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Interest and Price Parity and Foreign Exchange Market Efficiency: The Irish Experience in the European Monetary System

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Abstract: Purchasing power parity, interest rate parity and the question of whether the forward exchange rate is an unbiased predictor of the future spot exchange rate are all important relationships underlying exchange rate theory. The objective of this paper is to empirically evaluate the usefulness of these relationships in forecasting Ireland's sterling exchange rate and in doing so, to discuss certain issues relating to the EMS entry decision. The results suggest a breakdown of the long standing price and interest parity relationship between Ireland and the UK following EMS entry. The results also indicate that Ireland's sterling spot market does follow a random walk process and that the three month forward exchange rate is an unbiased predictor of the future spot exchange rate. A risk premium was also found to be important in forward contracts.

I INTRODUCTION

Purchasing power parity, interest rate parity and the question of whether the forward exchange rate is an unbiased predictor of the future spot exchange rate, are all important relationships underlying exchange rate theory. Under certain conditions, the various relationships are mutually dependent. For example, purchasing power parity can, in its own right, be interpreted as a theory of exchange rates. However, prices also influence nominal interest rates via the Fisher relationship. In turn, nominal interest rates, via interest parity theory, affects the forward exchange rate. Completing the circle, the forward exchange rate can be used to forecast the future spot exchange rate.

The objective of this paper is to examine these key theoretical relationships, particularly with regard to exchange rate forecasting, and in doing so to discuss certain issues relating to Ireland's membership of the EMS.

The outline of the paper is as follows. Purchasing power parity is examined in Section II. This is followed in Section III by a discussion on nominal and real interest rates. In Section IV, interest parity theory is evaluated and Sections V and VI examine the spot and forward exchange markets. The paper concludes with a summary of the main findings.

II PURCHASING POWER PARITY

Under floating exchange rates, Purchasing Power Parity (PPP) theory states that price or inflation differentials between two countries will be reflected in an equal but opposite change in the exchange rate. In the case of a small open economy (SOE), maintaining a fixed exchange rate with a dominant larger country, the theory could be taken to imply that the domestic price level is determined by the foreign price level. The theory may be stated as follows:

$$P^d_t . S_t = P^f_t \qquad (1)$$

where P^f_t and P^d_t are foreign and domestic prices and S_t is the spot exchange rate (foreign currency price of unit of domestic currency). The SOE version of PPP theory provided one of the principal theoretical reasons why Ireland joined the EMS and ended the sterling link.[1] The historical evidence strongly supported a PPP relationship between Ireland and the UK.[2] The authorities believed that if instead the currency was pegged in the EMS, PPP would be established between Ireland and Germany. In other words, Irish inflation would converge to the relatively lower German inflation rate.

There was a presumption here by the authorities that PPP would hold under fixed exchange rates rather than flexible exchange rates. It was possible, for example, for PPP to continue to hold between Ireland and the UK. Irish prices would then be determined by UK prices and by movements in sterling.

Following Walsh (1983), Equation 1 can be rearranged as $S_t = P^f_t/P^d_t$. Chart 1 graphs the two variables on either side of this equation for Ireland

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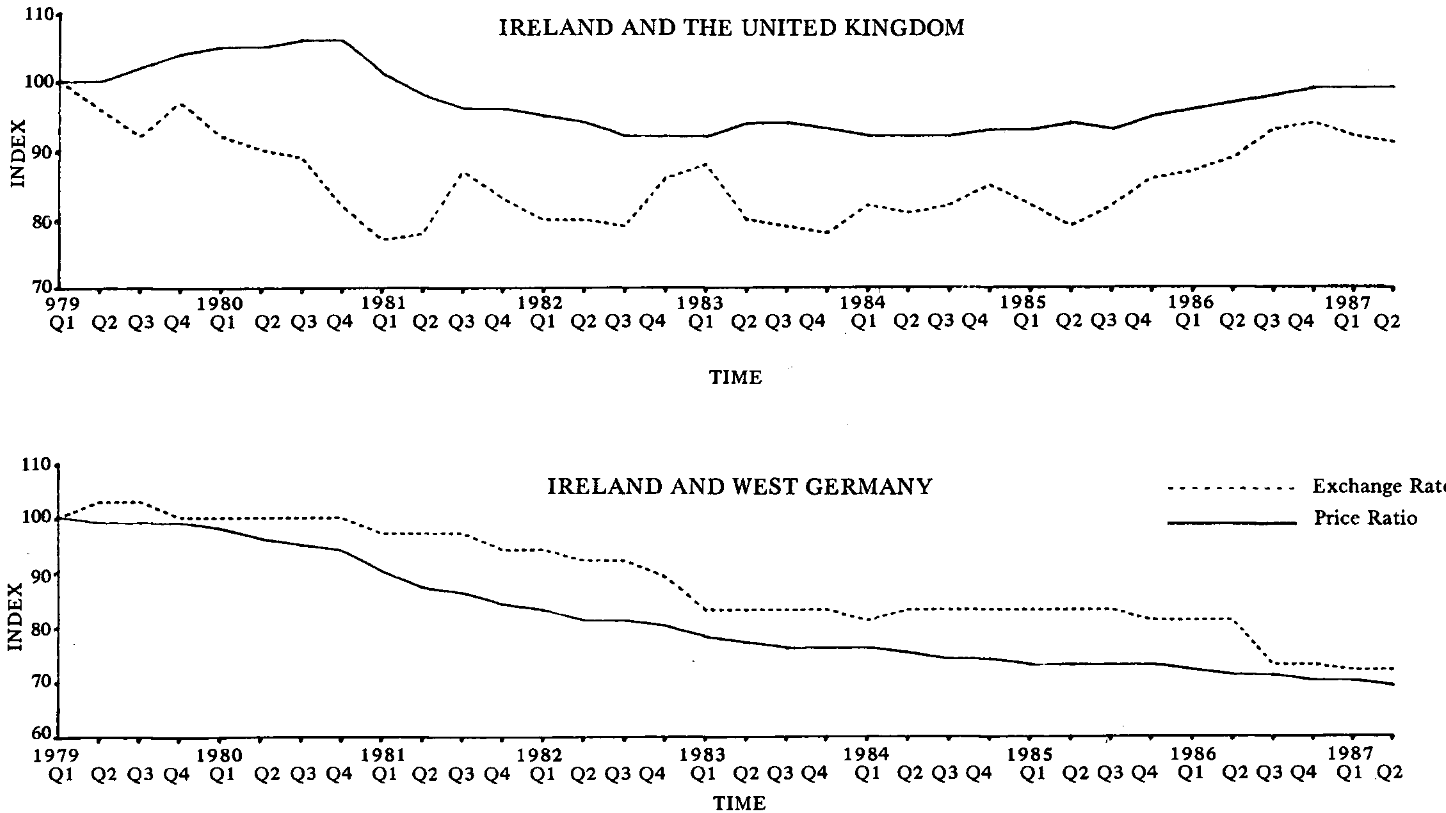
1. Entry into the EMS in March 1979 was accompanied by exchange controls.
2. See, for example, Geary and Jones (1975), Geary (1976), Walsh (1983) and Browne (1983b).

Chart 1: *Purchasing Power Parity*

Manufacturing Output Prices



Source: OECD Main Economic Indicators

and the UK and Ireland and Germany over the period 1979I to 1987II. The price ratios here were calculated using manufacturing output prices, in contrast to Walsh (1983) and Walsh *et al.* (1987) where consumer prices were used.

Since EMS entry there has been a continued divergence between the exchange rate and the price ratios. However, at times, there was an approximate return to the original real exchange rate. This is evident in the case of Ireland and Germany in 1983I and 1986III when the Irish pound was devalued in EMS realignments. Relative to the 1979 real exchange rate, Ireland had a consistent competitive gain *vis-à-vis* the UK and competitive loss *vis-à-vis* Germany.[3]

2.1 *Empirical Results*

Rearranging Equation 1 and defining $E_t = 1/S_t$, PPP theory can be empirically examined by estimating Equation 2.

$$P^d_t = \lambda + \delta (E_t . P^f_t) + v_t \tag{2}$$

PPP holds if $(\lambda, \delta) = (0, 1)$ and the residuals are free of serial correlation (see, for example, Frenkel (1980)). Using both UK and German prices as explanatory variables, Table 1, regressions 1 and 2, presents the empirical results, using both consumer and manufacturing output prices, for the period 1979II to 1987II.

In both cases the PPP hypothesis is rejected. The F-statistic rejects the joint null hypothesis, $(\lambda, \delta_1 + \delta_2) = (0, 1)$, and both the DW statistics and the Box-Pierce Q-statistic suggest autocorrelated residuals.[4] One implication of this result is that domestic policy could be used to influence domestic prices in the short run. It is possible, for example, that devaluation could confer on the Irish economy a short-run competitive advantage. A decision to devaluation would, of course, require consideration of other factors such as the impact on foreign indebtedness and the effects of increased exchange rate uncertainty.

It is of interest to compare the performance of the PPP model to some alternative approach. Consider for example the "adaptive expectations model" frequently used in the literature since the seminal paper by Stone and Rowe

3. If consumer prices are used, the real exchange rate does return to its original level in the case of Ireland and the UK (see Walsh, *et al.* (1987)). However, it would appear that this is due to swings in the sterling exchange rate (caused by external factors) and not by movements in Irish prices *per se*. Hence it is possible that the outcome was fortuitous and may not have occurred under different economic circumstances.

4. It is important to note that by using quarterly data the results relate only to short-run PPP. For the post-EMS entry period, there is not enough data to test for long-run PPP.

Table 1: *Domestic Prices*

Regression No.	*Constant*	$E_t.P^{UK}_t$	$E_t.P^G_t$	P^d_{t-1}	R^2	DW	Q	*Durbin* -h	F
Purchasing Power Parity									
Consumer Price Index									
1	-0.76	0.47	0.95		.988	0.967	11.83		182.9
	(5.5)	(8.8)	(16.9)						
Manufacturing Output Prices									
2	0.47	0.37	0.73		.979	0.708	19.7		52.5
	(3.15)	(5.8)	(5.8)						
Adaptive Expectations Model									
Consumer Price Index									
3	0.05	0.107	0.099	0.81	.998	2.34	11.0	-1.0	4925
	(0.5)	(2.9)	(1.4)	(13.1)					
Manufacturing Output Prices									
4	0.14	0.13	0.05	0.79	.997	1.32	5.14	2.04	3693
	(2.5)	(4.7)	(1.06)	(15.1)					

Note: The dependent variable in all four regressions is the domestic price level (P^d_t). The equations were estimated using logs and the figures in parentheses are t-statistics. The variables P^{UK}_t and P^G_t represent UK and German prices, respectively. Q denotes the Box-Pierce test statistic for autocorrelated residuals and was calculated for fifth order autocorrelation. For regressions 1 and 2 the F-statistic tests the joint null hypothesis (λ, $\delta_1 + \delta_2$) = (0, 1). The usual F-statistic for goodness of fit is given for regressions 3 and 4.

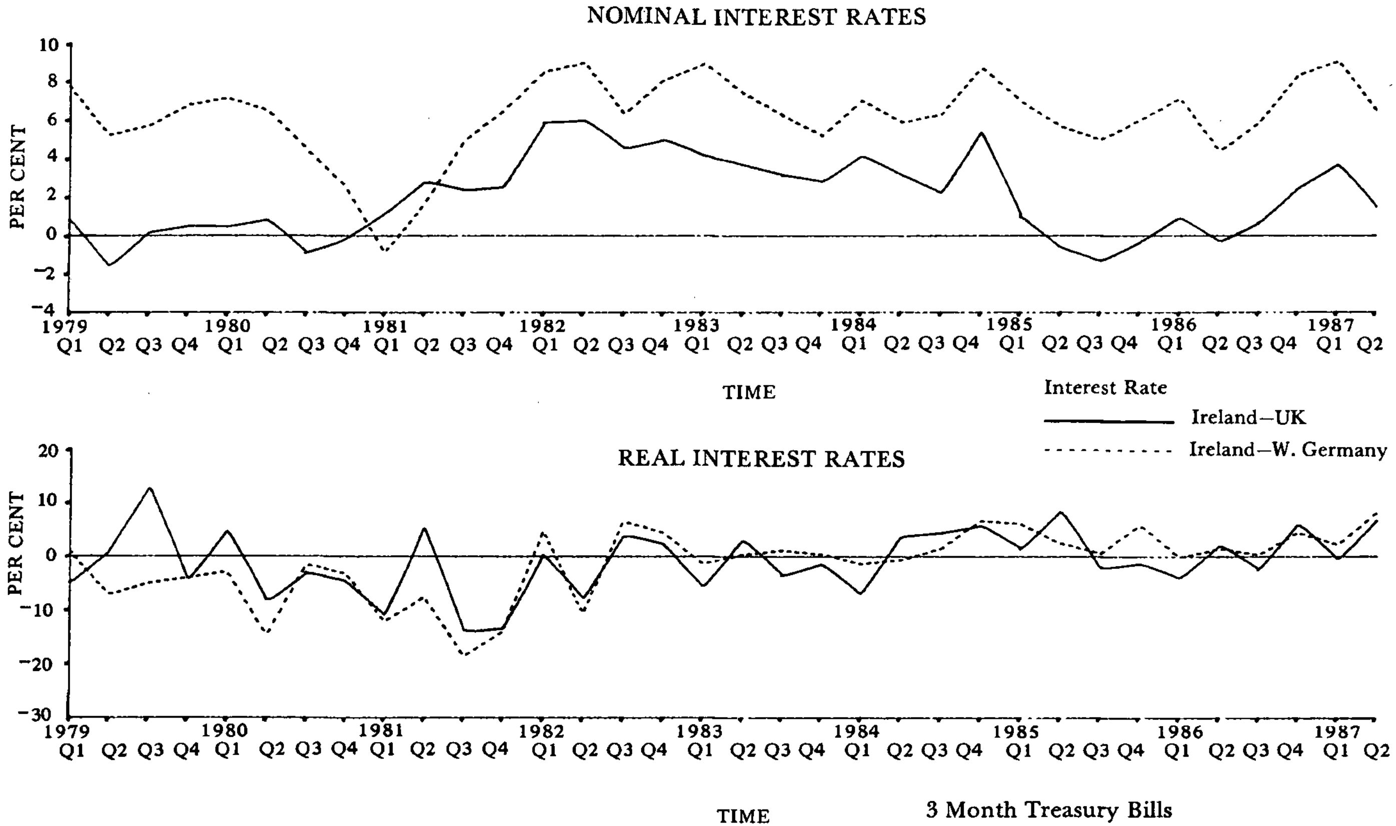
(1957). If it is assumed that the "desired" domestic price level is a function of the (exchange rate adjusted) foreign price level and that the realised price change in any given quarter is only a fraction of the "desired" price change, Equation 3 can be derived.

$$P^d_t = \phi + \psi(E_t.P^f_t) + \eta.P^d_{t-1} + v_t \qquad (3)$$

The results of estimating this equation over the period 1979II to 1987II are given in Table 1, regressions 3 and 4.

Overall the results are much improved as, in both equations, the Box-Pierce Q-statistics indicate serially uncorrelated residuals (the DW statistic is inconclusive). The Durbin-h statistic confirms this result in the case of consumer prices but not manufacturing output prices. The Durbin-h test invalidates the other tests and hence the "adaptive expectations" model may not be the

Chart 2: *Differentials in Nominal and Real Interest Rates*
Ireland, W. Germany and the United Kingdom



3 Month Treasury Bills
Source: OECD Main Economic Indicators.

entire story. The coefficients suggest that in the short run, Irish prices react only marginally to changes in UK prices and not at all to German prices. In general, the performance of the adaptive expectations model, particularly in the case of consumer prices, tends to confirm the inadequacy of PPP as a short-run theory of Irish prices.

III NOMINAL AND REAL INTEREST RATES

Chart 2 shows nominal and real interest rate differentials for Ireland and the UK and Ireland and Germany over the period 1979I to 1987II. On average, Irish nominal interest rates exceeded German and the UK rates by 6.2 and 2.0 per cent, respectively. The convergence of Irish interest rates to German rates, expected at the time of EMS entry, has therefore not materialised.

Furthermore, between 1973I and 1979I, the average difference between Irish and UK interest rates was 0.31 per cent. It is reasonable to assume a continuation of this small interest differential if the sterling link had been maintained. Consequently, Irish nominal interest rates would have been lower in the 1980s if the sterling link had been continued.

In contrast, real interest rates in Ireland were on average 0.83 and 1.4 per cent lower than rates in the UK and Germany, respectively.[5] Up to 1983 average real interest rates in Ireland and the UK were negative. This situation was reversed in recent years with positive rates of as much as 10 per cent being recorded. These real rates contrast strongly with the low real rates experienced in the 1960s and 1970s.

Lower average real interest rates in Ireland could be interpreted as a "benefit" associated with EMS entry. However, the "benefit" has been achieved in a rather paradoxical manner. High nominal interest rates in Ireland have been offset by even higher relative inflation and as a result real interest rates were relatively lower. This was hardly the outcome Irish policy makers had in mind in deciding to participate in the EMS. If the sterling link had been continued, it is possible that both nominal interest rates and inflation would have been lower and real interest rates marginally higher.

3.1 *Interest and Exchange Rate Volatility*

The decision to join the EMS while sterling floated on foreign exchange markets theoretically involved trading exchange rate volatility for interest rate volatility. Under fixed exchange rates, external shocks cause the authorities to intervene in the foreign exchange market and this in turn affects the

5. The Fisher equation states that the nominal interest rate is equal to the real interest rate plus expected inflation: $R^n_t = R^r_t + INF^e_t$. The equation can be used to calculate the real interest rate if it is assumed that expected inflation is realised.

Table 2: *Interest and Exchange Rate Variability*

	Exchange Rates (Index: 1980=100) 1979I-1987II	
	ECU/Irish Pound	*ECU/Sterling*
Mean	95.7	99.0
Standard Deviation	3.9	8.14

	Interest Rates (3 Month Treasury Bills) 1973I-1979I		1979II-1987II	
	Ireland	*UK*	*Ireland*	*UK*
Mean	10.08	9.77	13.46	11.46
Standard Deviation	2.07	2.1	2.48	2.33

monetary base and therefore domestic interest rates. Under flexible exchange rates, it is the exchange rate that varies and domestic interest rates are relatively unchanged.

Measured in terms of the ECU, Table 2 shows that sterling was much more volatile than the Irish pound since 1979. In contrast there was little difference in interest rate variability.[6] Hence, if the UK has experienced exchange rate volatility but stable interest rates, Ireland's exchange and interest rates have both been relatively stable. The supposed trade-off has therefore not materialised. This may in part be explained by the Central Bank sterilising the effect of changes in the external reserves on domestic interest rates (see Leddin (1986) and Browne (1986)).

IV INTEREST PARITY

Investors may avoid foreign exchange risk by buying or selling forward on the foreign exchange market. The forward exchange rate may be incorporated into the analysis by examining interest rate parity theory (IRPT). This theory states that the foreign exchange rate premium or discount on the domestic currency is equal to the differential between foreign and domestic interest rates. That is:

$$\frac{F_t - S_t}{S_t} = \frac{R^f_t - R^d_t}{1 + R^d_t} \qquad (4)$$

6. This is also true if monthly data are used. Furthermore, it was found that interest variability "between" years was higher for the UK. However, if the calculation was based on the average variance "within" years, interest variability was marginally higher in Ireland.

where F_t is the forward exchange rate in time t, S_t is the spot exchange rate (foreign currency price of domestic currency) and R^f_t, R^d_t are respectively foreign and domestic interest rates on identical (except for currency of denomination) securities. The rationale underlying the theory is that "covered interest arbitrage" will ensure interest parity and arbitrage profits will not be available.[7] There are numerous reasons, however, why the theory may not hold. Exchange controls, less than infinite elasticities for foreign and domestic securities being two possible reasons (see Levich (1985) and in the Irish context, Browne (1983a), for a discussion).

Over the perod 1979II to 1987II it was found that a transaction cost of 0.208 per cent was sufficient to give a mean arbitrage profit of zero. In other words, it was not possible, on average, to profit from Equation 4 by buying or selling forward on the foreign exchange market if the transaction costs incurred exceeded 0.208 per cent. While transaction costs vary between "turbulent" and "tranquil" periods on foreign exchange markets (Frenkel and Levich (1977)), the four different transaction costs involved (spot transaction, purchase and sale of government securities and the forward transaction) would appear to leave little scope for arbitrage profits. Taxation, of course, would lower profits even further.

It is possible that by averaging over the period, the data cover over individual "large" deviations from IRPT. However assuming no transaction costs the maximum and minimum arbitrage profit was 0.7589 and 0.0068 per cent, respectively. This maximum profit was available on only two occasions during the period.[8] It is possible to conclude from these figures that IRPT does "hold". This conclusion accords with Browne (1983a) where a spectral analysis technique applied to daily data supported interest parity in the case of Ireland and the UK for periods longer than eight days (this was also true for Ireland and the US but not Ireland and Germany).

V SPOT MARKET

The spot exchange rate is said to follow a random walk if in Equation 5, $(\alpha, \beta) = (0, 1)$ and the residuals are serially uncorrelated with mean zero and constant variance.

$$S_{t+1} = \alpha + \beta . S_t + v_t \tag{5}$$

7. The "modern theory of forward exchange rates" examines the relative importance of speculation, covered arbitrage and commercial hedgers in forward rate determination (see McCallum (1977)). Taylor (1987), for example, finds that the most important determinants of the forward rate are speculation relating to the future spot exchange rate and covered interest arbitrage.

8. This type of analysis is subjective and ultimately requires agreement on a "normal" profit boundary.

Table 3: *Random Walk Hypothesis*

Regression No.	*Dependent*	*Constant*	S_t	t*	$(S_t - S_{t-1})$	R^2	DW	Q	*Durbin* -h	F
1	S_{t+1}	−0.03 (1.9)	0.77 (7.0)			.62	1.63	3.1	1.33	2.2
2	S_{t+1}	−0.048 (1.6)	0.79 (6.8)	0.005 (0.5)		.628	1.68	4.54	1.25	1.5
3	$(S_{t+1} - S_t)$	−0.002 (0.2)			0.09 (0.5)	.009	1.93	3.5		0.3

Note: A log estimation was used and the figures in parentheses are t-statistics. In the case of regressions 1 and 2, the F-statistics test respectively the joint null hypothesis (0, 1) and (0, 1, 0). The usual F-statistic for goodness of fit is given in regression 3. The Dickey and Fuller (1981) critical values at the 5 per cent level, for a sample size of 50, are 4.86 and 5.13 for regressions 1 and 2, respectively. The Q-statistic was calculated for fifth order autocorrelation.

The results of estimating Equation 5, inclusive and exclusive of a time trend (time trends have been used by a number of researchers, including Tse (1986), in examining the foreign exchange market), over the period 1979II to 1987II are given in Table 3 (1979II is the first quarter following EMS entry).

The normal F-test cannot be applied to the parameter estimates because it assumes a stationary process. If Equation 5 follows a random walk this assumption is invalid (see Tse (1986)). However, Dickey and Fuller (1981) tabulated the empirical distributions for the F-statistic when the random walk is true. This distribution is employed in the empirical analysis.

In regressions 1 and 2, the DW statistic, the Box-Pierce Q-statistic and the Durbin-h statistic are consistent in pointing to serially uncorrelated residuals. Furthermore, the F-statistic cannot reject the joint null hypothesis of (0, 1) and (0, 1, 0) for regressions 1 and 2, respectively. Hence the results are consistent in supporting the random walk hypothesis.

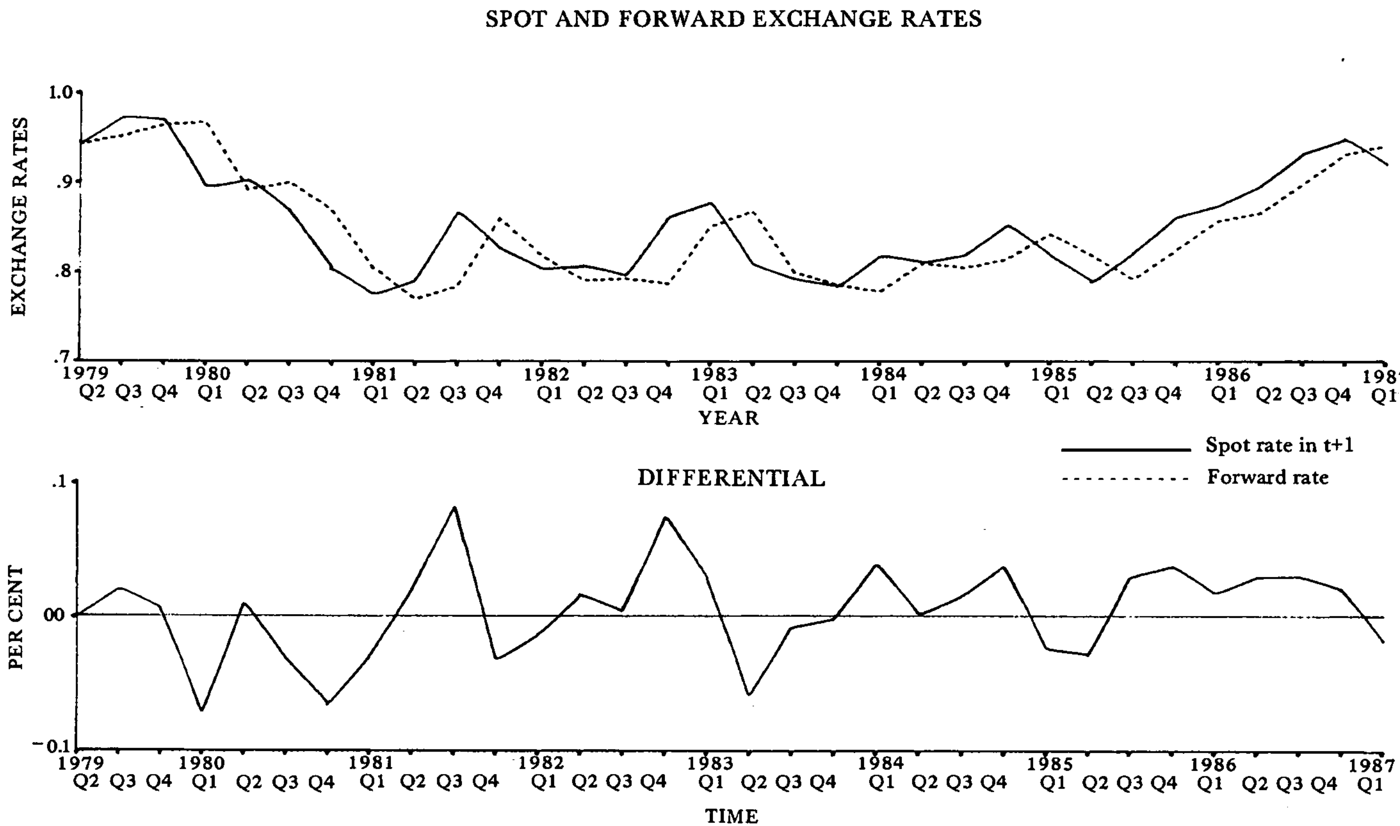
In regression 3, first differences, $(S_{t+1} - S_t)$, are examined. The parameter estimates are not statistically different from zero and both the DW and Box-Pierce Q-statistics indicate serially uncorrelated residuals. The Durbin-h statistic breaks down (because of high parameter variance).

VI FORWARD MARKET

One way of forecasting the future spot exchange rate, S_{t+1}, is to use the current forward rate, F_t. In particular, F_t is said to be an "unbiased" pre-

Chart 3: *Spot and Forward Exchange Rates*

Irish and UK Pounds



Source: AIB International Department.

dictor of S_{t+1} if in Equation 6, $(\epsilon, \rho) = (0, 1)$ and the residuals v_t are serially uncorrelated (Frenkel (1981)).

$$S_{t+1} = \epsilon + \rho F_t + v_t \tag{6}$$

Assuming zero transaction costs and risk neutrality, acceptance of the "unbiased" criteria implies forward market efficiency because all available information is quickly assimilated by rational investors into spot and forward exchange rates.

Before estimating Equation 6, it is informative to graphically examine the three month forward rate, (F_t), the future spot rate, (S_{t+1}), and the forecast error, $(S_{t+1} - F_t)$, since EMS entry. This is done in Chart 3. While the variables move in tandem it is noticeable that F_t consistently fails to predict S_{t+1} turning points. Consequently the forecast error is large when S_{t+1} changes direction.

Table 4 reports the results of estimating Equation 6 using Irish and UK quarterly data over the period 1979II to 1978II. Regression 2 includes an additional lagged explanatory variable and regression 3 includes a time trend, t*.

In all three equations the DW and Box-Pierce Q-statistics indicate serially

Table 4: *The Forward Rate as an Unbiased Predictor of the Future Spot Exchange Rate*

Regression No.	*Dependent*	*Constant*	F_t	F_{t-1}	S^*_t	S^*_{t-1}	t*	R^2	DW	Q	F
Future Spot Exchange Rate											
1	S_{t+1}	−0.03	0.75					0.63	1.62	3.12	2.76
		(1.86)	(7.2)								
2	S_{t+1}	−0.05	0.93	−0.26				0.62	1.97	1.78	2.24
		(2.5)	(5.1)	(1.4)							
3	S_{t+1}	−0.07	0.87	−0.19			0.001	0.64	2.0	3.0	1.62
		(2.8)	(4.7)	(1.1)			(1.3)				
Forecast Error											
4	S^*_{t+1}	0.003			0.12			.016	1.93	3.06	0.48
		(0.4)			(0.7)						
5	S^*_{t+1}	0.005			0.15	−0.28		.09	1.85	2.05	1.4
		(0.6)			(0.8)	(1.5)					
6	S^*_{t+1}	−0.03			0.03	−0.36	0.03	.27	2.0	3.64	3.2
		(1.5)			(0.2)	(2.1)	(2.5)				

Note: A log estimation was used and the figures in parentheses are t-statistics. The variable S^*_{t+1} equals $(S_{t+1} - F_t)$, where F_t is the three month forward rate. The Q-statistic was calculated for fifth order autocorrelation. The F-statistics, in the case of regressions 1, 2 and 3, test the joint null hypothesis of (0, 1), (0, 1, 0) and (0, 1, 0, 0), respectively. The usual F-statistic for goodness of fit is given for the remaining regressions.

uncorrelated residuals. Furthermore, the F-test statistic cannot reject the joint null hypothesis of (0, 1), (0, 1, 0) and (0, 1, 0, 0) for regressions 1, 2 and 3, respectively. Hence the results are consistent in supporting the hypothesis that F_t is an unbiased predictor of S_{t+1}.

An alternative way of evaluating forward market efficiency is to examine the forecast errors. In Table 4, regressions 4, 5 and 6, the forecast error, defined as $S^*_{t+1} = S_{t+1} - F_t$ is regressed on lagged values and a time trend and the autocorrelation function is calculated.

In all three regressions, the DW and Q-statistics indicate serially uncorrelated residuals and the Durbin-h statistic cannot be calculated because of high coefficient variance.

6.1 *Risk Premium*

In order to induce individuals to accept foreign exchange risk, a risk premium may be demanded on forward transactions. Market efficiency now requires that F_t differs from S_{t+1} only by a risk premium (RP_t). That is:

$$F_t = S_{t+1} + RP_t \tag{7}$$

The portfolio balance approach to exchange rates suggests that the premium is inversely related to monetary discipline (rapid growth in the money supply could indicate an acceleration in the inflation rate), low debt financed government expenditure and low exposure to real disturbances (see, for example, Fama and Farber (1979) and Levich (1985)). Levich (1985) has pointed out that one implication of this theory is that the premium can change sign over time. Since the above-mentioned factors are not noticeable characteristics of the Irish economy and because of the uncertainty created by the depreciation of the Irish currency within the EMS in 1983 and 1986, it is possible that, at times, a risk premium is present.

Unfortunately, the RP_t variable is unobservable. However, following Fama (1984), an indication of the relative importance of the premium in forward rate determination can be obtained by estimating Equation 8.

$$(S_{t+1} - S_t) = \psi + \pi(F_t - S_t) + v_t \tag{8}$$

Fama defines $(F_t - S_t)$ as being equal to the Premium, RP_t, plus the expected change in the exchange rate, $E_t(S_{t+1} - S_t)$. It is then argued that the sign of π indicates how RP_t and $E_t(S_{t+1} - S_t)$ are related (this argument is based on an analysis of the covariance of $(S_{t+1} - S_t)$ and $(F_t - S_t)$). If π is negatively signed this implies an inverse relationship and furthermore because of Cauchy-Schwarz inequality, variations in the forward rate are mostly due to changes

Table 5: *Risk Premium*

Regression No.	*Dependent*	*Constant*	(F_t-S_t)	F_t	$\hat{S}^*_{t+1}$	$\hat{S}^*_t$	ΔM^s_{uk}	ΔEXR_t	Z_t	R^2	DW	Q
1	$(S_{t+1}-S_t)$	0.0008 (0.08)	0.29 (0.22)							.001	1.8	3.86
2	$(S_{t+1}-F_t)$	-5.08 (0.5)					3.2 (1.4)	-3.06 (3.6)	-1.0 (2.3)	.47	1.9	5.9
3	S_{t+1}	0.12 (1.9)		0.68 (6.9)	0.04 (2.25)					.87	1.1	4.81
4	S_{t+1}	0.1 (1.8)		0.84 (6.8)	0.04 (2.7)	-.01 (1.8)				.91	2.0	2.39

Note: The equations were estimated using logs and the figures in parentheses are t-statistics. The variables M^s_{uk}, EXR_t and Z_t represent respectively the UK money supply, Ireland's external reserves and the deviation of Ireland's real sterling exchange rate from trend. The Q-statistic was calculated for fifth order autocorrelation.

in the risk premium (see, however, Garbers (1987) for a critique of this approach).

The results of estimating Equation 8 using Irish/UK quarterly data over the period 1979II to 1987II are given in Table 5, regression 1.

The Fama equation tends to perform rather poorly. The residuals are not serially correlated but the equation has a very low explanatory power. The π coefficient is not statistically different from zero and is positively signed. Overall it is difficult to derive any firm conclusions from the results.

6.2 *Risk Premium: an Alternative Test*

An alternative approach is to attempt a direct estimate of the risk premium. If the premium exists it must be contained in the forecast error: $S^*_{t+1} = S_{t+1} - F_t$. Hence if S^*_{t+1} is regressed on a number of variables thought to have an influence on the premium, a proxy measure may be obtained.

Using this approach, S^*_{t+1} was regressed on the deviation of the real exchange rate from trend (investors prefer low inflation currencies), the change in Ireland's external reserves (allowing for government foreign borrowing, this gives some indication of the degree of Central Bank intervention in the foreign exchange market) and the change in the UK money supply. A dummy variable representing EMS realignments was found to be statistically insignificant and was omitted from the final equation. The results are given in Table 5, regression 2. The equation performs reasonably well. The variables are correctly signed and both the DW and Q-statistics indicate serially uncorrelated residuals.

The explained proportion of S^*_{t+1}, denoted $\hat{S}^*_{t+1}$, was then used as a proxy for the risk premium and was estimated along-side F_t in Equation 6. The results are reported in regression 3, Table 5.

The $\hat{S}^*_{t+1}$ variable is statistically different from zero. However, the DW and Q-statistics suggest serially correlated residuals. Regression 4 shows the results when a lagged risk premium is added to the equation. The serial correlation is removed and the sum of the explanatory variable coefficients is not statistically different from one. Also the constant term is not statistically different from zero at the 2.5 per cent significance level. Hence regression 4 satisfies the "efficient market" hypothesis and points to the importance of a risk premium in forward exchange transactions.

VII CONCLUSION

The results relating to Purchasing Power Parity for both consumer prices and manufacturing output prices, suggested a break-down of the long-standing PPP relationship between Ireland and the UK following EMS entry. This has not, however, been replaced by a PPP relationship between Ireland and Germany as was anticipated at the time of EMS entry. In contrast, an "adaptive expectations" model seemed to out-perform the PPP model, particularly as far as consumer prices were concerned, as an explanation of short-run changes in Irish prices.

On average, nominal interest rates in Ireland exceeded UK and Germany rates since EMS entry. However, because of even higher relative inflation, average real interest rates have been lower in Ireland. This outcome raises a number of points. First, one of the most important anticipated benefits of EMS entry, that of a convergence of Irish nominal interest rates and inflation to German levels, has not been realised.

Secondly, if the sterling link had been continued, it is likely that interest rates and prices in Ireland would have continued to mirror UK rates and therefore would, on average, have been lower over the period. Thirdly, while higher nominal interest rates could be seen as a cost associated with EMS entry, lower real interest rates could be viewed as a benefit. If this is the case the benefit has been achieved in a rather paradoxical manner.

The conclusions relating to the foreign exchange market must be seen as tentative, principally because of the use of quarterly data and the concentration on the Irish pound/sterling exchange rate. Bearing this in mind, the initial results based on absolute values support the two principal hypotheses examined. That is the spot market follows a random walk and the forward rate is an unbiased predictor of the future spot exchange rate. Additional results based on first differences in the spot market and forecast errors in the forward market also provide support for both hypotheses. However, the evidence points to the importance of a risk premium in forward contracts. Even when this premium is allowed for, the forward market appears to satisfy the efficient market criteria. Consequently, speculative profits over and above the premium may not be available.

REFERENCES

BROWNE, F.X., 1983a. "Departures from Interest Rate Parity", *Journal of Banking and Finance*, North Holland, Vol. 7.

BROWNE, F.X., 1983b. "Price Setting Behaviour for Traded Goods – The Irish Case", *Applied Economics*, 15.

BROWNE, F.X., 1986. "A Monthly Money Market Model for Ireland in the EMS", Dublin: *Central Bank of Ireland, Annual Report.*

DICKEY, D.A., and W.A. FULLER, 1981. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica*, Vol. 49, No. 4, July.

FAMA, E.F., 1984. "Forward and Spot Exchange Rates", *Journal of Monetary Economics*, 14.

FAMA, E.F., and A. FARMER, 1979. "Money, Bonds and Foreign Exchange", *American Economic Review*, 69.

FRENKEL, J.A., 1980. "Exchange Rates, Prices and Money: Lessons from the 1920s", *American Economic Review*, 70.

FRENKEL, J.A., 1981. "Flexible Exchange Rates, Prices and the Role of 'News': Lessons from the 1970s", *Journal of Political Economy*, 89.

FRENKEL, J.A., and R.M. LEVICH, 1977. "Transaction Costs and Interest Arbitrage: Tranquil versus Turbulent Periods", *Journal of Political Economy*, November-December.

GARBERS, H., 1987. "A Misspecification Analysis of the Relationship Between Spot and Forward Exchange Rates", *European Economic Review*, 31, October.

GEARY, P.T., 1976. "World Prices and the Inflationary Process in a Small Open Economy – the Case of Ireland", *The Economic and Social Review*, Vol. 7, No. 4, July.

GEARY, P.T., and R.M. JONES, 1975. "The Appropriate Measure of Unemployment in an Irish Phillips Curve", *The Economic and Social Review*, Vol. 7, No. 1, October.

LEDDIN, A., 1986. "Portfolio Equilibrium and Monetary Policy in Ireland", *The Economic and Social Review*, Vol. 17, No. 2, January.

LEVICH, R.M., 1985. "Empirical Studies of Exchange Rates, Price Behaviour, Rate Determination and Market Efficiency", in R.W. Jones and P.B. Kenen (eds.), *Handbook of International Economics*, Vol. II, North Holland.

McCALLUM, B.T., 1977. "The Role of Speculation in the Canadian Forward Exchange Market: Some Estimates Assuming Rational Expectations", *Review of Economics and Statistics*, Vol. 26.

STONE, R., and D. ROWE, 1957. "The Market Demand for Durable Goods", *Econometrica*, July.

TAYLOR, M.T., 1987. "The Role of Speculation in the Forward Exchange Market: Some Consistent Estimates Assuming Rational Expectations", *Oxford Bulletin of Economics and Statistics*, August.

TSE, Y.K., 1986. "The Spot and Forward Exchange Rates: Some Empirical Evidence of Singapore", *Applied Economics*, 18.

WALSH, B.M., 1983. "Ireland in the European Monetary System: The Effect of a Change in the Exchange Rate Regime", in M. De Crecco (ed.), *International Economic Adjustment*, London: Basil Blackwell.

WALSH, B.M., J. O'LEARY, and A. LEDDIN, 1987. "Fiscal, Monetary and Exchange Rate Policy" in J.W. O'Hagan (ed.), *The Economy of Ireland: Policy and Performance*, 5th edition, Dublin: Irish Management Institute.

Appendix 1: *Data Sources and Definitions*

The data relating to prices, interest rates and the UK money supply was obtained from the OECD Main Economic Indicators. The spot exchange rates and the forward rates were provided by the AIB, International Department. The data on Ireland's external reserves were obtained from the Central Bank of Ireland, *Quarterly Bulletin* and the ECU exchange rates from *Eurostat*, Money and Finance, series.