Forward Exchange Rates in Efficient Markets: The Effects of News and Changes in Monetary Policy Regimes

Mack Ott and Paul T. W. M. Veugelers

SINCE the late 1970s, theoretical explanations of exchange rate determination have emphasized the asset approach rather than the expenditure approach.[1] Most of the empirical research applying the asset models of exchange rate determination also subsume the efficient market hypothesis. In this article, we test three efficient market hypotheses bearing on forward exchange rates: First, are forward rates unbiased forecasts of future spot exchange rates? Second, does "news" — in particular unanticipated changes in nominal or real interest differentials — explain forward rate forecast errors? Third, are forward rate forecast errors affected by change in the U.S. monetary policy regime? These hypotheses are tested by examining the forecast errors (the difference between the forward rate and the subsequently observed spot rate) for the U.S. dollar forward rate against the currencies of eight industrialized countries over the latest floating-rate era (1973–85).

EFFICIENT MARKETS AND FORWARD EXCHANGE RATES

The forward exchange rate in an efficient market reflects all the information possessed by individuals active in that market. Thus, in an open market, the forward rate should be an unbiased predictor of the future spot rate.[2] Hence, a regression of the observed spot rate at time t on the forward rate at time t − 1 (where exchange rates are measured by natural logarithms of the dollar prices of foreign exchange),

$$(1)\ s_t = a + b\,f_{t-1} + e_t,$$

should result in an estimated constant not significantly different from zero, an estimated coefficient on

Mack Ott is a senior economist at the Federal Reserve Bank of St. Louis and Paul T. W. M. Veugelers, formerly a professor in the Department of Monetary Economics, Erasmus University, is a private consultant in the Netherlands. *This article is the result of research undertaken in 1985 during an exchange of visits — Mr. Veugelers to this Bank and Mr. Ott to Erasmus University. The authors acknowledge the research assistance of James C. Poletti and the helpful comments of Clemens Kool.*

[1]One rationale for this shift is the observation that the interest rate parity (IRP) postulate of the asset view has held up substantially better than the purchasing power parity (PPP) postulate of the expenditure view; see Mussa (1979) and Frenkel (1981b). The former refers to the equality of asset yields across currencies, while the latter refers to the equality of purchasing power across currencies. PPP frequently, and for protracted periods, has been violated by exchange rates; see Frenkel (1981b). Thus, analysts have been faced with either modifying the PPP assumption and diluting its relevance, or accepting the evidence and developing theories to explain it. Indeed, some authors, Bomhoff and Korteweg (1983) and Darby (1981), argue that changing real exchange rates vitiate the relevance of PPP.

[2]See Dornbusch (1976), Mussa (1979), Frenkel (1981a), Bomhoff and Korteweg (1983) and Edwards (1983b).

the forward rate not significantly different from 1.0, and serially uncorrelated errors (e_t).[3]

Risk Premium

The empirical finding of a significant intercept has been sufficiently frequent in recent research that it is no longer interpreted as a departure from market efficiency. The question, then, is, what does the significant intercept represent?

The current view is that the intercept represents a return to speculation.[4] For example, if real interest rates on U.S. securities are higher than those on foreign securities, investors will shift their portfolios toward the higher-yielding securities denominated in U.S. currency; if these investors are risk-averse to unforeseen changes in currency values, they can hedge by selling the higher-yielding U.S. currency forward and buying their own currency forward. By IRP, the resulting upward pressure on the forward rate must just offset the higher yield obtained on the U.S. securities.[5] Thus, the forward rate in equation 1, in such cases, would overestimate the future spot rate so that the estimated intercept would be negative. Conversely, a higher rate on non-U.S. securities, by the same logic, would imply a positive intercept.

News of Interest Rate Changes

Frenkel (1981a) argues that changes in expectations between the time that the forward rate prediction is made and the spot rate is observed explain the forward errors. These changes in expectations, which he calls news, are based on information revealed after the forward contracts are made but before the spot rates are realized. Thus, unanticipated changes in interest rate differentials between time $t-1$ and t, — one example of news — explain part of the residual between the forward rate forecast f_{t-1} and the realized spot rate s_t. Incorporating this modification into equation 1 yields

$$(2)\quad s_t = a + bf_{t-1} + c[(i - i^*)_t - E_{t-1}(i - i^*)_t] + e'_t,$$

where i is an interest rate of the same term as the forward rate with asterisks indicating non-U.S. variables (interest rates are not in logs). Once again, risk-neutrality and efficient markets would imply an insignificant intercept and a slope coefficient of unity; the sign of the coefficient on the news variable, however, would depend upon whether the rise in the interest differential were due to a relative rise in U.S. inflation — in which case it would be positive — or a relative rise in U.S. real interest rates — in which case it would be negative.[6]

Frenkel's proxy for the expected interest rate differential was obtained from a regression of the interest differential on its own lagged values and the lagged forward exchange rate. Estimating this model over 1973–79 for the pound sterling, deutschemark and franc, he found the intercept to be insignificant and the coefficient of the lagged forward rate not significantly different from one; these findings are consistent with the efficient market hypothesis. Moreover, the coefficients on the news variable — the unanticipated interest rate change — were positive, which he interpreted as primarily reflecting the relatively high and rising U.S. expected inflation rate during this period.

THE ROLE OF NEWS IN THE FORWARD EXCHANGE MARKET

An important insight of the asset-market approach to exchange rate determination is the emphasis on expectations. Asset prices are much more dependent

[3]These propositions about the forward exchange rate have not been supported by recent empirical work. For example, Hansen and Hodrick (1980) find significant evidence of risk premia and explanatory power in lagged errors in both the 1920s and 1970s in one- and three-month forward markets. Baillie, Lippens and McMahon (1983), using a time series model on weekly data reject the hypothesis that the forward rate is an unbiased predictor of the future spot rate in weekly data. Fama (1984) argues that the risk premium explains much of the error in the forward rate's forecasts and finds that the risk premium and expected future spot rate are negatively correlated. Jacobs (1982) argued that the forward rate is an imperfect proxy for the expected rate and constructs a time series proxy for the expected rate. Unlike Fama, however, Jacobs found information in the past variables, that is, information not included in the efficiently constructed forward rate at time $t-1$. Jacobs' emphasis on omitted information is analogous to the decomposition suggested by Frenkel (1981a) and elaborated in Isard (1983) and Edwards (1983a, 1983b). Edwards (1983b) finds that market efficiency is not rejected in three out of four currencies in his study once news is included.

[4]Fama (1984) and Hodrick and Srivastava (1985). Hodrick and Hansen (1983) find that significant premia are both common and time varying. Frenkel (1981a) finds that news explains some of the risk premium while Edwards (1983b) finds that the combination of news and a system estimation technique eliminates the significant intercept.

[5]Investors are concerned about after-tax real rates of return; throughout this article we ignore the possibility that long-run real interest differentials may persist due to different tax rates on interest and investment income. Since our tests are on the effects of unanticipated *changes* in interest differentials, this possibility does not affect our results.

[6]An increase in the expected inflation rate differential implies that, in the future, the dollar price of foreign currency will rise faster, and fewer dollars will be demanded because of their higher holding cost; hence, s_t would rise. An increase in the U.S. real interest rate relative to foreign rates would increase the value of the dollar; hence, s_t would fall.

than current goods prices on the anticipated course of future events. Consequently, the role of news is most aptly captured in the change of expectations, not the error between the expected and realized yield differentials.

By an application of IRP and the efficient forward market hypothesis for foreign exchange, we can obtain an alternative form of the news equation 2 estimated by Frenkel. The alternative model takes the form (see shaded insert on the next page):

(3) $s_t - f_{t-1} = \alpha + \beta\Delta fp_t + \omega_t$.

This model has the advantage of using a market-implied interest differential as well as directly embodying the change in expectations rather than the empirically derived, expectation error proxy used by Frenkel.

The Distinction Between Real and Nominal News

Frenkel claimed that the positive coefficient on the interest rate news he found during 1973–79 reflected the relatively high and rising U.S. inflation rate during this period. Since the U.S. inflation rate has fallen both absolutely and relative to other nations in the years since 1979, the estimated coefficient on the expected nominal interest differential should be unstable over the full period 1973–85. One way to deal with this problem is to break the period into smaller units, each of which have uniform relative U.S. inflation rates. We, instead, separate the real and inflation components of the nominal news variable. That is, we will view the change in the nominal interest differential as the sum of a change in the expected real yield differential and the change in the expected inflation differential. These components of the news should have different effects on the forward rate errors.

A rise in the real yield on investments in one country relative to those elsewhere, in the absence of capital restrictions, will cause an immediate appreciation in its exchange rate and result in a negative error in equation 3. Such appreciations are transitory because capital inflows will bring down the initially higher yields, while the concomitant outflows raise the yields elsewhere, until equality of yields is restored.[7] Consequently, the very rise in the relative yield that causes a currency to appreciate also creates the anticipation of its subsequent depreciation as yield differences go to zero.

In contrast, an increase in the expected inflation differential primarily alters the rate of depreciation of the exchange rate by changing its PPP level; a rise in the inflation differential causes the exchange rate to rise faster over time by the amount of the inflation increase. The depreciation of the spot rate also will reflect the perceived increase in the holding costs of the country's currency which reduces the quantity demanded.

Thus, express the nominal news as the sum of its real and inflation components,

(4) $\Delta fp_t = \Delta(r_t - r_t^*) + \Delta(\pi - \pi_t^*)$,

where r_t = expected real interest rate, and
π_t = expected inflation rate.

Then, substitute the right-hand-side of equation 4 into equation 3, to obtain

(5) $s_t - f_{t-1} = \alpha + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(\pi_t - \pi_t^*) + \varepsilon_t$.

In equation 5, α is non-zero in the presence of a risk premium, β_1 is negative (since an unanticipated relative rise in U.S. real rates lowers s_t, implying $s_t - f_{t-1} <$ 0), β_2 is positive but smaller than β_1 (since a rise in the relative U.S. inflation rate will cause a change in the rate of depreciation of the dollar, and, through decreased demands for transaction balances, some decline in its level), and ε_t is a serially uncorrelated disturbance term.

Another Kind of News: Changes in Monetary Policy Regimes

The estimated parameters of an economic relation reflect the perceived policy stance of the government and monetary authorities. Thus, as Lucas (1974) argued, changes in policy, either broad goals such as the desired inflation rate or narrower ones such as the method in which the policy is implemented, may alter the public's response to prices and other information.[8]

[7]See Dornbusch (1976), Isard (1983), and Edwards (1983a). Nonetheless, the existence of risk premia implies that interest differences have persisted for some time in open capital markets; see Fama (1984). Hodrick and Hansen (1983) find these risk premia to be nonconstant and that their time variation is *not* summarized by nominal interest rate movements.

[8]We abstract from changes in the long-run real exchange rate in this analysis. That is, different rates of capital or human capital investment will cause different rates of productivity growth, or resource price changes that can alter the real exchange rate; see Darby (1980), Bomhoff and Korteweg (1983). Also, a reduction in the security of property rights can make investment in one currency less attractive than investments in other currencies, depreciating the currency and raising its real yields; see Dooley and Isard (1980). An apt application of the Dooley-Isard hypothesis may be the change in the French government in 1981, which was followed by significant nationalizations — especially in the banking sector. In our analysis, the only structural change considered is the U.S. monetary policy regime.

Forward Exchange Rate Errors, Efficient Markets and the News: the Role of the Forward Premium

In its strong form, the efficient market hypothesis implies that the intercept in equation 1 will be zero and the coefficient of the lagged forward rate will be unity. Consequently, the error term, e_t, is simply the error of the forward rate's forecast of the spot rate,

$$(2.1)\quad s_t - f_{t-1} = e_t.$$

Frenkel's insight concerning the role of news is to argue that this error is due to information revealed after t−1 (but before t) which alters expectations and, hence, s_t:

> . . . current exchange rates already reflect *current expectations* about the future, while changes in the current exchange rate reflect primarily, *changes in these expectations* which, by definition, arise from new information.[1]

Frenkel's specification, equation 2, employs the difference between the *realized* interest differential and the *expected* differential; however, his argument implies that the news variable should be the change in the expected differential between t−1 and t. That is,

$$(2.2)\quad e_t = \phi\,(E_t\,(i - i^*)_{t,t+1} - E_{t-1}\,(i - i^*)_{t-1,t}).$$

IRP implies that the annualized one-month forward premium,

$$(2.3)\quad fp_t \equiv 12(f_t - s_t),$$

is equal to the interest differential expected to prevail during t through t+1,

$$(2.4)\quad fp_t = E_t\,(i - i^*)_{t,t+1},$$

where the term to maturity of the interest rates is equal to the holding period in fp. If this equality did not hold, riskless opportunities for profitable arbitrage would exist.[2] Thus, substituting the relevant forward premia from equation 2.4 for the expected interest differentials in equation 2.2 and then substituting this expression for the error term in equation 2.1, we obtain

$$(2.5)\quad s_t - f_{t-1} = \phi\,(\Delta fp_t),$$

which can be written in an estimable form as

$$(3)\quad s_t - f_{t-1} = \alpha + \beta\,\Delta fp_t + \omega_t.$$

---

[1]Frenkel (1981b), pp. 700–701, emphasis added. Frenkel notes (see footnote 31, p. 701) that Gustav Cassel, "the most recognized proponent of the purchasing power parity doctrine" also recognized this forward-looking aspect:

> The international valuation of the currency will, then generally show a tendency to anticipate events, so to speak, and become more an expression of the internal value that the currency is expected to possess in a few months, or perhaps in a year's time (Cassel 1930, pp. 149–50).

[2]This is known as the covered arbitrage condition. For example, if the $fp_t < (i_{US} - i^*_{UK})_t$, an investor could sell pounds and buy dollars at time t, use the proceeds to buy a U.S. security; by buying forward pounds at t, the investor removes any exchange rate risk and obtains a higher yield than he would have in U.K. securities. Since this yield differential is riskless, arbitrage should drive it to zero and, in the process, ensure the equality shown in equation 2.4. For a fuller discussion and many instructive examples, see Wood and Wood (1985), pp. 378ff.

Therefore, regression estimates of equations 2, 3 or 5 may be sensitive to changes in policy goals and regimes.

In particular, the hypotheses for real and inflation news summarized above are dependent on the monetary policy regime. For example, when the monetary authority targets monetary growth, interest rates will be determined by the private and public demand for loanable funds; unforeseen changes in that demand will cause changes in interest rates. Interest rates also will reflect private expectations about inflation. In such a monetary policy regime, the Fisher hypothesis holds, so that real interest rates are simply the difference between nominal interest rates and anticipated inflation; consequently, equation 4 holds, while equation 5 follows as an implication of equations 3 and 4.[9]

In contrast, consider a monetary policy regime of

---

[9]However, a critical caveat in evaluating equation 5 (or 5′, see below) is Fama's assertion that, when complete PPP does not hold, uncertainty and differential tastes combine "to strip the Fisher equation of its meaning" (1984, p. 323).

targeting interest rates.[10] Under such a policy stance, movements in interest rates are, to some extent, policy determined in the short run since changes in the nominal interest rate induce offsetting changes in the money supply through a policy-reaction feedback.

Consequently, changes in interest rates under a regime of targeting interest rates convey different information than do interest rate changes under a regime of targeting monetary aggregates. A real interest differential under interest-rate targeting cannot be closed by capital flows alone if the monetary authority chooses to maintain a particular nominal target rate which maintains the differential. Over time, an interest rate target below the market rate will increase the inflation differential. The adjustment process then depends totally upon the relative inflation rates to restore PPP. And, again, the risk premium embodied in the intercept should be smaller during an interest-rate regime due to the reduced short-run, interest-rate uncertainty.

This policy regime hypothesis can be tested by an F-test on the restriction implicit in both equation 3 and 5 that the coefficients — α, β, β_1, β_2 — are stable over changes in monetary policy regimes. The restriction is tested by adding intercept and slope dummy variables to get equations 3′ and 5′, computing the F-statistic on the change in the residuals between the estimates of the restricted and unrestricted equations:

$$(3') \quad s_t - f_{t-1} = \alpha_0 + \alpha_{01}D + \beta_0 \Delta fp_t + \beta_{01} D\Delta fp_t + \omega_t'$$

$$(5') \quad s_t = f_{t-1} = \alpha_0 + \alpha_{01}D + \beta_1 \Delta(r_t - r_t^*) + \beta_{11} D\Delta(r_t - r_t^*)$$

$$+ \beta_2 \Delta(\pi_t - \pi_t^*) + \beta_{21} D\Delta(\pi_t - \pi_t^*) + \varepsilon',$$

$$\text{where } D = \begin{cases} 1 & \text{if October 1979} \leq t \leq \text{September 1982} \\ 0 & \text{otherwise.} \end{cases}$$

Summary of Testable Implications

The implications of the analysis in equations 3′ and 5′ are worth summarizing before reporting the estimation results. First, news about the real interest differential causes negative forecast errors, $s_t - f_{t-1}$, while changes in the inflation differential cause positive forecast errors. If there are periods dominated by relative volatility in inflation and other periods dominated by real yield volatility, then equation 3, which restricts the coefficients to equality, should be rejected by an F-test in comparison with equation 5 which does not restrict these coefficients to equality.

Second, the theory underlying equation 5 implies that news about the expected inflation differential will cause forecast errors, $s_t - f_{t-1}$, whose magnitude depends on the sensitivity of money demand to changes in the inflation rate. The coefficient should have the same sign as the change in the inflation differential. Given the shortness of the observation period — one month — the regression coefficient β_2 in equation 5 should be positive but may not be significant.

Third, since the interest rates (hence, forward premia) are assumed to be determined without a monetary policy reaction function in the analysis represented in equation 5, monetary policy based on interest-rate targets affects these hypotheses. If the monetary policy regime affects the market valuations, i.e., spot and forward exchange rates, hence forward-rate forecast errors, then the restrictions in equation 5 which are removed in equation 5′ will be rejected by an F-test on the improved fit of equation 5′ relative to equation 5.

Fourth, since it is well known that the variances of U.S. interest rates, both nominal and real, have been higher during monetary target regimes than alternative regimes, there is a greater likelihood of misforecasting interest rates under a monetary target regime.[11] The risk premium measured by the intercept, which primarily is determined by this risk, should be negative, larger and more significant during periods of monetary targeting than during periods of interest-rate targeting. This hypothesis can be tested by the significance of the intercept's dummy variable in equations 3′ or 5′.

Finally, under the efficient market hypothesis embodied in equations 3, 5, 3′ and 5′, the error terms should be serially uncorrelated. Correlation in the disturbance term implies incomplete use of past information and failure to exhaust profit opportunities. Alternatively, if markets are efficient, serially correlated residuals imply a misspecification of the estimating equation.

[10]Only two U.S. monetary policy regimes are distinguished in this study — the October 1979–September 1982 period and the remaining period before and after. Implicitly, this assumes that both the pre-October-1979 and the post-September-1982 periods are based on interest-rate targeting procedures; support for this characterization of these two periods is offered in Gilbert (1985), Kaufman (1982) and Rasche (1985). The foreign monetary policy stance might also be argued to be relevant; while this is a possibility for a refinement on the estimates reported in this study, there do not appear to have been substantial changes during the period 1974–83 in six of the eight countries. The policy procedures of six of the eight non-U.S. countries (excluding Italy and Netherlands) are reviewed in Johnson (1983).

[11]See Roley (1983) and Rasche (1985).

EMPIRICAL TESTS

The models specified in equations 1, 3, 5, 3′ and 5′ were estimated using monthly data from October 1973 through June 1985, using the U.S. dollar spot and one-month-forward prices of the currencies of Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland and the United Kingdom. The tests are nested in that equation 3 is obtained from equation 1 by imposition of the efficient market hypothesis. Equation 1 also contains both the restriction to suppress the real interest rate vs. inflation rate decomposition and the restriction to suppress the effects of changing monetary policy regimes on the regression coefficients' values. We first test the simple efficient market hypothesis by estimating equation 1. Next, we estimate the simple news model with the change in the nominal forward premium, equation 3. This model contains both the nominal news and the policy regime restrictions above. We can then test these restrictions by estimating 5′, which is unrestricted and comparing it through F-tests with equations 5 and 3′. F-tests on equation 5′ vs. equation 5 and 5′ vs. 3′ determine, respectively, whether the policy regime or nominal forward premium restrictions can be rejected.

Data

The spot and 30-day forward exchange rates used in the estimates are New York opening market (10 a.m. midpoints) for the last business day of the month as compiled by the Bank of America. The change in the real interest differential was obtained from the change in the forward premium: First, the forward premium was converted to an annualized rate; the change in this annualized forward premium is the news — that is, the change in the expected nominal interest differential. Second, an expected annualized inflation rate for the one-month horizon was computed for each country from its monthly CPI series.[12] The change in the differential, U.S. minus foreign inflation, is the change in the inflation differential used in estimating equations 5 and 5′. The change in the real interest differential is then the change in the annualized, nominal, one-month-forward premium minus the change in the expected inflation differential.

[12]Clemens Kool of Erasmus University computed this series using a multi-state Kalman filter. A simple Kalman filter is a forecasting method based on assumptions about the forecasted variable's relation to current and lagged data on itself and or other series. A multi-state Kalman filter allows this relation to vary according to a feedback or adaptive error loop; the multi-state modifier refers to the alternative sets of assumed weights. A concise description and illustrative example are contained in the statistical appendix to Bomhoff and Korteweg (1983).

Tests of Forward Market Efficiency

Table 1 reports the results of estimating equation 1 during the full sample period, October 1973 through June 1985. For six of the eight currencies considered, market efficiency is not rejected; for Japan and Switzerland, however, the market efficiency hypothesis is rejected at the 5 percent level. For all eight, the Durbin-Watson statistic indicates that hypothesis of serially uncorrelated disturbances is not rejected. Thus, except for Japan and Switzerland, the results in table 1 indicate that the news model specified in equation 3 is an appropriate empirical model.

For Japan and Switzerland, equation 1 was reestimated by subperiods before, during and since the U.S. monetary aggregate target regime of October 1979 through September 1982. For each country, the hypothesis of serially uncorrelated residuals was not rejected in any subperiod. For each of the subperiods, the efficient market hypotheses bearing on the coefficients for Switzerland were not rejected. For Japan, the earlier two subperiod estimates do not reject market efficiency, but the recent subperiod rejects market efficiency both in terms of a significant intercept and the deviation from unity of the lagged forward rate coefficient.[13]

Consequently, for neither Switzerland nor Japan is the estimation of equation 3 justified since equation 3 is derived from equation 1 assuming a unit coefficient on f_{t-1}. Yet, equation 3′ or equation 5′ may be justified for Switzerland since the dummy variables can account for the nonstable coefficient. For Japan, the failure of the efficient market hypothesis in the last subperiod is not offset by any of our variables, and it is consistent with this failure that Japan rejects each of the specifications equations 3′, 5 and 5′ as reported in tables 2 and 3.

Tests of News Model with U.S. Monetary Regimes Not Distinguished

Table 2 reports the results of estimating equation 3, the news model with the change in the nominal forward premium, over the full period, October 1973–June 1985. In sharp contrast to the results in table 1, which support this specification, the estimates uniformly reject this model: no coefficient is significant at

[13]The October 1982–June 1985 estimates for Japan are very curious. The estimated intercept is huge in comparison with the earlier-period Japanese estimates, the Swiss estimates or any of the estimates in table 1:

$$\alpha = -1.192 \text{ (s.e. } = 0.548), \beta = 0.783 \text{ (s.e. } = 0.100).$$

Table 1

Tests of Forward Exchange Market Efficiency for U.S. Dollar, October 1973–June 1985 (U.S. Monetary Regimes Not Distinguished)

	Coefficients[1]		Summary Statistics		Test
Currency	Intercept	f_{t-1}	$\bar{R}^2$	DW	F^2
Canada	−0.002 (0.002)	0.998 (0.012)	0.981	2.16	0.730
France	−0.002 (0.018)	1.001 (0.010)	0.985	2.07	0.573
Germany	−0.020 (0.016)	0.981 (0.018)	0.954	2.03	1.800
Italy	0.012 (0.052)	1.002 (0.007)	0.992	1.87	0.500
Japan	−0.298 (0.112)*	0.946 (0.020)*	0.940	1.80	3.734*
Netherlands	−0.013 (0.017)	0.991 (0.018)	0.957	2.01	1.486
Switzerland	−0.034 (0.013)*	0.961 (0.016)*	0.962	1.92	3.537*
United Kingdom	0.001 (0.009)	0.994 (0.014)	0.974	1.82	0.483

[1]Standard errors of estimated coefficients appear in parentheses; asterisks indicate rejection at 5 percent level of individual efficient market hypotheses — intercept is zero, slope coefficient = 1.0.

[2]F-test of joint efficient market hypothesis that intercept is zero *and* slope coefficient is unity; asterisk indicates rejection at 5 percent level.

any reasonable confidence level and the adjusted R^2 is negative for six of the eight currencies tested. Consistent with the efficient market hypothesis, however, the hypothesis of serially uncorrelated disturbances is not rejected. Nonetheless, the results require an investigation of alternative explanations for this model's uniform failure.

Decomposition of Nominal Forward Premium

Also reported in table 2 is the F-statistic for testing whether decomposing the change in the nominal forward premium into innovations in its expected real and inflation components is statistically warranted. The F-statistic is obtained from the difference in the explanatory power of equation 5 with respect to equation 3; the critical value for rejecting the restriction in equation 3 (that β_1, β_2 in equation 5 are equal) is 3.92. Only the Netherlands result rejects the restriction.

Tests of News Model with U.S. Monetary Regimes Distinguished

As discussed above, the U.S. monetary policy regime can be expected to affect the relationship between the dollar's exchange rates and U.S.-foreign interest differentials. Thus, the statistical results reported in table 2 may be invalid because they do not distinguish changes in the U.S. monetary policy stance. To test for such policy regime effects, equations 3′ and 5′, were estimated to isolate the period of U.S. monetary aggregate targeting, from October 1979 to September 1982, with slope and intercept dummies.

Table 3 reports estimates of equation 5′ and the F-statistics to test the effect of monetary regime changes and the equality restriction implicit in equation 3′ and removed in equation 5′. The estimates present a substantial contrast to those in table 2. Canada and Italy reject the nominal forward premium restriction (last

Table 2

Tests of News Model Using Change in Nominal Annualized Forward Premium on U.S. Dollar, October 1973–June 1985 (U.S. Monetary Regimes Not Distinguished)

	Coefficients[1]		Summary Statistics			Test
Currency	Intercept	Δfp	$\bar{R}^2$	DW	F	F[2]
Canada	−0.001 (0.001)	−0.069 (0.102)	−0.004	2.16	0.455	2.059
France	−0.003 (0.003)	−0.076 (0.066)	0.002	2.04	1.347	2.937
Germany	−0.004 (0.003)	−0.146 (0.188)	−0.003	2.06	0.600	1.898
Italy	−0.002 (0.002)	−0.016 (0.027)	−0.005	1.86	0.332	0.053
Japan	−0.002 (0.003)	−0.017 (0.035)	−0.006	1.80	0.236	1.254
Netherlands	−0.005 (0.003)	0.031 (0.031)	0.000	2.03	1.004	4.164*
Switzerland	−0.004 (0.003)	−0.011 (0.179)	−0.007	1.92	0.004	0.326
United Kingdom	−0.002 (0.003)	0.006 (0.123)	−0.007	1.83	0.002	1.888

[1]Standard errors of estimated coefficients appear in parentheses.
[2]F-statistic for testing the equality restriction on the coefficients of the change in the real and the inflation differentials (components of the change in the nominal forward premium); asterisk indicates rejection at 5 percent level.

column, F-test) but, in contrast to table 2, the Netherlands does not when the U.S. monetary regime shift is accounted for. Considering the appropriate specification, equations 3′ or 5′, six of the eight equations are significant in terms of their overall fit (F-statistics) at the 5 percent level, France is significant at the 6 percent level, and seven of eight countries reject the restriction of stable coefficients across monetary regime changes at the 10 percent level or better. Only Japan fails the F-test for the significance of the model.

In terms of the individual coefficients, six of the eight countries evidence a significant negative risk premium (10 percent or better) during the U.S. monetary aggregate targeting period, while the intercept is uniformly nonsignificant during the other U.S. monetary policy regime, October 1973–September 1979 and October 1982–June 1985. The impact of the different regimes is also notable in the slope interaction dummy. The coefficient on the change in the real forward premium is negative and significant for Canada, Germany, the Netherlands, Switzerland and the United Kingdom. For Germany, Switzerland and the United Kingdom, this entails a switch from a positive and significant coefficient during the U.S. non-monetary targeting regime.

Thus, for each of the seven currencies for which the market efficiency criteria are met, the U.S. monetary policy regime has a significant effect on the errors in the forward rate forecasts. More specifically, two generalizations can be advanced based on the results in table 3. First, the greater interest rate volatility during U.S. monetary aggregate targeting shows up in a significant risk premium tending to strengthen the dollar against six of the eight currencies. Second, given the failure to reject the nominal forward premium restriction of equation 3′, the negative significance of the slope dummy implies that the interest differential news was primarily interpreted as an increase in the inflation differential during U.S. non-monetary aggregate targeting periods and as an increase in real interest differentials during U.S. monetary aggregate targeting. In other words, the dollar appreciated along with unanticipated increases in the forward premium during October 1979 to September 1982, but depreciated

Table 3

Tests of News Model Using Unrestricted Specification, October 1973–June 1985 (U.S. Monetary Regimes Distinguished)

	Coefficients[1]						Summary Statistics			Tests	
Currency	Intercept	DI^2	$\Delta(r-r^*)$	Dr^2	$\Delta(\pi-\pi^*)$	$D\pi^2$	$\bar{R}^2$	DW	F	F^3	F^4
Canada	−0.002	0.000	0.299	−0.436	−0.343	−0.776	0.056	2.19	2.728*	3.658*	4.027*
	(0.001)	(0.003)	(0.188)	(0.223) +	(0.209) +	(0.253)*					
France	0.001	−0.015	−0.023	−0.077	−0.368	0.211	0.045	2.12	2.297*	2.352 +	2.133
	(0.003)	(0.006)*	(0.105)	(0.135)	(0.193) +	(0.282)					
Germany	−0.001	−0.014	0.540	−1.137	−0.311	−0.980	0.081	2.10	3.445**	4.837**	0.605
	(0.003)	(0.006)*	(0.299)*	(0.382)*	(0.395)	(0.511) +					
Italy	0.000	−0.011	0.012	−0.067	0.139	−0.568	0.059	1.92	2.731*	4.415**	3.990*
	(0.003)	(0.006) +	(0.033)	(0.056)	(0.100)	(0.181)*					
Japan	0.001	−0.012	0.029	−0.255	0.163	−0.434	0.016	1.89	1.443	1.899	1.093
	(0.003)	(0.006) +	(0.044)	(0.200)	(0.124)	(0.292)					
Netherlands	−0.001	−0.013	0.047	−0.816	−0.280	−0.536	0.107	2.06	4.324**	5.313**	2.098
	(0.003)	(0.006)*	(0.029)	(0.243)*	(0.161) +	(0.343)					
Switzerland	0.001	−0.018	0.433	−1.217	0.506	−1.191	0.088	2.03	3.688**	6.025**	0.162
	(0.004)	(0.007)*	(0.218)*	(0.356)*	(0.263) +	(0.437)*					
United Kingdom	−0.001	−0.006	0.382	−0.950	0.319	−1.087	0.097	1.79	3.979**	5.933**	1.052
	(0.003)	(0.006)	(0.149)*	(0.238)*	(0.180) +	(0.296)*					

[1]Standard errors of estimated coefficients appear in parentheses; asterisk indicates significance at 5 percent level and plus sign indicates significance at 10 percent level.

[2]DI, Dr and $D\pi$ equal 1.0 during period of U.S. monetary-target policy regime, October 1979–September 1982 and zero otherwise.

[3]F-statistic for testing restriction that coefficients are stable across different monetary regimes; double asterisk indicates rejection at 1 percent level, asterisk indicates rejection at 5 percent level, and plus indicates rejection at 10 percent level.

[4]F-statistic for testing the equality restriction on the coefficients of the change in the real and the inflation differentials (components of the change in the nominal forward premium); asterisk indicates rejection at 5 percent level, plus indicates rejection at 10 percent level.

with such news during the rest of the floating rate period. This is consistent with Frenkel's (1981a) results for 1973–79. Finally, the Durbin-Watson statistics in table 3 do not indicate serial correlation in the residuals, consistent with the maintained hypothesis of market efficiency.

There remain two puzzling results: (1) The estimated coefficients of the change in the inflation differential during the monetary regime are generally negative, refuting the hypothesis embodied in equation 5; this negative coefficient is significant at the 10 percent level or better in five countries. (2) Moreover, the decomposition of the nominal interest differential is significant only for Canada and Italy. This irrelevance of the distinction between real and nominal interest differentials may simply be a confirmation of Fama's (1984) assertion that, with risk aversion or without PPP, the Fisher equation does not hold (see footnote 9). Indeed, for six of the eight currencies, the F-test does not reject the implicit restriction of equality of changes in the nominal interest differential's two components displayed in table 3.

The Implications of Monetary Regimes: A Closer Look

The negative coefficient on the inflation differential during the 1979–82 monetary regime is both pervasive and puzzling. Two possible explanations are worth considering. First, the one-month horizon of the estimated, anticipated CPI inflation rates used in estimating equation 5′ may be too short, or the estimated expected inflation series simply may be bad proxies.

Second, the market may have determined that the U.S. monetary authority and the administration were committed to lowering the U.S. inflation rate. Consequently, a short-term increase in the U.S. expected inflation rate would lead market participants to expect a tightening of monetary growth.[14] If so, a short-term increase in U.S. inflation would lead to increases in the U.S. real interest rate as the market anticipated the monetary authority's reaction. This explanation, consistent with research by Cornell (1982), has not been tested here, but it is consistent with the decomposition of changes in the nominal interest differential generally not increasing the explanatory power of the equation for six of the eight currencies.[15]

CONCLUSION

We have tested the efficiency of forward exchange markets for the dollar against eight major currencies during the floating period. The regression estimates clearly demonstrate that failing to account for changes in the policy procedures of the U.S. monetary authority entails misspecification. Monetary regime changes alter the risk premia that market participants require on forward contracts and affect the direction of errors implied by nominal and real news, that is, unforeseen events occurring between the time of contract and its maturity. The implications of the standard model of exchange rate behavior were substantiated for nominal news under a monetary target regime, but its implication for inflation differentials was refuted. While a closer modeling of the policy procedure may explain this rejection, it remains a prominent puzzle in this study. Nonetheless, one interpretation of these results is that market participants regarded the U.S. monetary policy regime of 1979–82 as anti-inflationary. If this is correct, it follows that credible goals of monetary policy may be as significant for market participants as the mechanical details of that policy's execution.

[14]The U.S. CPI inflation rate was 13.3 percent in 1979, 12.4 percent in 1980, 8.9 percent in 1981 and 3.9 percent in 1982. There is also some support for this view in the impact of lagged reserve accounting during the monetary targeting period. As Kaufman (1982) notes, this results in more volatility of both money *and* interest rates since a decision to maintain a target growth path when the money supply has exceeded the path requires a subsequent reduction of reserve growth. Since banks already will have increased their required reserves, real rates will vary with the money supply errors and, perhaps, short-run inflation expectations.

[15]Cornell (1982) finds that unexpected monetary supply increases are correlated with an appreciation in the dollar, not the depreciation that an anticipated simple link with increased inflation would imply. Cornell suggests that the explanation is an anticipated policy reaction, a tightening of the money supply growth rate.

REFERENCES

Baillie, Richard T., Robert E. Lippens and Patrick C. McMahon. "Testing Rational Expectations and Efficiency in the Foreign Exchange Market," *Econometrica* (May 1983), p. 553–63.

Bomhoff, Eduard, and Pieter Korteweg. "Exchange Rate Variability and Monetary Policy Under Rational Expectations," *Journal of Monetary Economics*, 1983.

Cassel, Gustav. *Money and Foreign Exchange After 1914* (New York: McMillan, 1922).

Cornell, Bradford. "Money Supply Announcements, Interest Rates and Foreign Exchange," *Journal of International Money and Finance* (August 1982), pp. 201–08.

Darby, Michael R. "Does Purchasing Power Parity Work?" Proceedings of Fifth West Coast Academic/Federal Reserve Economic Research Conference, University of California-Los Angeles, National Bureau of Economic Research (December 1981).

Dooley, Michael P., and Peter Isard. "Capital Controls, Political Risk and Deviations from Interest Rate Parity," *Journal of Political Economy* (April 1980), pp. 370–84.

Dornbusch, Rudiger. "Expectations and Exchange Rate Dynamics," *Journal of Political Economy* (December 1976), pp. 1161–76.

Edwards, Sebastian. "Comment on Isard," Jacob A. Frenkel, in *Exchange Rates in International Macroeconomics* (University of Chicago Press, 1983).

________. "Floating Exchange Rates, Expectations and New Information," *Journal of Monetary Economics* (May 1983b), pp. 321–36.

Fama, Eugene F. "Forward and Spot Exchange Rates," *Journal of Monetary Economics* (November 1984), pp. 320–38.

Frenkel, Jacob A. "Flexible Exchange Rates, Prices and The Role of "News": Lessons From the 1970s," *Journal of Political Economy* (August 1981a), pp. 665–705.

________. "The Collapse of PPP in the 1970s," *European Economic Review* (1981b), pp. 145–65.

Gilbert, Alton. "Operating Procedures for Conducting Monetary Policy," this *Review* (February 1985), pp. 13–21.

Hansen, Lars Peter and Robert J. Hodrick. "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," *Journal of Political Economy* (October 1980), pp. 829–53.

________. "Risk Averse Speculation in the Forward Foreign Exchange Market: An Econometric Analysis of Linear Models" in Frenkel, Ed., *Exchange Rates in International Macroeconomics* (University of Chicago Press, 1983).

Hodrick, Robert J., and Sanjay Srivastava. "The Covariation of Risk Premiums and Expected Future Spot Exchange Rates," *Journal of International Money and Finance* (March 1986 Supplement), pp. 5–21.

Isard, Peter. "An Accounting Framework and Some Issues for Modelling How Exchange Rates Respond to News," in Jacob A. Frenkel, *Exchange Rates in International Macroeconomics* (University of Chicago Press, 1983).

Jacobs, Rodney L. "The Effect of Errors in Variables on Tests for a Risk Premium in Forward Exchange Rates," *Journal of Finance* (June 1982), pp. 667–77.

Johnson, Karen. "Foreign Experience with Targets for Monetary Growth," *Federal Reserve Bulletin* (October 1983), pp. 745–54.

Kaufman, George. "The Fed's Post-October 1979 Technical Operating Procedures Under Lagged Reserve Requirements: Reduced

Ability to Control Money," *The Financial Review* (November 1982), pp. 279–94.

Lucas, Robert E., Jr. Eds. Karl Brunner and Alan Meltzer, 1974, "Econometric Policy Evaluation: A Critique," *The Phillips Curve and Labor Markets*, Carnegie-Rochester Conference on Public Policy, Vol. 1, pp. 19–46.

Mussa, Michael L. "Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market," Vol. II *Carnegie-Rochester Conference Series on Public Policy*, 1979.

Rasche, Robert H. "Interest Rate Volatility and Alternative Monetary Control Procedures," *Economic Review*, Federal Reserve Bank of San Francisco (Summer 1985), pp. 46–63.

Roley, Vance. "The Response of Short-Term Interest Rates to Weekly Money Announcements," *Journal of Money, Credit and Banking* (August 1983), pp. 344–54.

Wood, John, and Norma L. Wood. *Financial Markets* (Harcourt Brace Jovanovich, Inc., New York) 1985.