuming the volatile case involves the euro, then Ireland will be affected considerably according to the data in Table 2.

Now examining the impact of exchange rate instability in a more formal context, we can start by noting that changes in economic growth and international trade are positively related (Sachs and Warner, 1995). This implies that a reduction in economic activity between countries reduces the welfare of their citizens. It is clear that both a decrease in investment, and uncompetitive prices being charged by risk adverse firms, due to nominal exchange rate fluctuations lead to a downturn in economic growth. Risk adverse agents will be put off extra intermediate consumption in the case of firms, and further final consumption in the case of households due to the uncertainty caused by currency fluctuations.

Supporters of a single currency as a prerequisite for a Single European Market (SEM) have always cited the lack of competitive pricing caused by volatility in Member State currencies. Unclear pricing signals led to unnecessary search costs that put the consuming economic agent at a disadvantage. These search costs were beneficial for domestic suppliers who could shield inefficiencies through their newly acquired extra market power. Removing these currency-induced distortions would enhance the competitive behaviour of the euro zone countries leading to increased economic growth. Other micro distortions that result in blurred price signalling include tax and labour market ones, resulting in a similar downturn in economic activity. The measurement of these distortions in economies is very difficult to compute however, as they are second order influences and their accurate forecasting is unresolved (Flood and Rose, 1995).[8]

Liquidity in financial markets also is affected by exchange rate fluctuations. There is a negative relationship here with increased volatility leading to reduced trade in financial products. First, this will worsen borrowing conditions for firms in domestic markets as foreign investment in these markets is reduced due to the exchange rate risk. Obviously, this will again reduce domestic economic growth. Second, the lack of financial market liquidity will reduce the choice of financial products available. Thus, risk management practices will neither be as wide ranging or efficient as a result, again leading to reduced economic growth (Obstfeld, 1994). Specifically, a lack of efficient risk management practices on an international scale that would provide effective hedging against exchange rate crises is of paramount importance given the relatively recent currency crises in Europe and Asia.[9]

4. STYLIZED FACTS OF NOMINAL EXCHANGE RATES

This section outlines the previous evidence on the time series properties of exchange rates. Two fundamental findings are made, namely that volatility clustering occurs and the tail behaviour of an exchange rate's first difference is non-Gaussian, or non-normal. First, volatility clustering implies that periods of turbulence (tranquillity) are followed by further periods of turbulence (tranquillity). The introduction of GARCH models, and their concentration on second moment dependence, has led to this characteristic being commonly used as part of the exchange rate modelling process.[10] The second characteristic is usually referred to as the *'fat-tail puzzle'* where an asset exhibits too many extreme returns in comparison to a normal distribution. Evidence of this property for currency time series also suggests that the extent to which a distribution of exchange rate returns exhibit fat tails reduces with the extent to which the currency is allowed to float (Koedijk and Kool, 1994). Thus, the stricter the regime, the greater the fat-tail characteristic.

Modelling of Time-Varying Volatility

The seminal development of examining time-varying volatility owes much to the ARCH model of Engle (1982). The process is formally outlined in Appendix A. Realistic descriptions of volatility persistence could now be examined by allowing the conditional variance to be time dependent as would be expected given the uncertainty that exists in the formation of exchange rates. Bollerslev's (1986) extension to the ARCH model allowed the conditional variance to be also dependent on past levels of the conditional volatility estimates. The GARCH (p, q) process is also outlined in Appendix A.[11] This study chooses a GARCH (1, 1) specification to obtain conditional volatility forecasts.

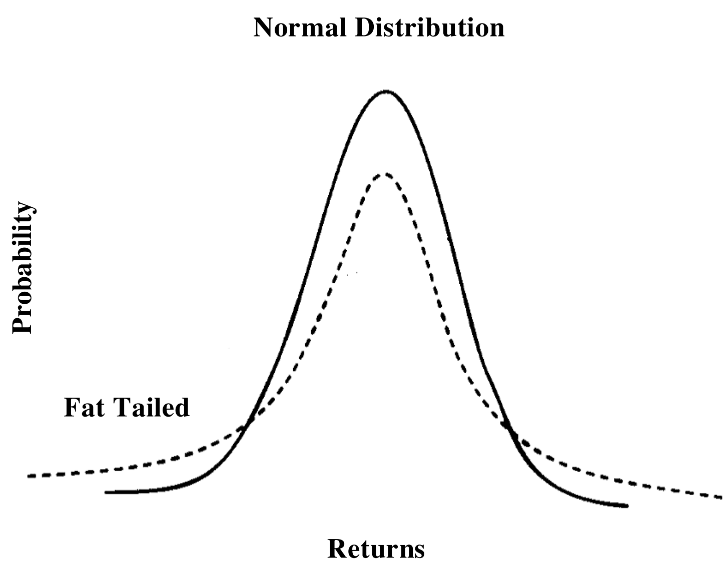
The main advantage for the context of this analysis is that if the conditional variance is to change for any reason over time these models are inherently set up to deal with such an event. This is critical for the modelling of the Irish pound, given the changes that have occurred during its history. Taking the 1992/93 currency crises as an example, volatility in European currencies increased dramatically. This was more pronounced for the pound given its attempt to closely track a currency, the mark, which remained within the EMS, and sterling that diverged on its own path by leaving the system.

Fat-tails and Risk Analysis

In many situations, the long-term risk of a venture is an important consideration of the decision making process. Take for example, the implication that Ireland's membership of the EMS would result in lower volatility vis-à-vis a floating system has been seen as an advantage in terms of international trading possibilities and capital movements into the economy. The rational for this implication is that over sustainable periods of time, but not necessarily immediately, or at any particular moment in time, the pound's exchange rate fluctuations with its trading partners would be smaller. So policy makers recognised that problems would occur at the beginning of Ireland's EMS membership given its previous ties with sterling, and also that they may occur at any time during its membership given that realignments were to be allowed under exceptional circumstances. An analysis of long term risk in such a system requires the examination of its unconditional distribution.

A wide range of techniques can be used in measuring the fluctuations of an unconditional distribution of exchange rate changes. The most common approach in the empirical literature is to assume that exchange rate behaviour approximates a particular standard statistical form, known as the normal distribution. Any derived economic implications from exchange rate movements are calculated on the basis of assumptions underlying this distribution. In reality, exchange rates, as well as other financial asset data, do not have all the properties of the normal variable. The main weakness is referred to as the 'fat tailed' characteristic and its importance cannot be understated as noted by the Chairman of the US Federal Reserve Bank, Alan Greenspan (1997) *"the biggest problem we now have with the whole evaluation of risk is the fat-tailed problem"*. This concept can be clearly seen in Figure 2 where the actual changes in exchange rates are imposed on a normal distribution.

Figure 2: Fat-tailed and Normal Distributions



Here, the probability mass for the fat tailed situation is greater around the tails vis-à-vis the normal distribution situation. This implies that volatility levels calculated assuming normality would be less (and incorrectly so) than that which reality dictates. Inferences regarding future volatility would suffer a similar problem. In contrast, our approach using Extreme Value Theory allows for the fat tailed situation. Rather than fully outline the operations of Extreme Value Theory, the main characteristics are discussed here with further results available in Appendix B.

We want to determine probabilities of exchange rate fluctuations reaching a certain magnitude. The greater the magnitude, the greater the levels of volatility. Looking at Figure 1, we have made two cut-off points where the currency appreciates (depreciates) by a large amount. Assuming that these thresholds each represent a certain percentile of all first differences analysed for a particular currency, we can use Extreme Value Theory to provide accurate information on a number of issues. We can examine a spectrum of arbitrary cut-off points, and determine the probability of exceeding this level of exchange rate changes using the Excess Probability estimator. The expression used to calculate this is given in Appendix B. Comparisons can then be made for currencies with different volatility levels.

The advantage of using Extreme Value Theory is that the exact distributional form of the asset being analysed does not have to known. Rather, we assume that there is convergence at the limit to one of three types of distribution, including one with fat-tailed characteristics. Convergence to the fat-tailed distribution is similar to the use of the central limit theorem with Extreme Value Theory relying on order statistics, whereas the latter deals with averages. In order to obtain the excess probability measure a tail estimate is required.[12] The semi-parametric *Hill Tail Index* is the efficient measure, and is chosen from a range of moment estimators (Kearns and Pagan, 1997).[13] This estimator is given in Appendix B.

Extreme Value Theory is used to address nominal exchange rate stability in two ways in this paper. First, it examines volatility levels of different exchange rate regimes, under two broad headings, floating and managed. In particular, it determines a worst case scenario at a given confidence interval and the length of time over which this event should occur. For example, the following type of statement could be made. There is a one percent chance (probability 0.01) that daily exchange rate fluctuations are in excess of ten percent for a regime every ten years. From this type of analysis, volatility levels can be compared for various exchange rate systems. Past evidence (for example, Flood and Rose, 1998) suggest that in general floating nominal exchange rates result in average fluctuations that are greater than their managed counterparts. This is intuitively true - managed systems rule that the rate fluctuates to a certain degree, and thereafter, intervention takes place to limit the exchange rate changes; but it does not take account of realignments or even worse, the managed system collapsing. Such crises in exchange rate markets are not supposed to happen, but unfortunately, reality dictates that they do. These incidents result in extreme volatility levels leading to massive costs for the economic agents affected.

Second, and related to the issue of exchange rate fluctuations, a spectrum of excess probability levels is provided at different volatility levels. This provides information for a comparative analysis of volatility levels inherent in alternative exchange rate systems, and policy makers can now see that exchange rate stability is of concern not just in the past, but more importantly, also in the future. That is, by using the Extreme Value approach, we can quantify a range of volatility possibilities at different confidence intervals. And the decision maker, whether they are an exporting firm or giving advice to the Department of Finance, can make their contribution by taking account of their risk preferences. For example, a highly risk averse exporter would try to introduce techniques such as hedging (or in an extreme case, change their trading strategy by concentrating on the domestic market) so as to combat the projections of exchange rate fluctuations as calculated by our technique.

5. DATA CONSIDERATIONS

Overseeing the analysis in this paper is a comparison of the Irish experience as part of the EMS, and possible future experiences under the euro. Spot exchange rates are chosen, as these are the variables that clear the market between importers and exporters. The euro futures contract is chosen due to lack of sufficient data available for the underlying asset. Before, determining the conditional volatility levels inherent in different nominal exchange rates, some preliminary findings are presented for a number of currency series. These series are presented in Table 3 giving the respective time periods of analysis.

Table 3:Exchange Rate Series

Currency	Time Period
Euro	May 97 – Oct. 99
Sterling	Mar. 79 – Dec. 98
Deutsche Mark	Mar. 87 – Dec. 98
Dollar	Mar. 87 – Dec. 98
Argentine Peso	Mar. 87 – Dec. 98

Five exchange rate series, four spot and one futures, are chosen to indicate different relationships that have affected Ireland in the past, and may also in the future.[14] The two main currencies that the Irish pound has had formal links with, the mark and sterling are included. The US dollar represents the currency of the main economy of the world, and has a major influence on world capital movements. The Argentine peso is included, not for reasons involving major economic interactivity between Ireland and Argentina, but rather, to indicate a more volatile relationship of which exchange rates are capable of. As well as the interest rate parity conditions that require focusing on in the futures series, the euro-dollar rate is chosen to indicate investors perceptions on the development of this new currency. This exchange rate also describes the levels of volatility that Irish economic agents may face over time.

Initially, the euro-dollar rate is available from May 1997 to October 1999. Dealing with the spot rates, we identify three separate time periods encompassing the lifetime of Ireland's participation in the EMS. First, there was the period between March 1979 and February 1987 where realignments within the system were commonplace, with the pound trying to track two diverging currencies, sterling and the mark. Second, involved a more coherent approach by participating members between March 1987 and September 1993, but also including the currency crises that led to the major revamping of the EMS.[15] Finally, the third sub-period focuses on the time frame between October 1993 and the conclusion of the EMS in December 1998. The bands of the ERM were widened in this period for exchange rate movements upto 15 percent, but in practice, governments followed a 'soft' exchange rate policy that allowed for large short run fluctuations, while at the same time, constraining long run changes to narrow bands.

6. PRELIMINARY FINDINGS

Some preliminary statistics for the exchange rate series are presented in Table 4. All currencies exhibit excess kurtosis and a lack of normality regardless of time period. [16] The excess kurtosis represents a distribution of exchange rate price changes that is peaked around the mean and is also fat-tailed. Time-varying volatility with periods of tranquillity and turbulence cause the leptokurtosis.[17] The absence of normality implies using alternative processes to correctly model currency movements. Also, skewness is generally present for the series' analysed giving a non-symmetric distribution of returns. There is a slight discrepancy between the spot series and the euro in terms of the direction of the asymmetry of returns. The euro is significantly positively skewed indicating more positive price changes than negative ones. Nevertheless, the impact of these negative rate movements outweighs the positive ones as the euro has actually depreciated in value against the dollar since its inception. However this depreciation, measured by the mean value, is not significant.

Table 4 Summary Statistics for Exchange Rate Returns Series

Currency	Mean	Std. Deviation	InterQ Range	Skew.	Kurt.	Normality
FUTURES RATES						
Euro	-0.02	0.59	0.72	0.43*	0.83*	0.06*
SPOT RATES						
Mar 1979 – Feb 1987						
Sterling	0.00	0.53	0.51	0.05	6.15*	0.08*
Deutsche Mark	NA	NA	NA	NA	NA	NA
Dollar	NA	NA	NA	NA	NA	NA
Argentine Peso	NA	NA	NA	NA	NA	NA
Mar. 1987 – Sept. 1993						
Sterling	0.00	0.46	0.37	-1.37*	28.45	0.10*
Deutsche Mark	-0.01	0.27	0.05	-20.17*	574.98*	0.30*
Dollar	0.00	0.78	0.72	-0.96*	11.57*	0.09*
Argentine Peso	-0.52	4.13	0.89	-7.40*	133.17*	0.30*
Oct. 1993 – Dec. 1998						
Sterling	-0.01	0.36	0.34	-0.09	3.47*	0.07*
Deutsche Mark	0.00	0.40	0.37	-0.38*	4.56*	0.11*
Dollar	0.00	0.54	0.57	-0.22*	2.64*	0.05*
Argentine Peso	-0.01	0.55	0.58	-0.27*	2.61*	0.05*

Notes: All exchange rates are in terms of one unit of an Irish Pound with the exception of the Euro which is quoted in Dollars. Std. Deviation, InterQ Range, Skew and Kurt represent the standard deviation, interquartile range, skewness and kurtosis coefficients respectively. Normality is tested using the Kolmogorov-Smirnov statistic. The critical value for the skewness, kurtosis and normality tests is zero. The symbol * indicates significance at the five percent level. Mean, standard deviation, range and interquartile range measures are presented in percentage form.

The interquartile range gives a preliminary indication of the extent of exchange rate movements by focusing on the difference between the seventy-five and twenty-five percentiles. We see that the floating currencies indicate greater values for this statistic than those with a more rigid relationship, thereby supporting the view that the volatility of fixed mechanisms is less than their flexible counterparts. More importantly, in the context of Ireland's history, the interquartile range of the euro is greater in magnitude than experienced by the pound-mark during its period of membership in the EMS. This is consistent with the finding for the pound-sterling rate.

Turning next to the most commonly cited volatility measure, the unconditional standard deviation, we see that this value is quite substantial for the euro with average values in excess of 0.5 percent. Again this value is in excess of that experienced by the pound-sterling rate. We can see that those currencies with a more rigid relationship, for example, the mark had relatively low average levels of volatility vis-à-vis floating currencies. In addition, we also note that there is in general an overall reduction in volatility over the lifetime of the EMS as demonstrated by this measure.

To summarise, it should be clear from the above analysis that the euro conforms to the characteristics of other currencies. The returns are non-normal, non-symmetric and are leptokurtotic. In addition, the initial signals of volatility indicate a currency that is greater than anything experienced by the pound-sterling rate during the last twenty years. Further analysis through the determination of conditional volatility with a GARCH process, and the impact of large exchange rate changes using Extreme Value Theory, will give us a greater overview of the risk profile of the euro.

7. CONDITIONAL VOLATILITY ESTIMATES

Following on from our initial analysis, this section focuses more narrowly in determining the comparative levels of volatility inherent in currencies past and present facing Irish economic agents. To aid brevity, all other currencies with the exception of sterling and the euro are hereafter ignored. Sterling is included to illustrate the comparative volatility for Ireland's main trading partner during the last two decades. Three areas related to conditional volatility estimates are examined. First, the conditional variance of the series' is measured using a GARCH (1, 1) process. This is followed by a graphical representation of the conditional second moments. Finally, a comparative analysis of the variances' descriptive statistics allows us to further infer on the extent of volatility that is inherent in the currencies.

Table 5: GARCH (1,1) Models for Daily Exchange Rate Returns Series'

	Euro	Sterling (79-87)	Sterling (87-93)	Sterling (93-99)
α_0	0.00	0.00	0.00	0.00
	(1.38)	(7.40)	(12.25)	(1.58)
α_1	0.04	0.16	0.10	0.05
	(2.33)	(9.68)	(12.84)	(7.75)
β_1	0.91	0.77	0.90	0.95
	(20.10)	(32.49)	(140.44)	(154.82)
Iterations	9	8	20	9
Log Likelihood	2380.98	8029.72	7056.39	6982.49

Notes: T-statistics are in parentheses.

The estimates of the GARCH (1, 1) model are presented for the exchange rate series in Table 5. The parameters appear to be well specified for each series. From these coefficents, estimates of conditional variance are determined and these are plotted in Figures 3 to 6. Focusing on the euro series, we can first see the time-varying characteristic of the short-run volatility. It appears that these fluctuations resulted in peaks around September 1997, September 1998 and July 1999, although daily individual exchange rate changes are reasonably small.[18]

The determination of the comparatively greatest conditional volatility is formally examined in Table 6 where some descriptive statistics are presented. We see here that the conditional volatility for sterling generally reduced during the lifetime of its membership of the EMS. However, it is clear that the average volatility of the euro (.0035) outweighs that of the other series analysed. Focusing on the percentiles we can see the pattern of risk values at different quantiles. Upto the seventy-fifth percentile, the euro volatility outweighs the others series, whereas thereafter this is reversed with the exception of sterling between 1993 and 1999. This points out an important characteristic of the volatility estimates, namely, that while the average variance estimate for the euro is larger than other exchange rate series, their tail values are much smaller than sterling's in the time frame before the widening of the EMS bands in 1993. As these tail values are of major importance to any economic agent who is exposed to them, this suggests that a more detailed analysis of the tail estimates of currency movements would be advantageous by providing information on the dangers caused by these large fluctuations.

Table 6: Mean and Percentiles for Conditional Volatility Estimates of Exchange Rate Returns Series'

Currency	Mean	**Percentiles**				
		5	**25**	**50**	**75**	**95**
Euro	0.0035	0.0025	0.0028	0.0033	0.0038	0.0050
Sterling (79-87)	0.0029	0.0012	0.0016	0.0022	0.0033	0.0066
Sterling (87-93)	0.0023	0.0006	0.0009	0.0015	0.0022	0.0069
Sterling (93-98)	0.0012	0.0002	0.0003	0.0008	0.0019	0.0036

Notes: Measures are presented in percentage form.

Figure 3: Conditional Variance for Euro-Dollar Series

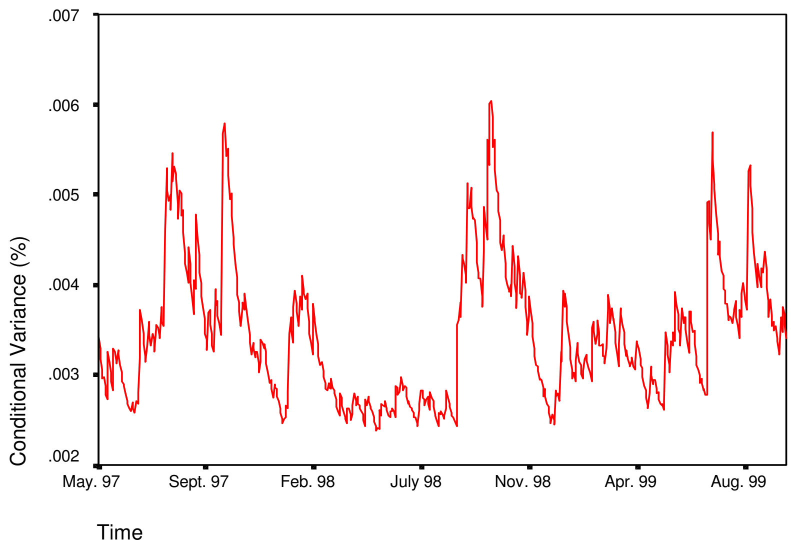


Figure 4: Conditional Variance for Punt-Sterling Series (1979-1987)

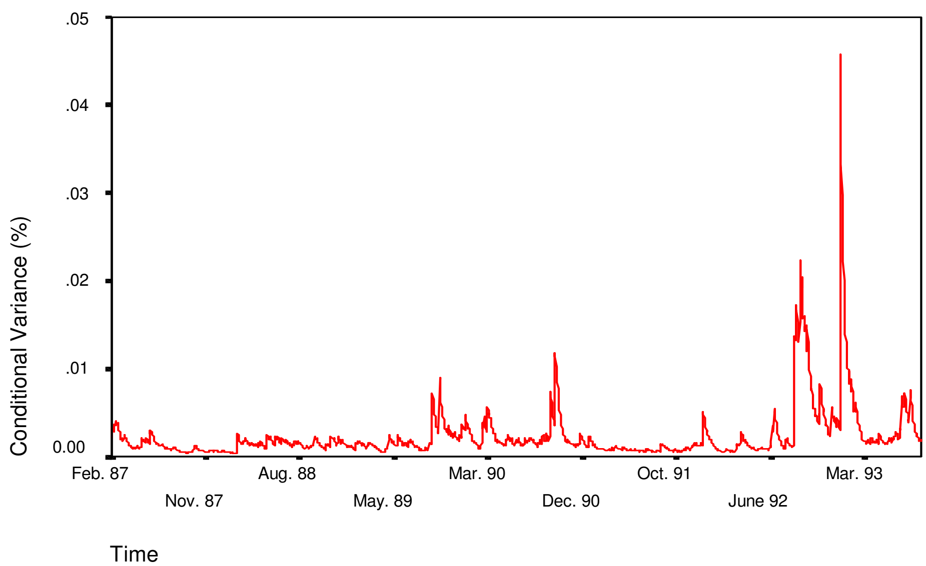


Figure 5: Conditional Variance for Punt-Sterling Series (1987-1993)

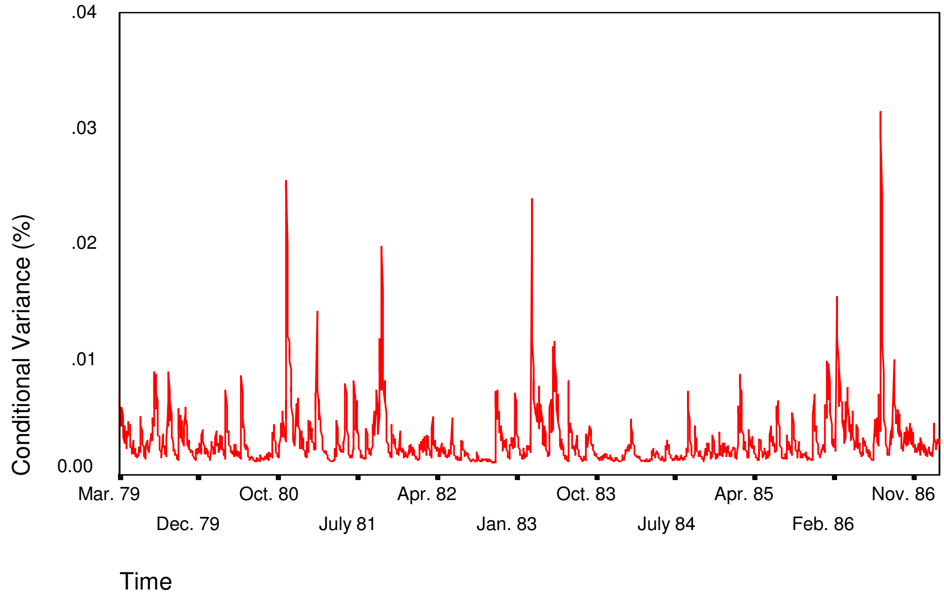
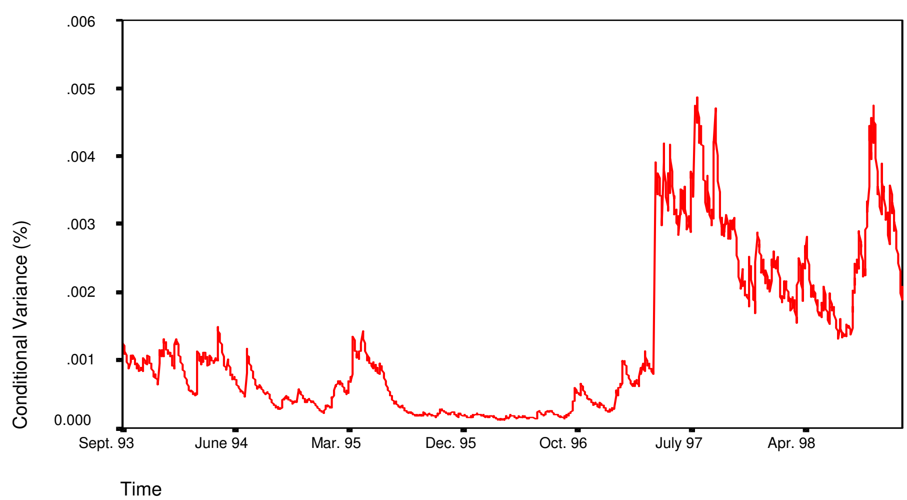


Figure 6: Conditional Variance for Punt-Sterling Series (1993-1998)



8. EXTREME VALUE ESTIMATES

The Extreme Value measure, the excess probability estimate, P_r, deals with the issue of having exchange rate fluctuations in excess of a certain percentage. In Table 7, we see that the probability of having an exchange rate change in excess of 10% to be very low, for example, 0.0008 in the case of the Euro. As we would expect *a priori*, the probability of exceeding a certain value increases as you move to smaller fluctuation levels.

Table 7: Tail Excess Probability Estimates for Exchange Rate Returns Series

Contract	P_r10%	P_r8%	P_r5%	P_r3%	P_r1%	P_r0.5%
Euro	0.0008	0.0020	0.0132	0.1040	8.8049	144.8392
Sterling (79-87)	0.0018	0.0037	0.0164	0.0826	2.6882	24.1949
Sterling (87-93)	0.0099	0.0174	0.0573	0.2099	3.4190	19.8848
Sterling (93-98)	0.0004	0.0010	0.0054	0.0343	1.8310	22.5126

Notes: P_r10%, P_r8%, P_r5%, P_r3%, P_r1%, and P_r0.5% represent the probability of an exchange rate movement being in excess of the associated percentages. The excess probability estimates are presented in percentage form.

The information in Table 7 can be used to make decisions on the basis of statistical inference. Whilst, much of the creation of the euro was down to political decision making, we can now make some comments about the euro that are based on the statistical evidence of extreme volatility levels. First, the probability of having the very large exchange rate changes in Table 7 are more likely for the sterling rate between 1979 and 1993 than the euro. Second, for comparatively smaller currency fluctuations, the probability of these occurring is larger for the euro than that of sterling.

Thus it can be seen that the euro has more characteristics of a floating currency than the pound-sterling rate. These attributes include having an average volatility level that is comparatively large, and also, extreme rate changes located in the tail of a distribution being reasonably smooth. In contrast, the pound-sterling rate always had the possibility of government intervention in the case of very turbulent times. This occurred through the Irish authorities informal tracking of sterling during the first sub-period of analysis, or through sterling tracking the mark (and as a consequence, tracking all ERM currencies) during the second sub-period. Government intervention would take place to support a currency, and speculators at certain times saw this as an opportunity to test the resources of the respective central banks. For example, in the case of the EMS currency crises, the extreme volatility in the market was caused by massive speculative activity that was being fought against by the authorities of the participating members.

This brings us to another but related issue. Namely are there any levels of fluctuations seen to be so large, that the authorities would not tolerate their continuation and so leading to an abandonment of the system. Remember the UK opted out of the ERM after speculative activity against sterling became so intense, that the monetary authorities felt that the case of maintaining the currency's value within the predefined bands was no longer worth it. In Table 7, we can see that given the extreme volatility levels inherent in the euro, the Irish government would be reasonably unperturbed by this issue. This is due to the probability of very large rate movements occurring being more likely with Ireland's previous relationship with sterling than with the euro.

However, more worrying for the euro, is its propensity to make reasonably small, but economically important, fluctuations. We can see in Table 7 that the probability of having an exchange rate change in excess of 0.5 percent is more likely for the euro that the experience of the pound-sterling. This issue is very relevant at the moment with sterling tracking the dollar, and given the extent of the extent of Ireland's trade dependence with the non-Euro area as described in Table 2. This Irish experience of the euro may be looked back on in the future as one that provided stability from extreme currency fluctuations, but also one where they suffered a reasonably high level of constant volatility with their main trading partners.

APPENDIX A: ARCH and GARCH Processes

Engle's (1982) ARCH (q) model is outlined in (A1) – (A3) where q is the number of lags. Two sequences {Yt} and {Zt} are related by the regression equation (A1). The distribution of the disturbance term is assumed normal with zero mean and conditional variance δ_t as in (A2). The conditional variance is modelled in (A3).

$$\mathbf{Y_t = bZ_t + \varepsilon_t} \qquad \textbf{(A1)}$$

$$\mathbf{\varepsilon_t \mid I_{t-1} \sim N(0, \delta_t)} \qquad \textbf{(A2)}$$

$$\mathbf{\delta_t = \alpha_0 + \Sigma\ \alpha_i \varepsilon^2_{t-i}} \qquad \textbf{(A3)}$$

where I_{t-1} is the information set at time t – 1, and δ_t is the conditional variance of the disturbance term, ε_t. Volatility is time-varying and modelled on past squared values of the disturbance term.

Empirically the lag structure, q, has been found to be large. A more parsimonious modelling procedure is presented by Bollerslev's (1986) GARCH (p, q) process. By again using (A1) as the relationship between the sequences {Yt} and {Zt}, the disturbance term is shown to have conditional variance h_t in (A4), and it is modelled by a GARCH process of order (p, q), given in (A5).

$$\mathbf{\varepsilon_t \mid I_{t-1} \sim N(0, h_t)} \qquad \textbf{(A4)}$$

$$\mathbf{h_t = \alpha_0 + \Sigma\ \alpha_i \varepsilon^2_{t-i} + \Sigma\ \beta_j h^2_{t-j}} \qquad \textbf{(A5)}$$

Bollersev's extension of the ARCH model allows the conditional variance term, h_t be defined as an ARMA process. If p=0, (A5) is equivalent to (A3). The conventional starting point, and generally supported specification for most speculative time series is the GARCH (1,1), where p=q=1. If p=q=0, there is no heteroskedasticity present, and conditional and unconditional volatility are constant.

APPENDIX B: Extreme Value Theory

Taking a sequence of stationary exchange rate changes $\{R_1, R_2,..., R_n\}$ that may, but not necessarily be identical and independently distributed (Leadbetter *et al*, 1983), and that has a distribution function F. This sequence is expressed in terms of the probability of minimum exchange rate changes being below a certain value, where

$$M_n = \min \{R_1, R_2, ..., R_n\} \quad \text{(B1)}$$

and

$$P\{M_n \leq r\} = F^n(r) \quad \text{(B2)}$$

where M_n is an order statistic that determines the maximum of the sequence of n returns with a probability of $F^n(r)$ of falling below a certain value, r.

This expression deals with the downside risk inherent in exchange rate movements as indicated in Figure 1.

Assuming, that the distribution of F converges at the limit to a distribution G, this limiting distribution can take on three forms (Hols and DeVries, 1991). This distribution G referred to as max-stable[19] adheres to the following types:

Type I: $G(r) = \exp(-e^{-r})$ $\quad -\infty < r < \infty$

Type II: $G(r) = 0$ $\quad r \leq 0$

$= \exp(-r)^{(-1/\alpha)} = \exp(-r)^{-\gamma}$ $\quad r > 0$

Type III: $G(r) = \exp(-(-r)^{(-1/\alpha)}) = \exp(-(-r)^{-\gamma}$ $\quad r < 0$

$= 1$ $\quad r \geq 0$ $\quad$ (B3)

where γ is the value of the tail index and α is its inverse, that is, $\gamma = 1/\alpha$.

The three types of converging distributions can be distinguished by their respective tail behaviour. Type I refers to a case where the tail declines exponentially and all moments of the distribution are finite. Type III refers to a case where the tail is bounded. Type II follows the characteristics of a power decline in the tail causing a relatively slow decay for convergence towards the limit, vis-à-vis the exponential decline of the Type I process. For this Type II max-stable process, the relatively slow decline represents a fat tail situation, and in this case, all the moments are not finite. Given the finding that exchange rate first differences exhibit fat tails, the distribution G takes on only one possible form:

$$G(r) = 0 \qquad r \leq 0$$
$$= \exp(-r)^{(-1/\alpha)} = \exp(-r)^{-\gamma}, \qquad r > 0 \qquad \text{(B4)}$$

Equation (B4) indicates that for fat tailed distributions, an estimate of the tail index, γ is used to give extreme risk measures.

The only sufficient property for the fat-tailed distribution to hold is that the data has a regular variation at infinity property (Feller, 1971), and is given as:

$$\lim_{t \to \infty} \frac{1 - F(tr)}{1 - F(t)} = r^{-\gamma} \qquad \text{(B5)}$$

The semi-parametric Hill (1975) estimator, γ, based on order statistics is used to determine the tail density coefficient:

$$\gamma = 1/\alpha = (1/m) \sum [\log r_{(n+1-i)} - \log r_{(n-m)}] \qquad \text{for } i = 1....m \qquad \text{(B6)}$$

This tail estimator is asymptotically normal, $(\gamma - E\{\gamma\})/(m)^{1/2} \approx (0, \gamma^2)$ (Hall, 1982). This estimation takes a cut-off point, m, which has an exchange rate return, $r_{(n-m)}$, that we want to compare all other currency movements against. Then a summation of differences between all exchange rate changes to the left of m (assuming analysis of downside risk) and at m itself is calculated. This is then averaged by dividing by m giving a measure of dispersion located at this area of the distribution.

An empirical issue in the application of Extreme Value measures is the optimal number of exchange rate changes entailed in the tail of a distribution. The approach adopted here in determining the optimal tail threshold value was developed by Hall (1982) and updated by Phillips *et al* (1996). The optimal threshold value, M_n, which minimises the mean square error of the tail estimate, γ, is $m = M_n = \{\lambda n^{2/3}\}$ where λ is estimated adaptively by $\lambda = |\gamma_1/2^{1/2}(n/m_2(\gamma_1 - \gamma_2)|^{2/3}$. The preliminary estimates of γ_1 and γ_2 are obtained using (B6) with data truncations $m_1 = n^{\sigma}$ and $m_2 = n^{\nu}$. Phillips *et a.* (1996) suggest using $\sigma = 0.6$ and $\nu = 0.9$ as the values of m and γ_1 are insensitive to the choice of σ and ν for small intervals around these estimates.

Using (B6) to determine the tail index, the tail excess probability calculation is then based on the following:

$$P_r = (r_{M,n}/r_p)^{1/\gamma} M/n \qquad \text{(B7)}$$

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Endnotes

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[1] The terms volatility, fluctuations and risk have a similar meaning and they are interchanged for each other in this paper.
[2] The 'peso problem' has been adopted as metaphor in the Extreme Value literature to describe a situation that will rarely happen (very low probability) but of costly consequences (very large losses).
[3] One can go further and say that large financial market volatility, including exchange rate instability, can have a knock on effect on other economic variables in that economy and also impact other economies. A clear example of this contagion is the fallout from the Asian crises that has rippled through the world economy in 1997/98.
[4] This currency was a weighted basket of European currencies, including the UK who did not join the EMS until 1990. The Irish pound's initial weighting in the ECU on entry to the EMS was 1.1 percent.
[5] As this paper shows, failure of such a dual tracking policy is to be expected given the volatility that is inherent in bilateral exchange rates.
[6] As yet, the UK has not formally declared whether they will join. In general commentators believe that membership will occur, but for the purposes of this paper, I assume that they will only agree to participation in the scheme from the time that they actually make this declaration. Given this context, the euro-sterling fluctuations are currently important in terms of trade because of Ireland's strong connections with the UK, but also in a political way in terms of North/South economic co-operation.
[7] Firms rather than individuals are usually cited for applying these methods.
[8]As a consequence, the benefit of removing these distortions is also difficult to compute.
[9] See Temperton (1993) and Corsetti *et al.* (1998) for the respective discussions on the EMS and Asian crises.
[10] The second moment refers to the standard deviation dispersion statistic of a distribution of exchange rate changes.
[11] A comprehensive review of GARCH related models can be found in Pagan (1996).
[12] The central limit theorem is used it this context as well as in general, to demonstrate that when the sample size of a variable under analysis gets very large it converges to the properties of a normal distribution.
[13] Weak convergence is only assumed so the relationship between the series of exchange rates and the max-stable distributions is semi-parametric in nature.
[14] All data was provided by DataStream.
[15] It is debatable as to whether the pound's closer relationship with the mark was a result of a conscious effort by Irish authorities, or actually caused by sterling's formal tracking of the German currency after 1987.
[16] Kurtosis is a combination measure of peakedness around the mean and magnitude around the tail.
[17] Leptokurtosis occurs when they are too many exchange rate changes located

around the mean and tail of a distribution relative to a normal distribution.

[18] It is not possible to compare the magnitude of exchange rate volatility at this juncture as they are drawn to different scale. Attempts to have a common vertical axis for the plots in Figures 3-6 were unsuccessful due to the large extreme values for the sterling rate in the time-period between March 1979 and September 1993.

[19] A max-stable distribution is different to be the stable distribution examined in Cotter (1998) which has the property that it has a characteristic exponent that remains unchanged across different sums of observations.