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THE 'SPECULATIVE EFFICIENCY' HYPOTHESIS

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ABSTRACT

The 'speculative efficiency' hypothesis is that forward prices are the best available (minimum variance) forecasts of future spot prices. This paper extends previous tests of the hypothesis by considering a pooled cross-section time-series data base of nine currencies over the period from July 1974 to January 1980. The multi-country framework increases the statistical efficiency of the tests of the hypothesis by incorporating cross-equation restrictions in the alternative forecasting equation and by accounting for the strong correlation in the forecast errors for the different currencies.

The paper also extends previous tests by directly calculating the mean and variance of speculative profits from a portfolio based speculative strategy. The results suggest that while the expected return from a single transaction has not been significantly different from zero during the sample period, the average return from a large number of speculative transactions has been significantly greater than zero.

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Introduction

The hypothesis that forward prices are the best unbiased forecast of future spot prices is often presented in the economic and financial analysis of futures markets. In economic analysis, the hypothesis often appears under the guise of rational expectations, while in the finance literature the term market efficiency is more generally employed. It is important to note, however, that best unbiased forecasting by the forward price is not a necessary component of either a rational expectations or an efficient markets approach. It is easy, for example, to construct a model in which market expectations are rational, in the sense of being based upon the forecasts implicit in the model itself, but in which forward prices are not equal to expected future spot prices because of transactions costs, information costs and risk aversity.[1/] In the same manner and for the same reasons, it is possible to construct a model in which markets are efficient in the sense of removing any opportunities for risk-adjusted excess returns but in which there is a predictable bias in the forward price forecast. For these reasons, this paper considers the hypothesis independently of its implications for rational expectations or market efficiency and in order to stress this fact, the term 'speculative efficiency' is used to characterize the state envisaged under the hypothesis. If a market is subject to efficient speculation, the supply of speculative funds is infinitely elastic at the forward price that is equal to the expected future spot price. The expected future spot price is a market price determined as the solution to the underlying rational expectations macroeconomic model. Although the paper is primarily concerned with testing this hypothesis in the foreign exchange market, the methodology introduced in the paper is of general application to all futures markets.

Given that speculative efficiency is not directly related to either market efficiency or rational expectations, it is necessary to begin with some

The main reason why a strong empirical test of the speculative efficiency hypothesis is difficult to perform is that the variance of the change in the exchange rate is very large relative to the variance of the forward premium. This fact is illustrated in the following table which lists the standard deviation of the one month rate of depreciation, the one month forward premium, and their ratio. These statistics are calculated for all of the major currencies over the period from July, 1974 to January, 1980.

TABLE 1.

THE STANDARD DEVIATION OF THE RATE OF DEPRECIATION AND THE FORWARD PREMIUM

Country	$\sigma_{\Delta s}$	σ_x	$\sigma_{\Delta s}/\sigma_x$
Canada	14	2	7.9
U.K.	30	4	8.4
Belgium	30	5	5.9
France	28	4	7.3
Germany	32	2	14.1
Italy	26	9	3.0
Netherlands	29	3	9.1
Switzerland	40	3	11.8
Japan	32	4	7.3

Notes: $\sigma_{\Delta s}$ = standard deviation of one month rate of depreciation.
σ_x = standard deviation of one month forward premium.
Definitions and sources of exchange rate data are described in the Data Appendix. Units of measurement are annual percentage changes.

The large difference between the standard deviation of the actual rate of depreciation and the standard deviation of the forward premium is a natural consequence of the fact that the forward premium is an estimate of the expected rate of depreciation. Any estimate of the mean of a series will always have a smaller standard deviation than that of the raw series. The difficulty is that the large variance in the actual rate hinders tests of the hypothesis that the forward premium is an unbiased estimate of the true expected rate because the confidence limits for the true expected rate are

TABLE 2.

O.L.S. ESTIMATES OF THE EQUATION:

$$\Delta s_t - x_{t-1} = \beta_0 + (\beta_1 - 1)\, x_{t-1} + u_t$$

COUNTRY	β_0	$\beta_1 - 1$	R^2	S.E.	D.W.	F(2,71)
Canada	-4.010 (2.05)	-1.804 (0.92)	.050	14.17	2.06	2.35
U.K.	1.928 (5.21)	-0.372 (0.99)	.002	30.52	1.57†	0.20
Belgium	5.270 (3.86)	-0.973 (0.69)	.027	29.88	2.18	1.29
France	0.407 (4.39)	-1.849* (0.86)	.061	27.72	2.32	2.62
Germany	6.737 (6.29)	-1.208 (1.65)	.007	31.91	2.33	0.37
Italy	-7.428 (4.73)	-1.372* (0.35)	.178	26.44	1.50†	8.04*
Netherlands	7.285* (3.61)	-2.741* (1.05)	.086	29.38	2.32	3.52*
Switzerland	11.32 (8.52)	-1.184 (1.38)	.010	40.11	1.99	0.48
Japan	3.917 (4.03)	-1.665 (0.86)	.049	32.50	1.57†	1.89

Notes: Standard errors are in parentheses beneath the coefficients. An asterisk indicates that the estimated coefficient is significantly different from zero at the five per cent significance level.
The F-statistic tests the joint hypothesis: $\beta_o = \beta_1 = 0$. The five per cent critical value for the F-distribution with 2 and 71 degrees of freedom is 3.12. An asterisk indicates a calculated F-statistic which exceeds this value.
A dagger indicates that the estimated Durbin-Watson statistic (D.W.) falls below the lower bound for this statistic, thus indicating the presence of significant first order autocorrelation in the residuals.
The estimation period includes four-weekly observations from July, 1974, to January, 1980.

since forward rates are typically available for maturities of one, three, six and twelve months. Joint tests of the efficiency of the entire term structure of forward rates, as undertaken by Hakkio (1980b), also promise some increase in econometric efficiency.

There is a difficulty, however, with both of these approaches. Although they effectively increase the number of observations, the new observations are not greatly different from those included in studies using either monthly data or one maturity. Since the precision of the estimates depends upon the sample variance of the forward premium as well as the number of observations, the gain in efficiency resulting from an increase in the number of observations is likely to be small.

For this reason, this study adopts an alternative approach in which the observations are aggregated both across countries and across time. Since the mean rate of depreciation has typically shown greater variance across countries than across time, this approach does offer a means of increasing the sample variance of the forward premium. Specifically, the following equation will be estimated:

$$\Delta s_{nt} - x_{nt} = \beta_o + \beta_1 x_{nt} + u_{nt} \qquad (3)$$

where n is an index of currency (or country) and t is an index of time. The estimation procedure that is appropriate for this pooled cross-section time-series regression clearly depends upon the nature of the error structure.

The first, simplest and least realistic description of the error structure is the classical assumption that the errors are spatially and temporally uncorrelated. This assumption leads directly to the following ordinary least squares estimates:

In any regression analysis, there is always a possibility that the results are dominated by a small number of outlying observations. This is certainly the case in the present instance because the distribution of the forward premium, shown in Figure 1, is highly skewed. Before proceeding, it is consequently worthwhile to check if the preceding results can be attributed to these extreme observations. This is done by dividing the observations into two groups - those less than ten per cent in absolute value and those greater than ten per cent in absolute value. Entering both variables in the regression resulted in the following estimates.

$$\Delta s_{nt} - x_{nt} = \underset{(2.53)}{2.986} + \underset{(0.53)}{0.091}\, x_{nt}^{SMALL} - \underset{(0.26)}{1.235}\, x_{nt}^{LARGE} + u_{nt} \qquad (5)$$

$$R^2 = .041 \quad F(2,663) = 11.453 \quad S.E. = 29.89$$

These results lead to a partial rehabilitation of the speculative efficiency hypothesis since they demonstrate that the negative results in the previous tests were due to the large outlying observations. For values of the forward premium in the range of plus or minus ten per cent, the forward premium does appear to be an unbiased forecast of the future actual rate of depreciation. The large value of the standard error of the coefficient on the x_{nt}^{SMALL} variable demonstrates, however, that the predictive power of this variable is quite small.

As far as the large values are concerned, the weight given to the forward premium is not only negative but also greater than unity. This implies that these values, on average, do not even capture the direction of change. More to the point, the statistics suggest that values of the forward premium in excess of ten per cent should be ignored for forecasting purposes. In terms of the debate over the efficiency of the forward exchange rate, the existence of 'destabilizing' speculation, and the presence of 'disorderly

market conditions,' the results suggest that episodes do exist in times of extreme stress in which the forward rate is not an unbiased forecast of the future spot rate. A risk averse speculator - private or public - would appear to be justified in intervening in the market when the forward premium exceeds ten per cent. For the most part, however, the forward rates are unbiased forecasts.

Generalized Least Squares Estimation

The previous ordinary least squares estimates have the virtue of being unbiased under the reasonable condition that the forward premium is uncorrelated with the future forecast error. These estimates are not very efficient, however, because they do not make use of the strong contemporaneous correlation in the forecast errors. On theoretical grounds, there are two major reasons why one would expect strong contemporaneous correlation in the forecast errors. In the first place, all of the exchange rates are expressed relative to the U.S. dollar so that shocks originating in the American monetary sector will influence all of the exchange rates. Second, there have been a number of formal and informal arrangements for exchange rate co-ordination, including the 'snake', the 'tunnel' and the recently creater European Monetary System, that ensures a high correlation between the forecast errors for the European currencies. These considerations are incorporated into the estimation through the assumption that $E(u_{nt}, u_{n't''}) = \sigma_{nn'}$ if $t = t''$, zero otherwise.

The results from this estimation procedure are given below.

$$\Delta s_{nt} - x_{nt} = \underset{(1.38)}{-2.434} \; \underset{(0.16)}{-0.844}\, x_{nt}^{SMALL} \; \underset{(0.15)}{-1.322}\, x_{nt}^{LARGE} + u_{nt} \qquad (6)$$

Apart from the significant increase in the precision of the estimates, the most noticeable feature of the results reported in equation (6) is that the weight given to x_{nt}^{SMALL} is now larger and significantly different from

is clearly the most appropriate procedure to use. In the following section of the paper, the speculative issue will be examined in greater detail. Before moving on to this topic, however, there is one additional restriction that can be imposed upon the previous estimates.

The results reported in equation (6) included a constant term. Since there is little reason to presume that there is a constant bias in the forecast on theoretical grounds, and since the constant term estimated in the equation is not significantly different from zero, the equation was re-estimated without a constant. The revised estimates are given below.

$$\Delta s_{nt} - x_{nt} = \underset{(0.15)}{-0.741}\, x_{nt}^{SMALL} - \underset{(0.12)}{1.280}\, x_{nt}^{LARGE} + u_{nt} \qquad (7)$$

As one would expect, these estimates are not greatly different from the preceding ones.

The Speculation Issue

It is important to begin with the caveat that these results are not meant to demonstrate the presence or absence of speculative profits in the foreign exchange market. In the first place, the forecasting rule is estimated over the same sample period as the speculative model is run. Since the parameters of the model were not available to market participants during the sample period, they cannot be considered to be part of the information set upon which tests of market efficiency are based. A true test of the existence of speculative profits must involve post-sample tests. These tests will be carried out after the results from this study have been disseminated.

What this section does attempt to do is to restate the previous results from the point of view of a speculative strategy. The profits

ently of the forecasts is not a particularly sophisticated characterization of our speculator's utility function, but it will do for illustrative purposes.

Two set of results will be presented below. The first set, denoted the in-sample statistics, covers exactly the same set of observations over which the model was estimated. The second set, denoted the inter-sample, takes a new sample in which each observation refers to an intermediate observation. Recall that the observations are four weekly. The in-sample sample takes the weeks 1, 5, 9, 13 etc.,while the inter-sample takes weeks 3, 7, 11, 15 etc.. The correlation between the two series depends upon the time series structure.[9/] While the inter-sample calculations are not a substitute for a full post-sample investigation, they are a useful check on the consistency of the model.

The results are summarized in terms of the standardized profit: the actual or expected profit divided by the expected standard deviation of profit. The values of these variables are described in the histograms in Figure 2. The vast majority of the expected profit variables are within two standard deviations of zero so that our speculator could generally not be 95 per cent confident of not making a loss. On the other hand, there are a few episodes - again associated with 'disorderly market conditions' in which the standardized expected profit is large. It is interesting to note that these episodes are more common in the inter-sample histogram than in the in-sample histogram.

In comparison with the expected standardized profit histograms, the histograms for actual standardized profits are more symmetric because there are a larger number of low and negative values. It is noticeable, however, that the distributions are still highly skewed towards positive profits. It is again the case that the majority of the values lie within plus or minus

two standard deviations of zero. Consequently, one could not be confident that the actual level of profits would be positive in any one period at the 95 per cent level of significance. On the other hand, it is worthwhile to remember that each gamble is uncorrelated with past and future history so that the expected value of a large number of gambles will be small. This point is illustrated in the following table.[10/]

MEAN STANDARDIZED PROFIT

	EXPECTED	ACTUAL
IN-SAMPLE	1.000	1.02
	(.11)	(.16)
INTER-SAMPLE	1.024	0.982
	(.11)	(.16)

The lesson from these results is that while the speculator cannot be sure of making a profit in every period, the expected profit from 74 gambles in the market is known with a reasonable degree of certainty.

We now ask the question: how well did the model guide the speculator? If the model is useful, the expected standardized profits should be correlated with the actual standardized profits. In the in-sample tests, this result is assured because the model was estimated over the period and because it is known to have statistically significant predictive power. In the in-sample model, the correlation between the expected standarized profit and the actual standardized profit is .73. The same statistic for the inter-sample model is .58. Thus there is some erosion in the predictive power of the model but there is still a strong, and presumably significant, correlation between the actual and expected standardized profits.

Some further evidence on this issue is presented in Table 2 in which the actual profits and the expected standardized profits are presented for the inter-sample model. If the speculator attempted to make $100 per gamble, she would actually have made $82 per gamble in the inter-sample. The 95 per

cent confidence limits for the mean lie between $48 and $115.

Conclusion

There is a world of difference between the demonstration that a particular mechanism forecasting would have made money in the past and the demonstration that it will make money in the future. This study has - unfortunately - only presented evidence on the first question. This evidence can be summarized in the statement that future spot rates have been closer to current spot rates than to current forward rates during the current floating rate period. To a first order of approximation, changes in the spot exchange rate are serially uncorrelated and the exchange rate evolves as a random walk without discernible drift. If this statement is a true characterization of the time series behavior of the exchange rate, the best forecast of the expected future spot rate is the current spot rate and, if the market satisfies the conditions for speculative efficiency, forward rates should be equal to spot rates. Any market participant who knew that spot rates were random walks would then bet against the market whenever the forward premium was non-negligible. In a sense, the speculator would not be gambling upon her own superior knowledge of exchange rate dynamics but upon her knowledge that the other market participants who jointly set the forward price do not know that the exchange rate is unpredictable. The paper demonstrates that a strategy of 'leaning against the wind' or betting against the market would have been profitable during the current floating rate period. Although this may have been the result of market inefficiency, it may also have been due to the influence of risk premia, transaction costs and information costs on the value of the forward premium.

Footnotes - 2.

9/ If the weekly change in the underlying time series is serially uncorrelated, the correlation coefficient between the in-sample and inter-sample four weekly series would be one half. The correlation coefficient will be larger if the weekly series exhibit positive serial correlation.

10/ The statements must be interpreted cautiously since they are based upon the assumption that the distribution of standardized profits is normal. The histograms displayed in Figure 2 demonstrate that this assumption is not warranted in the present instance.

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