Is the Forward Exchange Rate a Useful Indicator of the Future Exchange Rate?

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In the past two decades, there have been many empirical studies both in support of and opposing the unbiased forward rate hypothesis (UFH). The UFH argues that the forward rate "fully reflects" available information about the exchange rate expectations (Chiang 1988). One view of market efficiency states that the current prices reflect all available information. When this is applied to the foreign exchange market, it implies that 'economic agents' expectations about future values of exchange rate determinants are fully reflected in the forward rates (Chiang 1988)." To test this hypothesis, the conventional method uses an OLS regression, with the spot rate as the dependent variable, while the one-period lagged forward rate as the independent variable. To support the UFH, the constant term would not differ from zero, the coefficient of the one-period lagged forward rate would not significantly differ from one, and the error term would not exhibit any serial correlation. The purpose of this paper is to test the validity of the UFH.

The first section of this paper provides background information about forward exchange rates and reviews previous studies that have been conducted on the validity of the UFH. Section II reports the results from the regression analysis, while Section III presents the results from the regression, after the model was corrected for serial correlation. Section IV addresses the problem of non-stationarity in the estimate regressions, and Section V presents policy prescriptions to reduce the volatility of foreign exchange markets.

I. Theoretical Review

To fully understand the UFH, one must gain a basic understanding of the difference between the spot market and the forward market. In the spot market, two parties involved in a transaction arrange to conduct the exchange of currencies within a relatively short-term horizon. A forward transaction is a way for an individual or a business to arrange in advance to buy

foreign exchange for the purpose of making a future international payment. Purchasing or selling the foreign exchange forward allows those involved with the transaction to agree upon the exchange rate today. A forward rate can be interpreted as the sum of a premium and the expected future spot rate (Fama 1984). More precisely, "The forward exchange rate f_t observed for an exchange at time $t+1$ is the market determined certainty equivalent of the future spot exchange rate s_{t+1} (Fama 1984)." Eugene Fama conducted a study testing a model for measurement of both variation in the premium and the expected future spot rate components of forward rates. Assuming that the forward market is efficient or rational, the study found evidence that both components of forward rates vary through time. The study had two important conclusions. The first is that most of the variation in forward rates is due to the variation in the premiums and the second is that the premium and the expected future spot rate components of forward rates are negatively correlated. Fama utilized four equations to forecast the future spot rate. From the analysis of the standard deviation of forecast errors, the current spot rate is a better predictor of the future spot rate than the current forward rate. Also, in one of the equations utilized, the forward rate minus the spot rate *(F-S)*, autocorrelation was present. However, since this autocorrelation decreases with larger lags, this suggests that there is only first-order correlation. Partial correlations were large at the first lag, but got closer to zero at higher order lags (Fama 1984).

Thomas Chiang conducted a study developing a stochastic coefficient model to examine the UFH, proposing that "with effective use of information underlying the stochastic pattern of the estimated parameters in forecasting, it is possible to improve the accuracy of the exchange rate predictions (Chiang 1988)." Using data from the period January 1974 through August 1983, Chiang's study confirms the unbiased forward rate hypothesis for the markets studies (Canada, France, W. Germany, and UK). However, his study also found that, through use of the Brown-Durbin-Evans test and the Chow test, the constant coefficient hypothesis cannot be supported. He found that the constant term and the coefficient for the one-period lagged forward rate are subject to newly available information and vary through the sub-sample periods that he

tested. Specifically, he found that when he tested sub-samples, in many cases, the constant term was significantly different from zero and the coefficient of the one-period lagged forward rate was significantly different from one. Therefore, whether or not the UFH held depended on the sample period chosen. Another interesting aspect of Chiang's study is that he added the two-period lagged forward rate as an independent variable in predicting the spot rate, and this variable was not found to be significant at the 5% level, suggesting that it "contains no significant increase in explanation for the spot rate (Chiang 1988)."

Other studies have been conducted to determine the role that news plays in predicting the spot rate, because there was previously evidence that exchange rate movements respond to new information that is available to economic agents in every period. In other words, it has been suggested that the market forecasting error (the difference between the spot rate and the one-period lagged forward rate) is explained by the news captured in the spot rate that was not available when the forward rate was determined. Sebastian Edwards conducted an empirical study that examined the role that news plays in predicting the future spot rate. He found that in a world with more than two countries, the error terms in the standard market efficiency tests will be correlated, which means that the model displays serial correlation. Ultimately, his model found that the exchange rate could be "expressed as a function of factors known in advance--which are captured by the forward rate determined the in previous period--and 'news' regarding changes in domestic and foreign quantities of money, real incomes and real interest rates (Edwards 1982)." Edwards used a multi-currency approach and found that "The exchange rate market forecasting error can be expressed as a function of unanticipated changes in domestic and foreign quantities of money, real income and real interest rate and that in a multi-currency setting the error terms from the standard exchange-rate market efficiency tests will be correlated across currencies (Edwards 1982)." Edwards also found that using Zellner's seemingly unrelated regressions procedure (SUR) significantly improves the precision of the estimates.

Despite the studies that place emphasis on the need for including a variable that measures news, some economists still feel that the current exchange rate includes all information needed to predict the future rate.

> "The international valuation of the currency will, then, generally show a tendency to anticipate events, so to speak, and becomes more an expression of the internal value the currency is expected to possess in a few months, or perhaps in a year's time (Cassel 1928)."

> "If the foreign exchange market is efficient and if the exchange rate is determined in a similar fashion to other asset prices, we should expect the behavior in that market to display characteristics similar to those displayed in other stock markets. In particular, we should expect that current prices reflect all available information, and that the residuals from the estimated regression should be serially uncorrelated (Frenkel 1978)."

II. Results

Therefore, this study examines the effectiveness of the forward exchange rate (lagged one period) in determining the spot exchange rate. The equation utilized is:

$$(1) \qquad S_t = \beta_o + \beta F_{t-1} + e_t$$

Where S_t is the current spot exchange rate and F_{t-1} is the one-period lagged forward rate. The linear form of the variables was used.

Monthly exchange rate data was used from February 1991 to January 1999. The data was taken from the Haver DLX system. The equation is applied to exchange rate equations for the Canadian Dollar, French Franc, British Pound, Japanese Yen, and the German Mark. Both the spot and forward exchange rates are measured as units of currency per U.S. dollar. The spot rate used is the one-month middle rate, at the New York close, and the forward rate is the one-month offer rate. To run the regression, the Ordinary Least Squares Method (OLS) was used, which ensures that the coefficients will be best linear unbiased estimators (BLUE). The results of the OLS are contained in the table below (Table 1).

Table 1: OLS Results

Country	$ß_o$	$ß_1$	R_2	D-W
Canada	-.0083 (-.42)	1.01 (.714)	.98	1.64
France	.37* (1.83)	.93* (-1.86)	.87	1.2
Germany	.1* (1.73)	.94* (1.71)	.88	1.25
Japan	4.4 (1.52)	.96* (1.6)	.94	1.21
UK	.05* (2.35)	.91* (2.43)	.87	1.37

Note: The number under the coefficient is t-stat.
** denotes significance at the 5% level and * at the 10% level

At the 5% level of significance, the null hypothesis is only rejected for the UK. At the 10% level of significance, the null is rejected for the UK, France and Germany. When the null hypothesis is rejected, the alternative hypothesis can be accepted, concluding that the constant term does not equal zero. This assumption is essential for the UFH to hold.

Furthermore, at the 5% level of significance, the null hypothesis is rejected only for the UK, and the alternative hypothesis is accepted, concluding that the one-period lagged forward rate does not significantly differ from 1. At the 10% level of significance, the null hypothesis is rejected for France, Germany, UK and Japan, and the alternative hypothesis is accepted, concluding that the lagged forward rate does not significantly differ from 1.

To test for serial correlations, the Durbin-Watson test us utilized. The test shows that the models for France, Germany, Japan and the UK contain positive serial correlation. Although the test does not show that there is positive serial correlation in the model for Canada, the Durbin

Watson statistic is close to the rejection region, so the model will still be corrected for serial correlation.

III. Autocorrelation Correction

Since serial correlation is present, it is necessary to run the regression using the Cochrane-Orcutt method, which corrects for serial correlation. The following table (Table 2) contains the data for the regressions, corrected for serial correlation.

Table 2: Cochrane-Orcutt Results

Country	$ß_o$	$ß_1$	R_2	D-W
Canada	.0013 (.05)	.80 (.06)	.88	1.71
France	.99* (3.10)	.82 (3.10)	.68	1.71
Germany	.26* (2.91)	.84 (2.91)	.90	1.68
Japan	8.9* (1.95)	.92 (2.05)	.86	1.89
UK	.13* (3.55)	.80 (3.5)	.88	1.71

Note: The number under the coefficient is t-stat.
** denotes significance at the 5% level and * at the 10% level

After correcting for serial correlation (See Table 2), the t-statistics for the constant term increase, while the t-statistics for the one-period lagged forward rate decrease. This is because serial correlation increases the variance, which decreases the computed standard error, which in turn increases the t-statistic of the independent variables. Therefore, in the first equation (See Table 1), the null hypothesis is rejected for all of the countries except for Canada, and the alternative hypothesis is accepted, concluding that there is positive serial correlation in the models. After correcting for serial correlation (See Table 2), the Durbin-Watson statistic is not in the rejection

region for all of the equations, thereby accepting the null hypothesis and concluding that there is no positive serial correlation in any of the equations.

At the 5% level of significance, the null hypothesis is rejected for France, Germany and the UK. At the 10% level of significance, the null hypothesis is rejected for France, Germany, Japan and the UK, and the alternative hypothesis is accepted, concluding that the constant term is significantly different from zero. Therefore, the UFH does not hold, because a significant constant term may reflect the presence of a premium, or other factors, which may affect the spot exchange rate. Therefore, the forward rate does not capture all available information.

After correcting for serial correlation, this is the most significant change in the model. At both the 5% and 10% levels of significance, the null hypothesis can be rejected for all countries expect for Canada, and the alternative hypothesis can be accepted, concluding that the estimated coefficient of the one-period lagged forward rate does not significantly differ from one, which is a criteria for the UFH to hold.

One important assumption of the UFH is that the forward and spot rate is stationary. More sophisticated techniques in econometrics have shown that macroeconomic time series in their levels are non-stationary and hence their variances tend to increase with time. Victor Ukpolo conducted a study to test the UFH by applying cointegration techniques to the Japanese market, using monthly spot and forward rates. He found that they were non-stationary but appear to be stationary after first differencing. When he ran the augmented Dickey Fuller test, to find if the two series were cointegrated in subsequent cointegrating regression output and ADF (Augmented Dickey-Fuller) test, he found evidence in support of cointegration between the spot and forward rates (Ukpolo 1995).

IV. Stationarity Tests

To test for stationarity in the residuals, the Dickey-Fuller test was conducted (See Results in Appendix B). Stationarity occurs when "the correlation between a series and its lagged values

was assumed to depend only on the length of the lag and not on when the series started (Ramanathan 1995).” The following table (Table 3) depicts the t-statistics for the Dickey-Fuller test.

Table 3: Dickey-Fuller Tests

Country	t-Statistic
Canada	-17.61
France	-17.05
Germany	-16.98
Japan	-16.83
UK	-17.34

The null hypothesis is rejected for all countries, at both levels, and the alternative hypothesis is accepted, concluding that the residuals are stationary.

Next, it was necessary to test for stationarity of the spot rate and the forward rate themselves. For the spot rate the equation utilized is:

$$(2) \qquad S_t/(S_t - S_{t-1}) = \beta_o + \beta_1 S_{t-1} + e_t$$

The following table (Table 4) includes the results of the regression. When OLS was run, serial correlation was present for every country except for Canada. Therefore, the Cochrane-Orcutt method was used to correct for serial correlation.

Table 4: Spot Rate Regression Results

Country	Uncorrected t-Statistic	Corrected t-Statistic
Canada	-71.75*	NA
France	-29.02	-20.911
Germany	-30.52	-21.40
Japan	-42.77	-29.92
UK	-29.99	-21.12

Note: * denotes that serial correlation was not present when OLS was run.

For all countries, for both the corrected t-statistic and the uncorrected t-statistic, the null hypothesis can be rejected, thereby accepting the alternative hypothesis, concluding that the spot exchange rate is stationary.

For the forward rate the equation utilized is:

(3) $F_t/(F_t-F_{t-1}) = \beta_o + \beta_1 F_{t-1} + e_t$

The following table (Table 5) includes the t-statistics for the forward rate.

Table 5: Forward Rate Regression Results

Country	Uncorrected t-Statistic	Corrected t-Statistic
Canada	-68.24	NA
France	-28.73	-20.65
Germany	-30.30	-21.24
Japan	-42.95	-29.90
UK	-29.47	-20.74

Therefore, for all countries, for both the corrected t-statistic and the uncorrected t-statistic, the null hypothesis can be rejected, thereby accepting the alternative hypothesis, concluding that the forward exchange rate is stationary.

To further test for stationarity in the spot and forward rate, the dependent variable from the above for spot rates (S_t) was plotted across time, as was the spot rate (S_t) to observe how the variables vary over time. By examining these graphs, it is obvious that for the regular spot rate, there is a much stronger linear relationship than there is for the variable that measures the change in the spot rate.

The results of the regression do not fully support the UFH. For all of the countries, except Canada, the constant term is significantly different from zero after correcting for serial correlation. This means that the constant term is capturing information that is not captured in the one-period lagged forward rate, or that the forward rate does not fully reflect all information available to economic agents. Also, after correcting for serial correlation, the one-period lagged forward rate did not significantly differ from one for any countries except for Canada. The model for every country exhibited serial correlation except for Canada. Finally, the residuals, the spot rate and the forward rate were stationary for all countries.

V. Policy Prescription

Since the one-period lagged forward rate does not seem to reflect all available information, which it should for exchange rate market efficiency to be possible, there are policy prescriptions that could therefore reduce exchange rate volatility. One such proposal is the Tobin Tax, proposed by Nobel Laureate James Tobin. The tax is a "uniform international tax payable on all spot transactions involving the conversion of one currency into another, in both domestic security markets and foreign exchange markets (Spahn 1996)." Therefore, the transactions cost incurred when trading currency would be higher, thereby discouraging speculating. Speculators would not benefit from a Tobin Tax, while exporters, importers and long-term investors would benefit from more stable exchange rates (Felix 1995). One significant advantage of a Tobin Tax is the revenue raised from it. It has been estimated that a .5% tax on exchange transactions would increase government revenues globally by as much as $300 to $400 billion per year (Felix 1995). Another advantage to the Tobin Tax is that it would promote

market efficiency and global financial stability, because it would require countries to coordinate their macroeconomic policies (Spahn 1996). However, since it is purely a transaction tax, the Tobin tax is not perfect and does have significant drawbacks. First, the fundamental problems of its structure would prevent international financial markets from working efficiently and cause liquidity problems, without surviving its purpose, which is to create a disincentive to speculation (Spahn 1996). Although flawed, the benefits of the Tobin Tax could far outweigh its costs and therefore would be the most effective policy prescription.

VI. Conclusion

Future research should focus on the lagged effect of news, which in turn affects exchange rates. Unanticipated changes of some exchange rate determinant may not always be significant because in some countries it may take people more than one month to find out about the news, which could be because of a lag before announcements of actual changes in these variables are made (Edwards 1982). However, "according to the market efficiency hypothesis, once 'news' has been incorporated into the exchange rate, past innovations should have *no* effect (Edwards 1982)." In final analysis, exchange rate markets seem to be subject to inefficiencies, as are most markets. While the forward rate is a decent predictor of the future spot rate, it does not capture all information available to economic agents. This variance in exchange rates could be caused by news about economic factors such as changes in domestic and foreign quantities of money, real incomes, and real interest rates that were not available when the forward rate was first determined.

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