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PROFITABILITY AND STABILITY IN INTERNATIONAL CURRENCY MARKETS

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ABSTRACT

A number of recent empirical studies have rejected the hypothesis that forward exchange rates are unbiased forecasts of future spot exchange rates. This result implies that there have been opportunities for speculative profit during the post Bretton Woods period. Observers of the floating rate system have also noted that exchange rates have been more volatile than they were anticipated to be in the 1960's. In this paper, the link between the volatility of exchange rates and the existence of opportunities for speculative profit is explored. The question answered in the paper is the following: if there were no opportunities for speculative profit, would exchange rates have been more stable? The answer is yes. This answer implies that speculation (intervention) based upon the forecasting equation described in the paper would be both profitable and stabilizing.

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Since the demolition of the Bretton Woods system in the early seventies, international monetary economists have labored at the task of explaining the volatility of exchange rates in a way that is consistent with the presumption that international asset markets are efficient.[1/] In terms of theoretical contributions, this has been productive work: there are now a number of international macroeconomic models in which asset prices are well arbitraged and expectations are rationally formed which yield the prediction that exchange rates will be volatile relative to economic fundamentals. This literature, which has become known under the title of the 'asset market' approach, views the exchange rate as the relative price of national currencies rather than as the relative price of goods and services.[2/] Variants of the asset market approach include the monetary models of Frenkel (1976) and Mussa (1976), the Keynesian 'sticky price' model of Dornbusch (1978), and the models of current account dynamics introduced by Kouri (1976) and Calvo and Rodriguez (1979). All of these models, and most of those that followed them, assume that interest rates are arbitraged across currencies according to the interest rate parity condition and that forward rates are unbiased forecasts of future spot rates.

Although these assumptions are valid simplifications in an abstract theoretical model, recent empirical evidence has generally rejected the hypothesis that the forward rate is an unbiased and efficient forecast of the future spot rate. (See, for example, Hansen and Hodrick (1980) and Bilson (1981)) Specifically, it appears to be possible to construct simple alternative forecasts, based upon publicly available information, which generate predictable profits from foreign exchange speculation. In addition, Levich (1980) has presented evidence that commercial foreign exchange forecasting services have track records which, in some cases, are significantly superior to the forward rate at high marginal significance levels.

These predictable speculative profits need not be due to market inefficiency since, as Hansen and Hodrick have stressed, the substantial risk involved in currency speculation may result in a time varying risk premium. Although my own results suggest that the risk/return tradeoff is too favorable to be attributed to this source, it is not the purpose of this paper to attempt to resolve this issue. Instead, the paper explores the relationship between the bias in the forward rate as a forecast of the future spot rate and the volatility of the exchange rate. The purpose of the paper is to answer the question: if the forward rate had been an unbiased forecast of the future spot rate during the seventies, would the spot exchange rate have been more or less volatile?

In the next section of the paper, a simple theoretical model will be presented which provides an answer to this question. In the following section, the parameters of the model will be estimated and the question will be answered empirically.

I. The Theoretical Model

The theoretical model begins with a specification of the foreign exchange market equilibrium condition

$$s_t = z_t + \varepsilon x_t \tag{1}$$

where s_t is the log of the spot exchange rate, x_t is the forward premium (+) or discount (-), and z_t is defined as the value of s_t when x_t is equal to zero. In order to avoid controversy, the determinants of z_t will not be explicitly discussed; at the present time there are many specifications of z_t which are all equally consistent with the available empirical evidence. Following Kholhagen (1979), we may refer to z_t as the 'non-speculative' influence on the exchange rate and to $\varepsilon\, x_t$ as the 'speculative influence.' This decomposition is based upon the presumption that the forward premium reflects market expectations about the future value of the currency rather than a time varying risk premium. Primarily for purposes of exposition, this presumption is maintained in the following discussion.

In contrast to most previous work, however, the rational expectations assumption that the forward premium is the actual conditional expectation of the future change in the spot exchange rate is not made. Instead, the actual forecast and the forward premium are linked through the relationship described in equation (2).

$$\bar{s}_{t+1} - s_t = \alpha\, x_t \qquad (2)$$

In equation (2), $\bar{s}_{t+1}$ is the expected value of s_{t+1} conditional upon the information set available at t. If the α parameter is equal to unity, the model described in equations (1) and (2) reduces to the simple rational expectations model studied by Mussa (1976) and others. If α is greater than unity, the forward premium is a damped predictor of the actual rate of appreciation. This situation corresponds to the case of 'insufficient speculation' described by McKinnon (1976, p. 83):

> 'The ... hypothesis ... is that the supply of private capital for taking net positions in either the forward or spot markets is currently inadequate. Exchange rates then move sharply in response to random variations in the day-to-day excess demand by merchants for foreign exchange. Once a rate starts to move because of some temporary perturbation, no prospective speculator is willing to hold an open position for a significant time interval in order to bet on a reversal -- when the large daily and monthly movements in the foreign exchanges and the high bid-ask spreads.'

Within this interpretation, more active speculation would lead to a greater covariance between forecasted future rates of depreciation and the forward premium. Given the presumption that the z_t series is negatively correlated, high covariance would stabilize the spot rate.

The alternative interpretation is the old 'destabilizing speculation' argument associated with Nurkse (1944). In this case, the speculators are too willing to 'jump on the bandwagon' behind an anticipated appreciation or depreciation of a currency so that the forward premium is too volatile relative to the rational expectations forecast. Within the terms of equation (2), this case corresponds to a situation in which α is less than unity. In the exposition of this model by Friedman (1953) and Telser (1959), the non-speculative rate is assumed to be stable and positively correlated, so that the 'bandwagon' effect destabilizes the spot rate. To complement McKinnon's analysis, the case in which α is less than unity will be described as a case of 'excessive' speculation.

If there is either insufficient or excessive speculation in the market, it is possible to enter the market as a marginal speculator and make predictable profits. However, as should be clear from the preceding discussion, it is not possible to establish a direct relationship between profitability and stability in this model without describing the process generating the non-speculative rate. In McKinnon's case, insufficient speculation is destabilizing because the non-speculative rate is negatively correlated. In Nurkse's case, excessive speculation is destabilizing because the non-speculative rate is positively correlated. In addition, however, there are two other cases - insufficient and positive correlation; excessive and negative correlation - in which the entrance of additional profit maximizing speculators would destabilize the market.

This point can be established more formally by specifying the time series process generating the non-speculative rate. As in my previous papers (1978, 1979), z_t is assumed to be generated by a first order auto-regressive process in the first difference of the series.

$$\Delta z_t = \beta \, \Delta z_{t-1} + u_t \tag{3}$$

The β parameter may fall within the range of minus unity to plus unity. Negative autocorrelation in the z_t series is a characteristic of 'over-shooting' models of exchange rate determination. However, the pattern of negative autocorrelation in these models is generally more complicated than the simple AR1 process described in equation (3).[3/] Positive auto-correlation is a characteristic of the pure monetary models of Mussa (1976) and Bilson (1979) in which volatility is induced by the positive correlation between today's innovation, u_t, and the anticipated future growth of z_t.

To solve the model, substitute (2) into (1) to obtain the forward difference equation

$$s_t = (1-\gamma) \; z_t + \gamma \; \bar{s}_{t+1} \tag{4}$$

where γ is defined as $[(\varepsilon/\alpha)/1+(\varepsilon/\alpha)] < 1$. Equation (4) defines the current spot rate to be a weighted average of the current non-speculative rate, z_t, and the expected spot rate in the next period, $\bar{s}_{t+1}$. As α increases, implying a move from excessive to insufficient speculation, the weight given z_t increases and the weight given to $\bar{s}_{t+1}$ declines.

The full solution to equation (4) requires that the model be solved for the future expected values of the exchange rate and that the forecasting equation, equation (3), be substituted into the resulting solution in order to obtain the final reduced form. Since these procedures are now well known, only the final reduced form will be presented here.[4/] This equation is

$$\dot{s}_t = z_t + \frac{\gamma\beta}{1-\gamma\beta}\,\Delta z_t \;. \qquad (5)$$

In contrast to equation (4), equation (5) directly specifies the underlying forces (specifically $\beta\,\Delta z_t$) that are responsible for the market anticipation of appreciation or depreciation.

Having obtained a solution for the exchange rate, a measure of volatility must now be introduced. Of the numerous alternatives, I have chosen to defined volatility as the mean squared error of the forward premium as a forecast of the rate of depreciation. Formally, this measure is defined as

$$E(\Delta s_t - x_{t-1})^2 = E(\Delta s_t - \Delta\bar{s}_t)^2 + E(\Delta\bar{s}_t - x_{t-1})^2 \qquad (6)$$

The first term in this equation represents the variance of the unanticipated change in the exchange rate while the second term represents the squared forward rate bias. This measure of volatility appears to be close to the one that is implicit in popular discussions and it is preferable to the pure forecast error in that it does not require a specification of the true forecast of the rate of depreciation. It is also important to notice that the measure is defined upon the rate of depreciation - a stationary series - rather than the non-stationary level of the exchange rate.

Using equation (5), the variance of the forecast error may be found to be

$$E[\Delta s_t - \Delta\bar{s}_t]^2 = [\frac{1}{1-\gamma\beta}]^2\,\sigma^2 \qquad (7)$$

where σ^2 is the variance of the innovation, u_t, introduced in equation (3). The question at issue is the effect of departures from speculative efficiency ($\alpha = 1$) on the variance of the forecast error defined in this equation.

Remember that γ decreases with α so that as speculation moves from being excessive to insufficient, the weight given to anticipated future developments declines and the weight given to current market conditions increases. Equation (7) is stating that the effect of this transition on the volatility of the exchange rate depends upon the value of β, the parameter measuring the degree of serial correlation in the forcing variable z. If β is negative - as in McKinnon's J-curve analysis or Dornbusch's overshooting model - the absence of sufficient speculation is a source of volatility. Within the terms of the equation, a lower value of α (more speculative response) leads to a higher value of γ and to a smaller value for the term $1/1-\gamma\beta$. Essentially, this presentation merely repeats McKinnon's analysis within the framework of a specific model. However, it does point out that that analysis is crucially dependent upon negative autocorrelation in the underlying forcing series.

Consider, in contrast, the case in which the z series exhibits positive autocorrelation. If β is positive, higher values of γ increase the variance of the forecast error defined in equation (7). Positive autocorrelation in the forcing series generally arises when market participants have extrapolative expectations concerning the money supply growth rate and other series. In this case, excessive speculation leads to spot rate volatility because the current innovation in z creates anticipations of further changes in the same direction. Consequently interest rates rise, the currency sells at a discount, and the spot rate must fall to clear the market.

Within the terms of the model, then, the relationship between the degree of speculative activity and the volatility of the exchange rate forecast error cannot be described without some knowledge of the sign of the serial correlation in the forcing series. The model does predict, however, that economists who believe that the forcing series is negatively correlated will encourage speculative activity as a means to exchange rate stability while those who believe in positive serial correlation will tend to discourage speculative activity. Government officials, who are well aware of the positive correlation in the growth rates of their own policy variables, are prominent members of the latter group.

We now turn to the second term in equation (6): the squared bias in the forward rate forecast. This variable can be shown to be defined by

$$E[\Delta\bar{s}_t - x_{t-1}]^2 = \frac{[\beta(1-\alpha)(1-\gamma)]^2}{(1-\gamma\beta)^2(1-\beta^2)}\ \sigma^2. \qquad (8)$$

From the numerator of the coefficient on the right hand side of this equation, two sufficient conditions for lack of bias can be derived. The first, α equal to unity, simply states that if speculation is sufficient but not excessive, the forward premium will be an unbiased forecast of the future rate of depreciation. The second, γ equal to unity, may arise for two reasons. The first arises in a situation where the two currencies are perfect substitutes as transactions media and in which money holders are able to costlessly switch from one currency to the other. In this case, the perfect currency substitution case, both the expected rate of depreciation and the forward discount will be zero. The second case occurs when speculation becomes very excessive, so that α is close to zero and γ is close to unity. In this situation, too much of the future information is discounted into the current spot price so that the variance of the anticipated change in the exchange rate is very small.

More generally, however, it is not possible to specify the sign on the derivative linking the squared forecast bias to the γ parameter because two conflicting forces are at work. As mentioned above, higher γ values lead to more immediate discounting of future changes and hence reduce the variance of the anticipated change in the exchange rate. On the other hand, higher γ values increase the variance of the forward premium or discount. Since both of these variables should be of comparable dimensions, it is possible to argue that the aggregate effect could go in either direction.

To sum up the results of this section, we have seen that it is not possible to specify the relationship between profitability and volatility on purely theoretical grounds. The end result requires that the analyst know both the relationship between forward rates and future spot rates and the nature of the serial correlation in the forcing series. These issues are the subject of the following empirical investigation.

II. The Empirical Model

In this section, estimates of the main parameters will be provided for five major currencies: the Canadian dollar, the Pound Sterling, the Deutsche Mark, the French Franc and the Japanese Yen. The results are based upon 77 four-weekly observations running from January 17, 1975 to November 14, 1980 and the one month maturity is taken as an approximation for the four week maturity. For purposes of estimation, the model may is re-stated in the following equations.

$$s_{nt} = z_{nt} + \varepsilon x_{nt} \tag{9}$$

$$\Delta z_{nt} = \lambda_n + \beta_n \Delta z_{nt-1} + u_{nt}; \ -1 < \beta < 1 \tag{10}$$

$$E(u_{nt}) = E(u_{nt}, u_{nt-i}) = 0$$

$$E(u_{nt}, u_{n't}) = \sigma^2_{nn'}$$

$$\bar{s}_{nt} - s_{nt} = \alpha_n x_{nt} \tag{11}$$

The only major differences between this version of the model and the one presented above are that an 'n' subscript has been added to signify the currencies in the model, a trend term has been added to the autoregressive specification of the forcing series, and the innovations in the forcing series are assumed to be contemporaneously correlated. With the trend term, the solution for the level of the exchange rate may be found to be 5/

$$s_{nt} = z_{nt} + \frac{\lambda\gamma}{(1-\gamma)(1-\beta\gamma)} + \frac{\beta\gamma}{(1-\beta\gamma)} \Delta z_{nt}. \tag{12}$$

Using this result in conjunction with equation (10), the rate of change in the exchange rate may be written as

$$\Delta s_{nt} = \frac{\lambda}{(1-\beta\gamma)} + \frac{\beta(1-\gamma)}{(1-\beta\gamma)} \Delta z_{nt-1} + \frac{1}{(1-\beta\gamma)} u_{nt}. \tag{13}$$

Since the first two terms represent the expected change in the exchange rate based upon the information set in the previous period, equation (11) may be used to eliminate the unobservable Δz_{nt-1}.

$$\Delta s_{nt} = \alpha \, x_{nt-1} + \frac{1}{(1-\beta\gamma)} u_{nt} \tag{14}$$

Equation (14) makes the obvious point that the α parameter may be estimated from a regression of the actual rate of change in the exchange rate in period t on the forward premium in the previous period.

More importantly, however, the two equations also yield a solution for the forward premium or discount. Setting (13) equal to (14), the solution for the forward premium may be found to be

$$x_{nt} = \frac{\lambda}{\alpha(1-\beta\gamma)} + \frac{\beta(1-\gamma)}{\alpha(1-\beta\gamma)} \Delta z_{nt}. \tag{15}$$

In equation (15), the unobservable variable is eliminated by substituting for Δz_{nt} from equation (9) and by then substituting in a lagged version of equation (15) for Δz_{nt-1}. The resulting expression is

$$x_{nt} = \lambda\, f(\beta,\gamma,\alpha) + \beta\, x_{nt-1} + \frac{\beta(1-\gamma)}{\alpha(1-\beta\gamma)}\, u_{nt} \qquad (16).$$

where the function f( ) is a tedious combination of β, γ and α. Equation (16) demonstrates that the degree of autocorrelation in the forcing series may be estimated from running a regression of the forward premium on its own lagged value. In addition, the equation demonstrates that the residuals from estimating equation (16) will be correlated (in theory perfectly correlated) with the residuals from equation (14). Given the simplicity of the model, however, one would expect less than perfect correlation in the residuals from the two equations.

The most important result derived from this analysis is that the key parameters determining the relationship between profitability and volatility, α and β, may be estimated from the regression equations specified in equations (14) and (16). The 10 equations were estimated using Zellner's seemingly unrelated regression procedure in order to take account of the contemporaneous covariance in the residuals. In addition to the standard estimates, the parameters α and β were also constrained to be the same for all of the countries in the sample, which leads to more efficient estimates in this case.

The estimates presented in Table 1 support the view that a) currency speculation has been excessive and b) that the forcing series is positively correlated. In general, the first order autocorrelation coefficient lies within the range from .64 to .84, and the pooled estimate

TABLE 1: ESTIMATES OF THE KEY PARAMETERS

CURRENCY	CONSTANT	α	β
Canadian $	-.22E-03 (.10E-03)	-0.05 (0.66)	0.77 (0.04)
Pound Sterling	-.71E-03 (.25E-03)	0.44 (0.54)	0.78 (0.05)
French Franc	-.57E-03 (.32E-03)	0.39* (0.31)	0.64 (0.07)
Deutsche Mark	.51E-03 (.16E-03)	0.63 (0.49)	0.84 (0.04)
Japanese Yen	.44E-03 (.20E-03)	-0.81* (0.71)	0.70 (0.05)
Pooled		0.38* (0.21)	0.77 (0.03)

Notes: In the pooled regressions, the constant terms are allowed to vary across countries, but the α and β parameters are constrained to be equal.

Standard errors are given in brackets beneath the estimated coefficients. An asterisk indicates that the hypothesis that the true α is zero can be rejected at the 5 per cent level.

is 0.77. This figure is consistent with the observed correlation in possible candidates for the forcing series, including money supplies, real outputs, current account deficits, and the like. While the α coefficients are not as precisely estimated, it is noticeable that all of the estimates are below unity and that the constrained estimate is significantly below unity. In addition, it is never possible to reject the hypothesis that the true value of the α coefficient is zero. In other words, the data is more consistent with the hypothesis that the actual change in the exchange rate is unrelated to the forward premium than it is with the hypothesis that the forward premium is an unbiased forecast of the rate of change in the exchange rate.

In the preceding discussion, it was demonstrated that the combination of positive autocorrelation in the forcing series with excessive speculation lead to greater variance in the exchange rate than would be the case if the forward premium was set equal to the expected change in the spot rate. The underlying scenario views speculators as overreacting to market fundamentals: in response to a positive innovation, for example, speculators set the currency at an unwarranted premium and the spot exchange rate must appreciate in response to both forces. Hence it appreciates by more than it would if speculators were more modest in their assessment of their ability to forecast exchange rate developments. This interpretation relies, of course, on the assumption that the forward premium or discount solely reflects speculative expectations. If the premium also included a random risk premium, for example, the regression results could be equally well explained in terms of an errors in variables approach.

Has this form of 'destabilizing speculation' been an important source of exchange rate volatility during the post Bretton Woods period? One answer to this question may be given on the basis of the ratio of the actual mean squared error of the forward premium relative to that which would have occured if the forward premium was unbiased (i.e. if α was equal to unity. The answer to this question depends upon the value of ε, the parameter relating the spot exchange rate to the forward premium. Although this parameter could be estimated from the covariance matrix of the residuals from the two regressions,[6/] this procedure led to implausible values which suggested that the structure of the model was not strong enough to support inferences about the value of this parameter. As an alternative, the following calculations are based upon a presumed value of 10 for the semi-elasticity. Within the terms of the money demand literature, this value implies an interest elasticity of the demand for money of .1 if the monthly rate of interest is 1 per cent. This values also implies that the current spot rate is equal to a weighted average of the non-speculative rate, z_t, and the one month forward rate with ninety per cent of the weight being given to the forward rate.

The values of the mean squared error ratio are given below for the five countries and the pooled sample.

CURRENCY	MSE Ratio
Canadian $	1.84
Pound Sterling	1.32
French Franc	1.21
Deutsche Mark	1.34
Japanese Yen	2.40
Pooled	1.38

The MSE ratios suggest that the existence of profit opportunities in the forward market has been a substantial source of volatility in exchange rates. At the bottom of the scale, the MSE for the French Franc would have only been twenty per cent less if the forward premium had been unbiased. At the other extreme, the MSE for the Japanese Yen was 2.4 times the value that it would have been if the forward premium had been unbiased: the actual one month standard deviation for the Yen is around three per cent, these results suggest that it would have been around two per cent with unbiased forecasting. And while the results for the other countries are not as dramatic, it is clear that the excessive volatility in the forward premium has been an important source of volatility in the exchange rate in the cases studied.[7/]

III. Conclusion

Most studies of the time series behavior of the exchange rate have concluded that the exchange rate, like many other asset prices, follows a random walk. At the same time, major currencies have consistently stood at substantial premia or discounts against the dollar. If the random walk model is correct, then a speculator could profit by selling currencies that are at a premium (and buying currencies that are at a discount) in the forward market. The results of this paper demonstrate that this activity would not only be profitable, it would also result in more stable exchange rates. In a world in which such profit opportunities are eliminated, forward premia or discounts would typically be closed to zero, thus also leading to greater stability in international interest rate differentials.

There is, of course, no reason why private speculators should not enter the market and take advantage of the apparent profit opportunity. However, given that private speculation is likely to be a cause of the excessive volatility in the forward premium, these results could be used to justify an active intervention strategy by central banks. This strategy, which would be a variant of the 'leaning against the wind' model, would typically put the central bank in the position of buying weak currencies and selling strong currencies.

The model presented in this paper is not intended to provide the foundations for such an intervention strategy: its purpose was to explore the issue at a very simplified level. Consequently, only one form of forecast bias was considered and the model was not subject to any post-sample tests of the stability of the coefficients. This is a very important consideration, since market forces are likely to drive the α coefficient towards unity over time. However, the general methodology may be extended to include more sophisticated models of forecast bias and empirical methods may be used to estimate the extent and direction of the parameter drift.

FOOTNOTES

1/ For a survey of these developments, see Bilson (1979).

2/ Frenkel (1976), Mussa (1976).

3/ In the Dornbusch (1976) model, for example, the exchange rate is generated by an ARIMA (1,1,1) process. In words, the log first difference of the exchange rate contains both an autoregressive and a moving average component.

4/ See Bilson (1979).

5/ In order to simplify the notation, the country subscripts on the coefficients will be omitted in these derivations.

6/ If δ is defined as the covariance of the errors of the two equations divided by the variance of the forward premium equation, then the model suggests an estimate of ε of $\delta\beta-\alpha$. Two considerations suggested that this was not a useful estimate: first, the model predicted that the correlation coefficient between the forecast errors should be unity, when in fact the estimated correlation coefficients were low, and second, the estimated δ terms were negative, when they should be of the same sign as the β coefficient.

7/ In every case, the fraction of the MSE due to bias was less than one per cent. There is consequently very little difference between the use of the MSE and the variance as estimates of volatility.

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