The Forward Exchange Rate Bias Puzzle Is Persistent: Evidence from Stochastic and Nonparametric Cointegration Tests

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Abstract

An important puzzle in international finance is the failure of the forward exchange rate to be a rational forecast of the future spot rate. We document that even after accounting for nonstationarity, nonnormality, and heteroskedasticity using parametric and nonparametric tests on data for over a quarter century, U.S. dollar forward rates for the major currencies (the British pound, Japanese yen, Swiss franc, and the German mark) are generally not rational forecasts of future spot rates. These findings deepen the forward exchange rate bias puzzle, especially as these markets are the most liquid foreign exchange markets with very low trading costs.

Keywords: forward rate puzzle, cointegration, expectations

JEL Classifications: F31, F47, G14, G15

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1. Introduction

There is consistent empirical evidence that forward rates are neither efficient nor rational forecasts of future spot rates. This is a puzzle with important economic (e.g., currency overlay policies in portfolio management) and public policy implications.

The efficient markets hypothesis (EMH) suggests that if markets are efficient (in the sense that the expected rate of return to speculation in the forward exchange market will be zero (e.g., Geweke and Feige, 1979; Hansen and Hodrick, 1980)), then forward exchange rates fully reflect available information about investors’ expectations of future spot rates, and thus forward rates should be unbiased forecasts of future spot rates (e.g., Levich, 1979; Lin, 1999; Lin, Lin, and Chen, 2002).

It is clear that tests of market efficiency are thus composed of joint tests of two null hypotheses: one is the market efficiency hypothesis (EMH), and the other is the forward rate unbiasedness hypothesis (FRUH). While the theoretical foundations of both seem sound, the vast amount of empirical work used to test the EMH and the FRUH in the foreign exchange markets has very rarely supported these theoretically elegant hypotheses. The standard spot return or forward premium regressions have long been known to provide rejection of the FRUH (e.g., Engel, 1996). More recently, researchers have debated the empirical findings on the grounds of limitations in the statistical methodologies and of inappropriate inference procedures (e.g., Maynard and Phillips, 2001; Tauchen, 2001; Maynard, 2003, 2006; Liu and Maynard, 2005).

This study represents an improvement over the existing literature in a number of ways. Unlike prior literature on the tests of the forward rate as a forecast of the future spot rate, we augment traditional models and use the recently developed nonparametric model of Breitung (2002) and procedures that account for nonstationarity and normality used in Aggarwal, Mohanty, and Song (1995) to test the EMH for foreign currency markets. The methodology features several innovations compared to the statistical procedures used in prior studies of the forward-spot relation.

Unlike the research designs used in prior literature, the cointegration methodology used here accounts for nonstationarity and nonnormality in the data series, qualities widely documented in spot and forward exchange rate data. Thus, as suggested by Sephton and Larsen (1991), our methodology meets the need for a more thorough analysis of cointegrating regressions and the error correction models used to describe equilibrium relations.

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Finally, we use a long sample period (of over a quarter century) from January 1973 (the start of the recent period of floating rates) to December 1998 (just prior to the consolidation of the European currencies into the Euro) that covers a wide range of major currencies with forward rates over various forecast horizons (one, three, six, and 12 months). Thus, the statistical procedures represent a significant improvement over prior studies of forward rates as forecasts of future spot exchange rates, and the extended time span used should allow for robustness in the convergence of any parameters.

We document that even after accounting for nonstationarity, nonnormality, and heteroskedasticity using parametric and nonparametric tests on data for over a quarter century, U.S. dollar forward rates for horizons ranging from one to 12 months for the major currencies (the British pound, Japanese yen, Swiss franc, and German mark) are generally not rational forecasts of future spot rates. These findings of nonrationality in forward exchange rates for the major currencies continue to be puzzling, especially as these foreign exchange markets are some of the most liquid asset markets with very low trading costs.

2. Forward rate unbiasedness hypothesis

As noted, the FRUH has generated a large theoretical and empirical literature. Early regressions of the (log) spot rate $S_{j,t+m}$ directly on the (log) of forward rate $F_{j,t,m}$ (e.g., Cornell, 1977; Levich, 1979; Frankel, 1980)

$$S_{j,t+m} = \beta_0 + \beta_1 F_{j,t,m} + \epsilon_{j,t,m},$$

where $m$ = the length of the forward contract, generally provide support for FRUH with estimates of $\beta_1$ close to 1. However, the initial tests of the FRUH in Equation (1) were abandoned due to the unit root behavior of exchange rates and the concern about the spurious regression phenomenon illustrated by Meese and Singleton (1982). The nonstationarity of the spot and forward rates has led researchers (e.g., Bilson, 1981; Longworth, 1981; Hansen and Hodrick, 1983; Fama, 1984; Huang, 1984) to adopt a

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4 We terminate the data at the end of 1998, with the introduction of the Euro, for two reasons. First, we are interested implicitly in how different currencies behave, requiring a number of them for analysis. Second, we desire a long series of data that are homogenous. By ending the data in 1998, we have a set of data that is longer and larger than that used in prior studies on this topic.

5 We have carefully avoided investigating the many possible behavioral and/or economic reasons for the persistence of this forward rate anomaly. Instead we have chosen to focus on making sure with much greater confidence that the observed anomaly does indeed exist. The forward rate bias is an important anomaly in spite of a truly voluminous literature on the topic. Further, prior literature notes the need for and recommends the use of improved statistical procedures to investigate and make sure that this anomaly does indeed exist.

“difference” version of Equation (1). It is obtained by subtracting the (log) current spot rate from both sides as follows:

\[ S_{j,t+m} - S_{j,t} = \beta_0 + \beta_1(F_{j,t,m} - S_{j,t}) + \epsilon_{j,t+m}. \]  

Under the null hypothesis of unbiasedness in the above regression, one would expect the estimates with \( \beta_0 = 0, \beta_1 = 1, \) and \( E(\epsilon_{j,t+m}) = 0. \) Surprisingly, results from such Equation (2) not only provide strong rejection of unbiasedness, but also generally yield negative estimates of \( \beta_1, \) often significant (e.g., Engel, 1996). These findings, based on Equation (2), have been difficult to reconcile with theoretical predictions (e.g., Engel, 1996), giving rise to a puzzle. One of the reasons for the failure of the regression model (2) is due to the presence of a time-varying risk premium in foreign exchange markets (Hansen and Hodrick, 1980, 1983; Fama, 1984; Hodrick and Srivastava, 1986). The time-varying risk premium can also be viewed as a missing variable in Equation (2); and if it is negatively correlated with forward premium \((F_{j,t,m} - S_{j,t}), \) it could cause a downward bias in estimates of \( \beta_1 \) (e.g., Obstfeld and Rogoff, 1996). Froot and Frankel (1989) suggest that the forecast bias can be attributed to the systematic forecast error, which is negatively correlated with a forward premium rather to a forward market risk premium. However, prior studies find such explanations difficult to reconcile with reasonable levels of risk aversion (e.g., Domowitz and Hakkio, 1985; Mark, 1985; Hodrick, 1989; Baillie and Bollerslev, 1990). Engel (1996, p. 124) concludes that “models of the risk premium have been unsuccessful at explaining the magnitude of this unbiasedness.”

Previous studies have offered several alternative explanations. These include heterogeneous trading behavior (Frankel and Froot, 1988), feedback from monetary policy (McCallum, 1994; Chinn and Meredith, 2004), and alternative econometric models (Chiang, 1988; Naka and Whitney, 1995; Bakshi and Naka, 1997; Roll and Yan, 2000; Zivot, 2000; Maynard and Phillips, 2001; Maynard, 2003, 2006; Liu and Maynard, 2005). The focus of this paper is the last of these possible explanations.

A large number of studies that have investigated the unbiasedness of the forward exchange rates provide evidence that the spot and forward rates are nonstationary (e.g., Meese and Singleton, 1982; Baillie and Bollerslev, 1989). Roll and Yan (2000) find that the forward rate \((F_{j,t,m}), \) spot rate \((S_{j,t}), \) and forward premium \((F_{j,t,m} - S_{j,t})\) follow nearly nonstationary time series processes. Nonstationarity implies that the estimates of \( \beta_1 \) for both regression Equations (1) and (2) are biased and inconsistent (e.g., Phillips, 1986; Baillie and Bollerslev, 1989), given the nonstationarity of the forward premium \((F_{j,t,m} - S_{j,t})\) in the “difference” Equation (2). Later studies provide mixed evidence in support of the FRUH (e.g., Gregory and McCurdy, 1984; Chiang,

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7 Out of the over seventy-five (75) studies examined estimating Equation (2), none of them find an estimate of \( \beta_1 \) greater than 1 and only a few estimates of \( \beta_1 \) are greater than 0 (e.g., Froot, 1990).
However, developments in the theory of cointegration (Engle and Granger, 1987; Engle and Yoo, 1991) provide new econometric tools. Several studies have investigated models of cointegration between the future spot rate and forward rate. Examples include Baillie and Bollerslev, 1989; Hakkio and Rush, 1989; Barnhart and Szakmary, 1991; Corbae, Lim, and Ouliaris, 1992; Evans and Lewis, 1995; Naka and Whitney, 1995; Bakshi and Naka, 1997; Hai, Mark, and Wu, 1997; Luintel and Paudyal, 1998; and Zivot, 2000. The cointegration relation between the spot rate and forward rate has several important implications for tests of the FRUH. First, the estimate of slope coefficient ($\beta_1$) obtained from Equation (1) is superconsistent (Stock, 1987). Second, changes in spot rates can be modeled by an error correction model (e.g., Hakkio and Rush, 1989; Naka and Whitney, 1995; Bakshi and Naka, 1997). Third, Hakkio and Rush (1989) show that if the future spot and forward rate is cointegrated with a cointegrating factor of one, then for the FRUH to hold, the forecast error ($S_{j,t+m} - F_{j,t+m}$) must be stationary. Most recently, researchers have tested the FRUH using the error correction model. These tests have utilized mainly two specifications to test the FRUH: differences (e.g., Hakkio and Rush, 1989; Bakshi and Naka, 1997) and levels (e.g., Evans and Lewis, 1995; Naka and Whitney, 1995).

While several studies find that both spot and forward exchange rates for major currencies have unit roots and are cointegrated (e.g., Baillie and Bollerslev, 1989; Hakkio and Rush, 1989; Barnhart and Szakmary, 1991; Naka and Whitney, 1995; Bakshi and Naka, 1997), the empirical evidence for the FRUH is somewhat mixed. The reason for the mixed evidence summarized by Engel (1996, p. 141) is as follows: “To some extent these conflicts may arise from different sampling periods, but more likely they result from different properties of the various test statistics employed.” Roll and Yan (2000) suggest that the puzzle arises because the forward rate, spot rate, and forward premium used in Equation (2) follow a nonstationary time series process. The findings of prior studies using appropriate econometric specifications have led to concerns regarding the validity of asymptotic inference procedures. These studies also suggest that the traditional FRUH test statistics have nonstandard limit distributions with long left tails, which may explain the forward discount anomaly as a statistical artifact (e.g., Baillie and Bollerslev, 2000; Maynard and Phillips, 2001). Furthermore, Maynard (2003, p. 314–315) suggests that the differencing procedure used in Equation (2) not only “leaves the forward premium with a nonstationary component” but can “add a unit root distribution term into the limiting distribution of the slope coefficient, which can severely bias the estimator.”

More recently, newer econometric techniques have refocused research on the earlier Equation (1) in levels (e.g., Maynard, 2003, 2006; Liu and Maynard, 2005). Yet, these studies provide mixed evidence in support of the FRUH. One of the reasons given is that the statistical procedures used in prior literature have limitations. It is often contended that better statistical procedures and robust methods are necessary for better results in this area (Maynard, 2003).
We therefore revisit the test of the FRUH using an alternative econometric method known to provide reliable inference in a cointegration framework (see Section 4 for details). We test the FRUH utilizing Equation (1) in levels for several reasons. First, given the potential cointegration relation, the regression relation in Equation (1) can be interpreted in terms of cointegrating or long-run relation between future spot rates and forward rates. Second, the slope estimate in cointegrating Equation (1) is super-consistent. Third, the changes in spot rates can be modeled by the error correction model. Fourth, the parameters of the level specification appear in the error correction term, and hence the error correction model provides a direct link to the levels specification (e.g., Naka and Whitney, 1995; Bakshi and Naka, 1997). Liu and Maynard (2005, p. 615) also suggest that “if one has to stay within the framework of the original unbiasedness regression/test as in (1), it is more convenient to maintain the same estimator, but modify the critical values in order to adjust for the nonstandard nature of the distribution.”

Most recent studies have utilized different econometric models that have addressed the concern related to either the asymptotic inference (e.g., Bekaert and Hodrick, 2001) or the size distortion (Liu and Maynard, 2005), but not both. We use an improved econometric specification, which addresses both concerns. Following the cointegration framework developed by Engle and Yoo (1987), we conduct proper tests of $\beta_1 = 1$ and use test statistics that are appropriately modified for biases regarding the estimates of cointegrating factor, size distortion, serial correlation in residuals, and the whiteness of the forecast errors. Furthermore, the conflicting results found in the literature not only depend on the particular econometric specification estimated, but also on differences in forecast horizon and the period of estimation (e.g., Barnhart and Szakmary, 1991; Engel, 1996). Our study covers data series that span over a quarter century for U.S. dollar forward rates for horizons ranging from one to 12 months for five major currencies.

3. Data and research design

The month end spot and forward rates for five major currencies, expressed in terms of U.S. dollars, were collected from The Wall Street Journal and Datastream. The forward rate time horizons considered are $m = \text{one, three, six, and 12 month(s)}$. The data used cover the period January 1973–December 1998, yielding 312 monthly observations, a total of 7,800 observations. The starting point is chosen to reflect the advent of floating rates, and the ending point is dictated by the availability of data for all five currencies examined in the study.$^8$ These currencies are the Canadian dollar, French franc, German deutsche mark, Japanese yen, and United Kingdom pound sterling.

$^8$ In essence, the replacement of the Deutsche mark by the Euro.
3.1. Model specifications and tests of FRUH

The market efficiency hypothesis in forward exchange markets, as defined in Hansen and Hodrick (1980), implies that market participants have rational expectations. The rational expectations hypothesis (REH) states that economic agents should make use of all available information in forming expectations; there should be no systematic patterns in forecast errors, and such errors should be white noise. Thus, the REH asserts that the market’s subjective probability distribution for any variable is identical to its objective probability distribution, conditional on all available information. Following Mishkin (1983) and Aggarwal, Mohanty, and Song (1995), the appropriate model specification to test the REH is as follows:

\[ E_m(S_{j,t+m} | \phi_t) = E(S_{j,t+m} | \phi_t), \]  

(3)

where \( \phi_t \) is the set of information available including all present and past values of spot and forward rates at time \( t \), \( S_{j,t+m} \) is the spot exchange rate for currency \( j \) in period \( t + m \), \( E_m(\cdot | \phi_t) \) is the subjective expectation assessed by the market, and \( E(\cdot | \phi_t) \) is the objective expectation conditional on \( \phi_t \).

Thus, rational expectations, given in Equation (1), imply the following condition:

\[ E(S_{j,t+m}) - E_m(S_{j,t+m} | \phi_t) | \phi_t) = 0. \]  

(4)

Combining Equations (3) and (4), the market equilibrium condition can be written as follows:

\[ E(S_{j,t+m} - F_{j,t,m} | \phi_t) = 0, \]  

(5)

where \( F_{j,t,m} = E_m(S_{j,t+m} | \phi_t) \) is the forward exchange rate for currency \( j \) in period \( t \) for delivery in \( m \) periods(months).

The orthogonal condition represented by Equation (5) implies two key properties characterizing rational expectations: (1) the forecast errors (the errors resulting from the use of forward rates for forecasting spot rates) conditional on the available information set (\( \phi_t \)) have zero means (i.e., the forecasts are unbiased); and (2) the forecast errors \( S_{j,t+m} - F_{j,t,m} \) should be uncorrelated with any information in \( \phi_t \), and, therefore, also with their own past values.

3.1.1. Tests of the FRUH

We first focus on an unbiasedness test, a necessary pretest before carrying out the tests of REH. To test whether forward rates \( (F_{j,t,m}) \) are unbiased forecasts of future spot rates \( (S_{j,t+m}) \), we use the following model based on Muth (1961):

\[ S_{j,t+m} = \beta_0 + \beta_1 F_{j,t,m} + \varepsilon_{j,t+m}, \]  

(6)

when \( \beta_0 = 0 \) and \( \beta_1 = 1 \), \( E(\varepsilon_{j,t+m}) = 0. \)
As in Muth (1961), \((\epsilon_{j,t+m}, (F_{j,t,m})\) must be uncorrelated with \((F_{j,t,m})\), the expected value. Moreover, the error series \(\epsilon\) should be characterized by no significant serial correlation. If any of these conditions are not satisfied, then the hypothesis of unbiasedness is rejected.

3.1.2. Accommodating nonstationarity

It is well known that when regressing one nonstationary series against another such series can lead to spurious results in that conventional significance tests will indicate a relation between the variables when in fact none exists (e.g., Phillips, 1986). Prior research on the efficiency of the foreign exchange markets provides evidence that spot rates and forward rates are nonstationary and follow unit root processes.\(^9\) In such cases, a more appropriate approach is to estimate a cointegrating factor (e.g., Engle and Granger, 1987; Phillips and Perron, 1988), which is estimated from the cointegrated regression.

To examine the issue surrounding nonstationarity and unit roots associated with spot and forward rates, we use an augmented Dickey–Fuller (ADF) test that allows for serial correlation in the error term \((\epsilon_{j,t+m})\). The ADF test for unit roots is estimated by running the following ordinary least square (OLS) regression:\(^{10}\)

\[
S_{j,t+m} - S_{j,t-1+m} = \beta_0 + \beta_1 + S_{j,t-1+m} + \beta_2 S_{j,t-1+m} \\
+ \beta_3 S_{j,t-2+m} + \beta_4 S_{j,t-3+m} + \nu_{j,t+m}. \tag{7}
\]

If spot rates \(S_{j,t+m}\) and forward rates \(F_{j,t,m}\) are nonstationary and follow unit root processes, a cointegration test has been suggested. Consistent with Engle and Granger (1987) and Hakkio and Rush (1989), spot rates \((S_{j,t+m})\) and forward rates \((F_{j,t,m})\) are said to be cointegrated if they satisfy the following three conditions. First, the spot rates \((S_{j,t+m})\) and the forward rates \((F_{j,t,m})\) are nonstationary in levels. Second, both spot and forward rate series \((S_{j,t+m} and F_{j,t,m})\) are stationary in first difference. Third, there exists a linear combination of levels, where \(u_{j,t+m} = S_{j,t+m} + \beta F_{j,t,m}\) is stationary.

The appropriate tests of the FRUH in foreign exchange markets must meet the following three conditions: (i) spot rates \((S_{j,t+m})\) and the forward rates \((F_{j,t,m})\) must be cointegrated; (ii) the cointegrating factor must be one; and (iii) forecast error must be a white noise process, a special case of a stationary series. To test the FRUH, we use the above restricted cointegration tests along with the Q-statistics to test for serial correlation in the residuals.


\(^{10}\) Lag lengths are chosen based on the Schwarz Information Criterion.
3.1.3. Corrections for nonnormality

The cointegrating factor can be estimated by simply running an OLS regression of spot rates \( S_{j,t+m} \) on forward rates \( F_{j,t,m} \). Stock (1987) shows that if \( (S_{j,t+m}) \) and \( (F_{j,t,m}) \) are cointegrated, then the estimate of \( \beta_1 \) (cointegrating factor) in the regression will possess a superconsistency property such that the estimated coefficient (cointegrating factor) should converge to its true value more quickly than under more general assumptions. However, one problem that exists in the above analysis is that the estimator can be biased and asymptotically nonnormal (e.g., Phillips and Ouliaris, 1990). Thus, usual inference procedures do not work (e.g., Campbell and Perron, 1991). Therefore, we need to correct the estimator of the cointegrating regression using the following three-step error correction model (e.g., Engle and Yoo, 1987; Aggarwal, Mohanty, and Song, 1995).

**Step I.** The cointegration regression coefficient is estimated from the Equation (6)

\[
S_{j,t+m} = \beta_0 + \beta_1 F_{j,t,m} + \varepsilon_{j,t+m}.
\]

**Step II.** Estimate \( \gamma \) from the following regression equation

\[
\Delta S_{j,t+m} = \gamma (S_{j,t+m} - \hat{\beta}_0 - \hat{\beta}_1 F_{j,t,m}) + \beta_1 \Delta F_{j,t,m} + \beta_2 \Delta S_{j,t-1,m} + \beta_3 \Delta F_{j,t-1,m} + \omega_{j,t+m}, \quad (8a)
\]

with \( \omega_{j,t+m} = \delta_0 + \delta_1 (-\gamma * F_{j,t-1,m}) + \mu_{j,t+m} \).

**Step III.** The correct estimate of cointegration regression coefficient (\( \beta_1 \)) is given as

\[
\beta_1 = \hat{\beta}_1 + \hat{\delta}_1, \quad (8c)
\]

where the studentized coefficient is given by: \( t = \beta_1 / \text{std}(\delta_1) \).

Breitung’s (2002) alternative, nonparametric method is also deployed. Let \( y_t \) be a process

\[
y_t = \delta' d_t + x_t, \quad (9)
\]

where \( d_t \) is deterministic and \( x_t \) stochastic. The \( d_t \) can include constant, time trend, or dummy variables. The stochastic element, \( x_t \), is decomposed as a random walk and a transitory component that represents a short-run dynamic of the process. Breitung (2002) first suggests a variance ratio test statistic for a unit root, similar to the one of Kwiatkowski, Phillips, Schmid, and Shin (1992). Breitung’s variance ratio test tests the null hypothesis that \( y_t \sim I(1) \) against the alternative \( y_t \sim I(0) \). The statistic constructed is

\[\text{For additional details on the advantages and limitations of using cointegration and analysis to assess time series data (see Phillips and Perron, 1988; Campbell and Perron, 1991; Banerjee and Hendry, 1992; Engle and Granger, 1992).} \]
\[
\hat{\rho}_T = T^{-1} \sum_{i=1}^{T} \hat{U}_i^2 / \sum_{i=1}^{T} \hat{u}_i^2, \quad (10)
\]

where \( \hat{u}_i = y_i - \hat{\delta}'d_i \) and \( \hat{U}_i = \sum_{i=1}^{i'} \hat{u}_i \). The limiting distribution of the test statistic is

\[
T^{-1} \hat{\rho}_T = \frac{T^{-4} \sum_{i=1}^{T} \hat{U}_i^2}{T^{-2} \sum_{i=1}^{T} \hat{u}_i^2} \Rightarrow \int_0^{1} \int_0^{a} \tilde{W}_j(s) \, ds \, \int_0^{1} \tilde{W}_j(a) \, da. \quad (11)
\]

Breitung (2002) provides simulated critical values of the asymptotic distribution under the null hypothesis. Breitung (2002) then generalizes the variance ratio statistic for a nonparametric unit root to test hypotheses on cointegrating rank. The alternative hypothesis here is of stationarity. It is assumed that the process can be decomposed into a \( q \)-dimensional vector of stochastic components \( \xi_t \) and \( (n-q) \)-dimensional vector of transitory components \( \upsilon_t \). The dimension of the stochastic component is related to the cointegration rank of the linear system by \( q = n - r \), where \( r \) is the rank of the matrix \( \Pi \) in the vector-error correction representation of the process \( \Delta y_t = \Pi y_{t-1} + e_t \). The test statistic for cointegration rank is based on the eigenvalues \( \lambda_j \) \( (j = 1, \ldots, n) \) of the problem

\[
|\lambda_jB_T - A_T| = 0, \quad (12)
\]

where \( A_T = \sum_{i=1}^{T} \hat{u}_i \hat{u}_i' \), \( B_T = \sum_{i=1}^{T} \hat{U}_i \hat{U}_i' \), and \( \hat{U}_i = \sum_{i=1}^{i'} \hat{u}_i \). The eigenvalues of Equation (13) can be found by finding the eigenvalues of the matrix \( R_T = A_T B_T^{-1} \). The eigenvalues of Equation (13) can be written as

\[
\lambda_j = \frac{(\eta_j'A_T \eta_j)}{(\eta_j'B_T \eta_j)}, \quad (13)
\]

where \( \eta_j \) is the eigenvector associated with the eigenvalue \( \lambda_j \). The test statistic for the hypothesis that \( r = r_0 \) is given by

\[
\Lambda_q = T^2 \sum_{j=1}^{q} \lambda_j, \quad (14)
\]

where \( \lambda_1 \leq \lambda_2 \leq \lambda_3 \leq \cdots \leq \lambda_n \), is the series of ordered eigenvalues of the matrix \( R_T \).

The advantage of the testing procedure is that it is independent of the Engle-Granger and Dickey–Fuller family of cointegration analyses and provides a degree of methodological triangulation to the research. In particular, it corrects for the issues surrounding nonnormality and potential sources of nonstationarity from heteroskedasticity.
4. Empirical results

Prior to estimating Equation (6), it is necessary to know whether the spot rates and forward rates follow a random walk. We use ADF tests to evaluate the stationarity of spot and forward rates ($S_{jt+m}$ and $F_{jt,m}$) for five currencies considered during the full sample period, January 1973 through December 1998. These tests are estimated based on Equation (7). The coefficient estimates on the lagged value of the spot rates, as well as forward rates and their studentized coefficients, are reported in Table 1 for one-, three-, six- and 12-month-ahead forecast horizons. The 5% and 1% critical values are $-2.93$ and $-3.58$, respectively (see tables in Dickey and Fuller, 1979). As can be seen from Table 1, the unit root hypothesis for each of these currencies cannot be rejected at the 5% level.12 Consistent with previous findings, the general conclusion that emerges from these results is that while spot and forward exchange rates are nonstationary, they are stationary in first differences.

Next, we turn to the cointegration regression tests. Table 2 presents the results of the cointegration tests for all forecast horizons ($m = $ one, three, six, and 12). Tests of cointegration are used to examine whether the residuals based on regressing $S_{jt+m}$ on $F_{jt,m}$ with a constant in Equation (6) have unit roots. As can be seen from Table 2, the null hypothesis of no cointegration can be rejected at the 5% level of significance for all exchange rates with the exception of six- and 12-month-ahead forecasts for the Swiss franc. We find that for all forecast horizons ($m = $ one, three, six, and 12), forward rates and spot rates are cointegrated in the case of British pound, German deutsche mark, Japanese yen, and the Canadian dollar. By contrast, in the case of the Swiss franc, spot and forward rates are cointegrated only for one- and three-month-ahead forecast horizons ($m = 1$ and 3). With the exception of six- and 12-month-ahead forecasts for Swiss franc, our results suggest that there exists a long-run or equilibrium relation between the forward rates and the corresponding future spot rates. Thus, the spot rate ($S_{jt+m}$) and the forward rate ($F_{jt,m}$) series for these cases do not drift too far apart from each other over time (i.e., $S_{jt+m}$ and $F_{jt,m}$) and are long-term convergent (e.g., Engle and Granger, 1992).

However, the EMH also requires that the cointegrating factor be unity. The cointegrating factor is estimated by running an OLS regression of spot rates ($S_{jt+m}$) on forward rates ($F_{jt,m}$). As mentioned earlier, the OLS estimation method might suffer from misspecification error because the distribution of the OLS estimator of the cointegrating regression (cointegrating factor) is not asymptotically normal so that the cointegrating factor estimated from the OLS regression is likely to be biased. Therefore, the null hypothesis of unbiasedness of the forward rate as a predictor of the future spot rate is likely to be rejected. We correct the bias in the cointegrating

12 Although not shown for brevity’s sake, normality is rejected overwhelmingly for the data using a Jarque–Bera test.
Table 1

Unit root tests: Spot and forward exchange rates

This table provides unit root test results for spot rates, as well as forward exchange rates for five major currencies using sample period January 1973–December 1998. The Augmented Dickey–Fuller test is based on the following regression

\[ S_{j,t+m} - S_{j,t-1+m} = \beta_0 + \beta_1 S_{j,t-1+m} + \beta_2 \Delta S_{j,t-2+m} + \beta_3 \Delta S_{j,t-3+m} + \ldots + \beta_m \Delta S_{j,t-n+m} + \nu_{j,t+m}. \]

The variable \( S_{j,t+m} \) = time series exchange data. Value of \( t \)-ratio is reported in parentheses. The 5% and 1% critical values for the Fuller (1976) tests are \(-2.89\) and \(-3.14\), respectively.

<table>
<thead>
<tr>
<th>Augmented Dickey–Fuller Tests</th>
<th>British Pound</th>
<th>German Mark</th>
<th>Japanese Yen</th>
<th>Canadian Dollar</th>
<th>Swiss Franc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot levels</td>
<td>-0.030</td>
<td>-0.017</td>
<td>-0.006</td>
<td>-0.005</td>
<td>-0.017</td>
</tr>
<tr>
<td></td>
<td>(-2.484)</td>
<td>(-1.804)</td>
<td>(-0.921)</td>
<td>(-0.835)</td>
<td>(-1.899)</td>
</tr>
<tr>
<td>Spot differences</td>
<td>1.033</td>
<td>-0.961</td>
<td>-0.018</td>
<td>-1.073</td>
<td>-0.928</td>
</tr>
<tr>
<td>One-month forward levels</td>
<td>-0.026</td>
<td>-0.017</td>
<td>-0.007</td>
<td>-0.006</td>
<td>-0.017</td>
</tr>
<tr>
<td></td>
<td>(-2.531)</td>
<td>(-1.789)</td>
<td>(-0.960)</td>
<td>(-0.940)</td>
<td>(-1.905)</td>
</tr>
<tr>
<td>One-month forward differences</td>
<td>-0.099</td>
<td>-0.981</td>
<td>-0.950</td>
<td>-1.106</td>
<td>-0.937</td>
</tr>
<tr>
<td>Three-month forward levels</td>
<td>-0.026</td>
<td>-0.017</td>
<td>-0.007</td>
<td>-0.008</td>
<td>-0.017</td>
</tr>
<tr>
<td></td>
<td>(-2.548)</td>
<td>(-1.788)</td>
<td>(-0.954)</td>
<td>(-1.110)</td>
<td>(-1.917)</td>
</tr>
<tr>
<td>Three-month forward differences</td>
<td>-0.929**</td>
<td>-0.988</td>
<td>-0.952</td>
<td>-1.136</td>
<td>-0.934</td>
</tr>
<tr>
<td>Six-month forward levels</td>
<td>-0.027</td>
<td>-0.018</td>
<td>-0.007</td>
<td>-0.008</td>
<td>-0.017</td>
</tr>
<tr>
<td></td>
<td>(-2.587)</td>
<td>(-1.745)</td>
<td>(-0.914)</td>
<td>(-1.123)</td>
<td>(-1.930)</td>
</tr>
<tr>
<td>Six-month forward differences</td>
<td>-0.906</td>
<td>-1.042</td>
<td>-1.070</td>
<td>-1.143</td>
<td>-0.960</td>
</tr>
<tr>
<td>12-month forward levels</td>
<td>-0.030</td>
<td>-0.019 - 1.054</td>
<td>-0.006 - 0.990</td>
<td>-0.009 - 1.129</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>(-2.493)</td>
<td>(-1.794)</td>
<td>(-0.914)</td>
<td>(-1.241)</td>
<td>(-1.936)</td>
</tr>
<tr>
<td>12-month forward differences</td>
<td>-1.031</td>
<td>-1.031</td>
<td>-0.998</td>
<td>-0.998</td>
<td></td>
</tr>
</tbody>
</table>

**Evidence of rejection of a unit root at the 5% level.

***Evidence of rejection of a unit root at the 1% level."
Value of $t$-ratio is reported in parentheses. The 5% and 1% critical values for the Dickey–Fuller tests are $-2.90$ and $-3.58$, respectively.

Table 2 presents cointegration regression test results for all forecast horizons. The Augmented Dickey–Fuller tests are based on the following regression:

$$\Delta U_t = \Phi_0 + \Phi_1U_{t-1} + \Phi_2\Delta U_{t-1} + \Phi_3\Delta j_{t-2} + v_t.$$  

$U_t$ is the residual from regression $\delta j_{t+m}$ on $F_{j,t,m}$. The null hypothesis of unbiasedness (i.e., cointegrated factor equal to one) is rejected at the 5% level.

<table>
<thead>
<tr>
<th>Currency/Horizon</th>
<th>Month = 1</th>
<th>Month = 3</th>
<th>Month = 6</th>
<th>Month = 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>British pound</td>
<td>$-0.975^{***}$</td>
<td>$-0.630^{***}$</td>
<td>$-0.331^{***}$</td>
<td>$-0.059^{**}$</td>
</tr>
<tr>
<td>German mark</td>
<td>$-0.851^{***}$</td>
<td>$-0.707^{***}$</td>
<td>$-0.491^{***}$</td>
<td>$-0.269^{***}$</td>
</tr>
<tr>
<td></td>
<td>($-9.103$)</td>
<td>($-8.123$)</td>
<td>($-6.578$)</td>
<td>($-4.766$)</td>
</tr>
<tr>
<td>Japanese yen</td>
<td>$-0.663^{***}$</td>
<td>$-0.516^{***}$</td>
<td>$-0.462^{***}$</td>
<td>$-0.209^{***}$</td>
</tr>
<tr>
<td></td>
<td>($-8.333$)</td>
<td>($-7.208$)</td>
<td>($-6.632$)</td>
<td>($-4.393$)</td>
</tr>
<tr>
<td>Canadian dollar</td>
<td>$-0.896^{***}$</td>
<td>$-0.686^{***}$</td>
<td>$-0.401^{***}$</td>
<td>$-0.205^{***}$</td>
</tr>
<tr>
<td></td>
<td>($-9.880$)</td>
<td>($-8.278$)</td>
<td>($-6.100$)</td>
<td>($-4.307$)</td>
</tr>
<tr>
<td>Swiss franc</td>
<td>$-0.435^{***}$</td>
<td>$-0.108^{**}$</td>
<td>$-0.055$</td>
<td>$-0.042$</td>
</tr>
<tr>
<td></td>
<td>($-6.203$)</td>
<td>($-3.116$)</td>
<td>($-2.403$)</td>
<td>($-2.313$)</td>
</tr>
</tbody>
</table>

**Rejection of null hypothesis of no cointegration at the 5% level.
***Rejection of null hypothesis of no cointegration at the 1% level.

Table 3 presents cointegration regression results for all forecast horizons ($m = $ one, three, six, and 12) using the OLS estimator (column 2) and the corrected estimator (column 3) based on the three-step error correction model. Results reported in Table 4A (column 3) for the one-month-ahead forecast horizon show that the null hypothesis of the cointegrating factor being unity is rejected at the 5% significance level for British, German, and Switzerland foreign exchange rates. In contrast, the corrected estimators for the three-month-ahead forecast horizon suggest that the null hypothesis of unbiasedness (i.e., cointegrated factor equal to one) is rejected at the 5% significance level for British, German, and Japanese exchange markets. When examining the corrected estimates of the cointegrating factors for both six- and 12-month-ahead forecast horizons, we notice that the cointegrating factor is significantly different from unity at the 5% significance level for both British and Japanese foreign exchange markets. The estimated cointegrating factors for the six- and 12-month-ahead forecast horizon for the Swiss franc are not estimated because the spot and forward rates have been found to be not cointegrated. Our test results show that only the corrected cointegrating factor for all forecast horizons for Canadian dollars is not significantly different from unity, providing support for the FRUH for the forward exchange rate for the Canadian dollar. Test results for all other currencies provide mixed results. For each of the one-, three-, six-, and 12-month-ahead forward exchange rates for the British pound indicate that the forward rate is a biased indicator of the
The rational expectations hypothesis suggests that the cointegrating factor must be one. This table provides the results for the cointegrating factor before and after the correction. Cointegration regression: $S_{j,t+m} = \beta_0 + \beta F_{j,t,m} + E_{j,t+m}$. Estimated coefficient is based on the cointegration regression. Corrected coefficient is based on the three-step error correction model suggested by Engle and Yoo (1987).

<table>
<thead>
<tr>
<th>Currency</th>
<th>Estimated Coefficient ($\beta_1$)</th>
<th>Corrected Coefficient ($\beta_1$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Pound</td>
<td>1.011*** (0.004)</td>
<td>1.010*** (0.003)</td>
</tr>
<tr>
<td>German Mark</td>
<td>0.997 (0.007)</td>
<td>0.987*** (0.003)</td>
</tr>
<tr>
<td>Japanese Yen</td>
<td>0.999 (0.004)</td>
<td>0.997 (0.003)</td>
</tr>
<tr>
<td>Canadian Dollar</td>
<td>1.006 (0.004)</td>
<td>1.005 (0.004)</td>
</tr>
<tr>
<td>Swiss Franc*</td>
<td>1.003*** (0.001)</td>
<td>1.003** (0.001)</td>
</tr>
</tbody>
</table>

Month $= 1$ (0.004) (0.007) (0.004) (0.004) (0.001)

Month $= 1$ (0.003) (0.003) (0.003) (0.004) (0.001)

Month $= 1$ (0.005) (0.008) (0.004) (0.005) (0.002)

Month $= 3$ (0.005) (0.004) (0.003) (0.005) (0.005)

Month $= 3$ (0.005) (0.009) (0.005) (0.006)

Month $= 3$ (0.005) (0.004) (0.003) (0.005) (0.006)

Month $= 6$ (0.006) (0.009) (0.005) (0.006)

Month $= 6$ (0.008) (0.007) (0.004) (0.008)

Month $= 12$ (0.007) (0.011) (0.005) (0.008)

Month $= 12$ (0.009) (0.013) (0.007) (0.017)

**Cointegrating factor significantly different from unity at 5% level.

***Cointegrating factor significantly different from unity at 1% level.

future spot rate. While the FRUH for six- and 12-month-ahead forward rates cannot be rejected, the FRUH for the one- and three-month-ahead forward rates is rejected for the German deutsche mark. With the exception of the one-month-ahead forward rate, the FRUH is rejected for all other horizons for the Japanese yen. Similarly, while the FRUH for three-month-ahead forward rate cannot be rejected, the results for the one-month-ahead forward rate do not provide support for the FRUH for the Swiss franc. In general, except for the Canadian dollar, there is little support for the FRUH among the other major currencies.
Table 4

**Spot and forward exchange rates: Q-statistics for forecast errors**

This table presents results for Q-statistics, which indicates whether the forecast errors follow white noise processes (a special case of stationary series). The 5% significant levels for Q-statistics: Q(1) = 3.84, Q(2) = 5.89, Q(3) = 7.81, and Q(4) = 9.49. Month 1 estimates go up to 12 lags while the others go up to four lags. In the case of monthly forecast, we chose longer lag length (up to 12 lags) due to largest number of observation available for the horizon.

### A: Month = 1

<table>
<thead>
<tr>
<th>Currency</th>
<th>Q(1)</th>
<th>Q(3)</th>
<th>Q(6)</th>
<th>Q(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>British pound</td>
<td>0.877</td>
<td>1.020</td>
<td>2.472</td>
<td>2.894</td>
</tr>
<tr>
<td>German mark</td>
<td>0.004</td>
<td>1.188</td>
<td>4.343</td>
<td>19.175</td>
</tr>
<tr>
<td>Japanese yen</td>
<td>0.017</td>
<td>4.753</td>
<td>14.848**</td>
<td>58.618**</td>
</tr>
<tr>
<td>Canadian dollar</td>
<td>0.652</td>
<td>6.999</td>
<td>7.455</td>
<td>27.011**</td>
</tr>
<tr>
<td>Swiss franc</td>
<td>24.715**</td>
<td>28.762**</td>
<td>34.114**</td>
<td>44.149**</td>
</tr>
</tbody>
</table>

**Indicates rejection of no serial correlation in forecast errors at the 5% level.**

### B: Month = 3

<table>
<thead>
<tr>
<th>Currency</th>
<th>Q(1)</th>
<th>Q(2)</th>
<th>Q(3)</th>
<th>Q(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>British pound</td>
<td>10.459**</td>
<td>11.623**</td>
<td>12.552**</td>
<td>15.938**</td>
</tr>
<tr>
<td>German mark</td>
<td>0.115</td>
<td>2.184</td>
<td>5.683</td>
<td>5.736</td>
</tr>
<tr>
<td>Japanese yen</td>
<td>0.442</td>
<td>0.816</td>
<td>9.608**</td>
<td>10.218**</td>
</tr>
<tr>
<td>Canadian dollar</td>
<td>5.901**</td>
<td>16.743**</td>
<td>16.861**</td>
<td>18.567**</td>
</tr>
<tr>
<td>Swiss franc</td>
<td>46.873**</td>
<td>47.537**</td>
<td>47.542**</td>
<td>47.601**</td>
</tr>
</tbody>
</table>

### C: Month = 6

<table>
<thead>
<tr>
<th>Currency</th>
<th>Q(1)</th>
<th>Q(2)</th>
<th>Q(3)</th>
<th>Q(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>British pound</td>
<td>26.307**</td>
<td>26.597**</td>
<td>26.683**</td>
<td>30.442**</td>
</tr>
<tr>
<td>German mark</td>
<td>3.100</td>
<td>7.687</td>
<td>15.722**</td>
<td>16.768**</td>
</tr>
<tr>
<td>Canadian dollar</td>
<td>21.321**</td>
<td>36.835**</td>
<td>36.8756**</td>
<td>41.269**</td>
</tr>
</tbody>
</table>

### D: Month = 12

<table>
<thead>
<tr>
<th>Currency</th>
<th>Q(1)</th>
<th>Q(2)</th>
<th>Q(3)</th>
<th>Q(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>British pound</td>
<td>0.005</td>
<td>0.435</td>
<td>6.235</td>
<td>6.317</td>
</tr>
<tr>
<td>German mark</td>
<td>16.648**</td>
<td>19.133**</td>
<td>27.283**</td>
<td>28.280**</td>
</tr>
<tr>
<td>Japanese yen</td>
<td>18.893**</td>
<td>24.557**</td>
<td>31.730**</td>
<td>31.730**</td>
</tr>
<tr>
<td>Canadian dollar</td>
<td>44.995</td>
<td>59.605</td>
<td>60.564</td>
<td>64.317</td>
</tr>
</tbody>
</table>

The acceptance of the FRUH not only requires that the spot rates \(S_{j,t+m}\) and the forward rates \(F_{j,t,m}\) are cointegrated and the cointegrating factor must be one, but also that the forecast errors in the forward rate forecasts of the future spot rate must be white noise. We analyze each of the five currencies and four forecast horizons for which the cointegration analysis for testing the FRUH is appropriate. In Table 4, we report Q-statistics that test for serial correlation in the forecast errors. The critical values for the Q(1), Q(2), Q(3), Q(4), Q(6), and Q(12) statistics are 3.84, 5.99, 7.81, 9.49, 12.59, and 21.03, respectively, at the 5% significance level. Our results indicate that Q-statistics are significant for most cases and that there is significant serial
correlation in the residuals. Although evidence from the cointegration tests suggests that the unbiasedness hypothesis for the forward exchange rates is not rejected for most cases, the significant Q-statistics associated with forecast errors suggest the rejection of the REH.

The approaches above, however, are all parametric approaches. Table 5 shows the results of the Breitung estimations, which do not require assumptions of normality. In all cases, the application of a nonparametric approach indicates cointegration, in all but a few cases this being at the 5% level.

4.1. Discussion

Unlike prior literature, our methodology accounts and corrects for both non-stationarity and nonnormality in the data series. Our results indicate little empirical support for rational expectations in forward rates as a forecast of the future spot rate and suggest that the seeming failure of market efficiency is attributable to either expectation errors, risk premiums, or both. Studies since Fama (1984) have suggested that time-varying risk premiums in the foreign exchange markets may account for the failure of the tests for the EMH and the FRUH. A second explanation for these failures has centered on expectation errors. For example, Frankel and Froot (1987) provide evidence that investors in the foreign exchange market may not have rational expectations.

Prior studies also suggest (e.g., Frankel, 1981; Ott and Veugelers, 1986) that forward exchange rates that predict future spot exchange rates are influenced by changes in interest and inflation rate differentials and monetary policy changes between countries. These studies imply that the changes in expectations between the time that forward rate prediction is made and the spot rate is observed, partly explain the forecast errors. For example, unanticipated changes in interest rate differentials between time $t$ and $t + m$ could lead to expectational errors. While the reasons for deviations from the EMH and the FRUH remain a topic for future research, using an improved statistical methodology, the study shows clearly that both hypotheses are violated in most foreign exchange markets—the puzzle continues!

However, our results do provide possible directions for future research on the topic. Given the similarity in economic and monetary policies between Canada and the United States and that we cannot reject efficiency and rationality for the U.S. dollar forward rate for the Canadian dollar, future research on the topic can usefully examine differences related to distance as well as monetary and economic policies as possible sources of deviations from efficiency and rationality. As financial integration continues apace in conjunction with both technological and communications

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13 Unlike other asset markets, the concept of risk premiums in foreign exchange markets is particularly difficult to apply consistently as each currency value is denominated in terms of another currency (i.e., each exchange rate by its very nature specifies two currencies). What would be a risk premium from the perspective of one currency would be a risk “discount” from the perspective of the other currency in a foreign exchange rate.
Table 5  
Spot and forward exchange rates: Breitung nonparametric cointegration estimations  
This table shows the calculated test statistic for Breitung’s nonparametric cointegration test. This tests $H_0: r = 0$ against $H_a: r > 0$, where $r$ is the rank of the matrix $\Pi$ in the vector-error correction representation of the process $\Delta y_t = \Pi y_{t-1} + e_t$. The test statistic for cointegration rank is based on the eigenvalues $\lambda_j$ ($j = 1, \ldots, n$) of the matrix $R_T = A_T B_T^{-1}$. The test statistic for the hypothesis that $r = r_0$ is given by $\Lambda_q = T^2 \sum_{j=1}^q \lambda_j$, where $\lambda_1 \leq \lambda_2 \leq \lambda_3 \leq \cdots \leq \lambda_n$, is the series of ordered eigenvalues of the matrix $R_T$.

<table>
<thead>
<tr>
<th></th>
<th>Japanese No drift</th>
<th>Japanese Drift</th>
<th>UK No drift</th>
<th>UK Drift</th>
<th>Swiss No drift</th>
<th>Swiss Drift</th>
<th>Germany No drift</th>
<th>Germany Drift</th>
<th>Canada No drift</th>
<th>Canada Drift</th>
</tr>
</thead>
<tbody>
<tr>
<td>No drift</td>
<td>2,563.73** 2,337.2**</td>
<td>5,306.04** 5,543.51**</td>
<td>4,134.49** 4,272.42**</td>
<td>2,654.4** 2,730.49**</td>
<td>2,441.87** 2,487.94**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift</td>
<td>938.27** 1,001.5**</td>
<td>1,842.06** 2,150.35**</td>
<td>1,636.36** 1,873.96**</td>
<td>1,190.7** 1,283.1**</td>
<td>605.36** 638.8**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 No drift</td>
<td>505.69** 584.52**</td>
<td>1,061.69** 1,278.39**</td>
<td>918.07** 1,164.75**</td>
<td>689.68** 798.8**</td>
<td>340.05** 387.11**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift</td>
<td>251.28* 314.99*</td>
<td>555.28** 722.56**</td>
<td>467.37** 702.99**</td>
<td>369.39** 477.62**</td>
<td>217.57* 262.91*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Indicates rejection of the null at 5%, * at 10%.
advances, informational asymmetries can be removed or at least made more transparent. The likely consequence of any of these is that, without a greater degree of monetary coordination, we may expect to see markets moving toward the theoretical paradigm.

5. Conclusions

In spite of much investigation, high liquidity, and low trading costs, forward exchange rates appear to be neither efficient nor rational forecasts of future spot rates. The study uses a new and improved statistical methodology to examine the rationality of forward exchange rates as forecasts of future spot rates and uses data over a long period and for forecast horizons ranging from one to 12 months for the major industrialized nations’ currencies. Unlike prior literature, our improved methodology accounts and corrects for nonstationarity, nonnormality, and heteroskedasticity in the data series. We still find significant deviations from efficiency and rationality for the U.S. dollar forward rate as a forecast of the future spot rate for the British pound, Japanese yen, Swiss franc, and the German deutsche mark. Thus, the forward exchange rate puzzle generally seems robust when applied to improved statistical procedures. These findings of nonrationality indeed deepen the forward exchange rate bias puzzle, especially as these foreign exchange markets are the most liquid asset markets with very low trading costs.

However, our results do provide a small hint about the possible direction for future research on the topic. Given the similarity in economic and monetary policies between Canada and the United States and that we cannot reject efficiency and rationality for the U.S. dollar forward rate for the Canadian dollar, future research can examine international differences related to geographic and cultural distance and to differences in monetary and economic policies as possible sources of these deviations from efficiency and rationality.

References


