Real versus Nominal Forecast Errors in the Prediction of Foreign Exchange Rates

by

Stephen A. Meyer and Richard Startz

Working Paper No. 5-81

April 1981

The Wharton School

University of Pennsylvania

Acknowledgments: Rudiger Dornbusch gave us much useful and gracious advice. The paper was written while Professor Meyer was on leave at the Federal Reserve Bank of Philadelphia, which provided the data, computational support, and the able research assistance of Mike McNamara.

Theories of exchange rate behavior may be roughly dichotomized according to whether they emphasize real or nominal economic factors. A number of models, particularly those relying on purchasing power parity, suggest that exchange rate forecast errors result from errors in forecasting relative inflation rates. (See Bilson (1978), Frenkel (1978), and Hodrick (1978) for prominent examples.) Other models, notably Frankel (1979), recognize errors in inflation forecasts, but emphasize real changes in exchange rates. (For a more extensive discussion of the various theories, see Dornbusch (1978).) We attempt here to shed some light on the question of whether exchange rate forecast errors are in fact mostly real or mostly nominal.

Several recent papers offer empirical tests of various models of real exchange rate determination. Dornbusch (1980) finds that unanticipated changes in the currrent account balance explain a good deal of unanticipated variation in the real dollar-yen exchange rate and less of the unanticipated variation in the real dollar-mark exchange rate during the floating rate period. Hooper and Morton (1980) suggest that fluctuations in the weighted average value of the dollar were caused in about equal parts by monetary shocks, current account shocks, and changes in the deviation of the actual rate from equilibrium. Both of these papers focus upon surprises in the current account as a measure of real shocks. This is likely to understate the importance of real shocks; information about real shocks may well be available long before it shows up in the current account. In addition, the tests in these papers are model specific; the expected exchange rate from which unanticipated deviations are measured is derived from one or another version of the asset approach model of exchange rate determination. We avoid imposing a restrictive definition of what constitutes a real shock. In addition, our tests are not model specific.

In this paper we show that the imposition of a small number of common, but fairly strong, assumptions allows the variance of the forecast error (realized spot exchange rate minus the matching forward rate) to be decomposed into its parts--that part due to errors in forecasting inflation (the "nominal" error), and that part due to "real" shocks. We show that real shocks have been predominant during the period of floating exchange rates which has followed the Bretton Woods System. This result is interesting for two reasons. First, it implies that the poor performance of simple forecasting models has not been caused by large and unexpected variations in relative rates of inflation. Second, our result implies that models of exchange rate determination that do not explicitly incorporate real shocks are inappropriate for explaining the behavior of exchange rates in the post-Bretton Woods world.

Let s_{t+1} and f_t represent the (natural logarithms of the) realized spot exchange rate (the dollar price of foreign exchange) and the matching forward exchange rate. The forecast error can be decomposed into a nominal part, the error in forecasting relative inflation rates at home and abroad, $\varepsilon^{\Delta\pi}$, and a real part, ε^{f}.

$$(1) \qquad s_{t+1} - f_t = \varepsilon^{\Delta\pi} + \varepsilon^{f}$$

Although we can measure the left side of (1), neither term on the right is observable. However, even though the errors are unobservable, we can measure their respective variances. By imposing three assumptions we are able to decompose the variation of $s_{t+1} - f_t$ into a nominal error variance, a real error variance, and a covariance of nominal with real errors. The three assumptions are: (1) the forward rate is the expected future spot rate; (2)

the "closed economy Fisher effect", that is expected real interest rates and expected inflation rates are uncorrelated; and (3) rational expectations, that is subjective market expectations are mathematical expected values conditional on available information. While these assumptions are strong, they have been widely used in the exchange rate literature. We briefly discuss the implications of relaxing these assumptions in the appendix.

Four sample statistics provide all the required information. The statistics are:

a) the variance of $s_{t+1} - f_t$;

b) the variance of the relative inflation rates;

c) the covariance of the relative inflation rates with the nominal interest rate differential;

d) the covariance of the relative inflation rates with $s_{t+1} - f_t$.

With these four statistics we decompose the total variance into its component parts. (A more mathematical derivation appears in the appendix.) Consider statistic c). The inflation differential consists of an anticipated component and a relative inflation forecast error. The nominal interest differential consists of the anticipated inflation differential and the expected real interest differential. The only correlated elements between the inflation differential and the interest differential is the anticipated inflation differential. Statistic c) measures the variance of anticipated inflation. Since statistic b) equals the variance of anticipated inflation plus the variance of unanticipated inflation, statistic b) minus statistic c) gives us the variance of the inflation forecast error. We are about halfway to the goal.

Examine statistic d). The part of the inflation differential that is anticipated is uncorrelated with the exchange forecast error. The inflation forecast error is correlated with both the real and nominal parts of the exchange forecast error. Therefore statistic d) equals the variance of unanticipated inflation plus the covariance of unanticipated inflation with the real exchange rate error. We found the former in the analysis of the previous paragraph, so the covariance is easily isolated.

With one variance and the covariance in hand we can find the variance of real forecast errors by subtracting from statistic a). To summarize our measures we have: nominal variance = b-c; real variance = a + (b-c) - 2d; nominal and real covariance = d - (b-c).

Empirical Results

We calculated the test statistics suggested above for several exchange rates among industrialized countries for the post-Bretton Woods period. We partitioned the variance of the forecast error of the one-month forward exchange rate for the U.S. dollar price of the British pound, Dutch Guilder, Swiss Franc, and West German Mark. In each case the "real" error variance dominates the "nominal" error variance.[1]

Spot and forward exchange rate quotations were taken at (or near) the middle of the month, and were matched for maturity date ("value date"). Interest rate differentials were calculated from one-month eurocurrency deposit rates, with quotation dates chosen to match the spot and forward exchange rate quotations. Consumer price indices were employed as measures of inflation. The sample period extends from October 1973 to November 1980.[2]

---

[1]The results for the three-month forward rate, sampling every third month, are essentially the same. Real errors dominate by far.

[2]Spot and forward exchange rate quotations are taken from Data Resources, Inc.: Financial and Credit Information Service Data Base. CPI quotations are taken from International Financial Statistics, various issues.

Forecast errors were large over this period. The standard deviations for the four countries respectively were 2.3 percent, 2.6 percent, 3.6 percent, and 3.0 percent.

The sources of exchange rate forecast errors are presented in the table below. The principal source of variation may be summarized in a word: "real".

Real and Nominal Forecast Errors

(as % of Total Variance)

	Br. Pd.	D.fl	Sw.Fr.	D.M.
var (ε^f): Real	119.60	107.93	104.27	107.94
var ($\varepsilon^{\Delta\pi}$): Nominal	13.67	4.44	2.22	1.57
cov ($\varepsilon^{\Delta\pi}, \varepsilon^f$)	-16.63	-6.18	-3.24	-4.75
Total	100%	100%	100%	100%

Conclusions

In a set of both small and large industrialized countries, real forecasting errors outweigh those due to errors in forecasting relative rates of inflation during the period since the end of the Bretton Woods fixed exchange rate system. This result implies that the poor forecasting performance of simple asset or monetary models of exchange rate determination is not primarily due to errors in forecasting future price levels. Rather, the poor performance is due, in large measure, to ignoring various real shocks which affect exchange rates. Our results lead to the conclusion that models of exchange rate determination which exclude any direct effect of real shocks upon exchange rates are inappropriate for explaining the variability of exchange rates since 1973.

Appendix

In this appendix we prove more formally the propositions set out in the body of the paper and then consider the consequences, first of failure of the Fisher effect and, second of the presence of a risk premium in the forward rate. The forecast error has a nominal and a real component as in (A1). The forecast error variance can be decomposed as in (A2), statistic a).

$$\text{(A1)} \qquad s_{t+1} - f_t = \varepsilon^{\Delta\pi} + \varepsilon^{f}$$

$$\text{(A2)} \qquad \text{var}\ (s_{t+1} - f_t) = \text{var}\ \varepsilon^{\Delta\pi} + \text{var}\ \varepsilon^{f} + 2\ \text{cov}\ (\varepsilon^{\Delta\pi}, \varepsilon^{f})$$

The relative inflation rate, $\Delta\pi$, has an anticipated and an unanticipated component. Under rational expectations, these are uncorrelated, so the variance of relative inflation may be decomposed as in (A4), statistic, b).

$$\text{(A3)} \qquad \Delta\pi = \Delta\pi^{e} + \varepsilon^{\Delta\pi}$$

$$\text{(A4)} \qquad \text{var}\ (\Delta\pi) = \text{var}\ (\Delta\pi^{e}) + \text{var}\ (\varepsilon^{\Delta\pi})$$

The relative nominal interest rate differential equals the anticipated inflation differential plus the difference between expected real interest rates.

$$\text{(A5)} \qquad \Delta i = \Delta r^{e} + \Delta\pi^{e}$$

To find the covariance for statistic c), examine the expected cross-product of (A3) and (A5). The expected real interest rate is uncorrelated with the expected inflation differential by the Fisher effect and with the unanticipated component in (A3) by rational expectations. Thus (A6) gives us statistic c).

(A6) $\quad \text{cov}\ (\Delta i,\ \Delta\pi) = \text{var}\ (\Delta\pi^e)$

In order to find the covariance for statistic d), examine the expected cross-product of (A1) and (A3). The anticipated inflation differential is again uncorrelated with any of the error components leaving us with (A7).

(A7) $\quad \text{cov}\ (s_{t+1} - f_t,\ \Delta\pi) = \text{var}(\varepsilon^{\Delta\pi}) + \text{cov}\ (\varepsilon^{\Delta\pi},\ \varepsilon^{f})$

It follows immediately that the combinations of the statistics a through d, as indicated in the main text, do give us the required decompositions.

It is interesting to see how the partitioning statistics are biased if some of the restrictive hypotheses fail. Suppose the closed economy Fisher effect is false. The covariance of Δr^e with $\Delta\pi^e$ must be added into (A6). The variance of the inflation forecast error, b-c, is understated by $\text{cov}\ (\Delta r^e,\ \Delta\pi^e)$. The size of the misstatement is $\text{cov}\ (r^e,\ \pi^e) + \text{cov}\ (r^{e*},\ \pi^{e*}) - \left(\text{cov}\ (r^e,\ \pi^{e*}) + \text{cov}\ (r^{e*},\ \pi^e)\right)$, where asterisks indicate foreign country variables. To the extent that covariances between expected real interest rates and expected inflation are the same across countries as within countries, the effects cancel. To the extent that the covariances are unequal, one would probably guess that the cross-border covariances are smaller in absolute value than the within-border covariances. There is evidence for the United States that real rates and anticipated inflation are negatively correlated (see Summers (1980)). If this holds in other countries as well, b-c overestimates the variance of the inflation forecast error. The covariance of real and nominal exchange rate forecast errors is underestimated by the same amount, as is the variance of real exchange rate forecast errors. The probable net effect then of a failure of the Fisher effect is to attribute too much variation to nominal causes and too little to real causes.

Suppose that the forward rate is not an unbiased predictor of the future spot rate. Instead, suppose that the forward rate equals the rationally expected value of the future spot rate plus a premium that might be either positive or negative. The simplest case is a constant premium. With a constant premium none of the statistics is affected. What if, rather than a constant, the premium is time varying, but that it is uncorrelated with expected inflation? The only final statistic that changes is the variance of real exchange forecast errors, which would be overstated by exactly the same amount that the variance of the total exchange forecast error is overstated. In other words, a risk premium is itself a real factor,[3] though not a real error.

---

[3]Hooper and Morton (1980) find that the risk premium is unimportant in explaining changes in exchange rates.

Bibliography

Bilson, John F.O. (1978), "The Monetary Approach to the Exchange Rate: Some Empirical Evidence," IMF Staff Papers (March), pp. 48-75.

Dornbusch, Rudiger (1978), "Monetary Policy Under Exchange Rate Flexibility," in Federal Reserve Bank of Boston Conference Series No. 20, Managed Exchange-Rate Flexibility: The Recent Experience, pp. 90-122.

__________ (1980), "Exchange Rate Economics: Where Do We Stand?," Brookings Papers on Economics Activity (No. 1), pp. 143-185.

Frankel, Jeffrey A. (1979), "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials," American Economic Review (September), pp. 610-622.

Frenkel, Jacob A. (1978), "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence," in Frenkel, Jacob A. and Harry G. Johnson, Eds., The Economics of Exchange Rates (Reading, Massachusetts; Addision-Wesley), pp. 1-25.

Hodrick, Robert J. (1978), "An Empirical Analysis of the Monetary Approach to the Determination of the Exchange Rate," in Frenkel and Johnson, op. cit., pp. 97-116.

Hooper, Peter and John Morton (1980), "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination," Federal Reserve Board, International Finance Discussion Paper No. 168 (October).

Summers, Lawrence H., "The Non-Adjustment of Nominal Interest Rates: A Study of the Fisher Effect," mimeo, M.I.T., August 1980.