Several Econometric Tests of Exchange Rate Efficiency for a Few European Countries

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Abstract

This paper uses an efficiency specification model of the spot and forward foreign exchange markets and tests the hypotheses for random walk (which cannot be rejected), general efficiency, and unbiasedness by using a regression estimation and various specification and diagnostic tests for the series and the error terms (residuals). Whereas the forward rate is usually viewed as an unbiased predictor of the future spot rate, the unbiased forward rate hypothesis has failed to be rejected for the Canadian dollar, although more research is needed in this particular area so that better statistical inferences can be drawn in the future.

Keywords: efficiency, foreign exchange, exchange rates, econometric tests, technical analysis, forward rates

1. Introduction

Economic theorists posit that the forward exchange rate will be an unbiased predictor of the future spot rate whenever we have the condition of efficient markets coupled with rational expectations (i.e., correct on average). This begs the question, however, about which market is efficient. According to Eugene Fama (1970), a market can be termed "efficient" if its prices always "fully reflect" all information available to its participants. Economists, though, have not even reached agreement yet on major economic issues such as how the general resources and the ownership of the economy's capital stock should be allocated. Up to this point, we have merely depended on whatever our economic system deems to be optimal markets and price mechanisms. For example, all our models today assume that market efficiency exists; but does it actually exist? An understanding of market efficiency and any improvements in it are important to government policymakers, central bankers, managers of multinational corporations, and international investors. Market behavior is of the greatest importance to government policymakers in particular so that they can design appropriate macro-policies to achieve the goals of efficient resource allocation, steady growth, full employment with price stability, and improvement in their fellow citizens' health and standard of living.

Fifteen years after Fama's definition, Samuelson and Nordhaus (1985) further described an efficient market as one in which new information would be quickly absorbed by market participants and also be immediately reflected in market prices. The academic domestic finance literature has subsequently developed this efficient markets hypothesis extensively, with its underlying importance coming from the assumption that, if a market is efficient, the current price of an asset will fully reflect all available information regarding its valuation. The prices of financial assets thus provide signals for portfolio allocation, but is the pertinent "available information" the full information that people absolutely need?

In addition to domestic finance, the efficiency hypothesis has been used in many foreign exchange market studies. This hypothesis itself suggests that there are no unexploited profit opportunities and, particularly in the foreign exchange market, implies that the forward rate summarizes all relevant and available information that could be used in a forecast of the future spot rate. Analyzing this aspect of efficiency requires an equilibrium model of pricing in the foreign exchange market. Consequently, any empirical test of efficiency is a joint test of efficiency (full information) and the equilibrium (harmony) (Note 1) model. The hypothesis of market efficiency in the foreign exchange rates market states that, in general, the expected value of the future spot rate is the current forward rate (Hakkio 1981).

Hansen and Hodrick (1980, 1983), Fama (1984), and Domowitz and Hakkio (1985) have recently conducted tests showing that the evidence supporting the unbiased forward rate hypothesis is notably scant, finding that an inconstant risk premium exists in several major foreign exchange markets, with the implication being that one cannot directly use the forward rate as an accurate and consistent predictor of the future spot rate.

Robichek and Eaker (1978) concluded that the forward rate is a biased predictor of the future spot rate and that speculative positions do not receive a return above that expected in the Capital Asset Pricing Model (CAPM) framework. On the other hand, Chiang's (1988) empirical analysis, based on the full-sample estimation covering January 1974 through August 1983, confirms the unbiased forward rate hypothesis for France, Canada, and the United Kingdom, although his evidence from the Brown-Durbin-Evans test and the Chow test cannot support the constant coefficient hypothesis in the exchange rate regression model and his empirical results from the subsample study using joint-rolling regressions also reject the unbiasedness hypothesis in most cases. Leachman and El Shazly (1992) found empirical evidence supporting the efficiency criterion in four out of five countries, although Chan, Gup, and Pan's (1992) results show that currency futures markets are multi-market inefficient and that currency futures prices appear to be a random walk. Fittingly, Hopper (1994) answered the question about the existence of market efficiency with the response “Maybe.”

In this paper, we start from an equilibrium state in the foreign exchange markets and then try to study the model’s stochastic coefficients’ dynamics used in testing the unbiased efficiency hypothesis while performing statistical and time series tests on the model’s variables and many diagnostic tests on both the model’s underlying assumptions and the adequacy of its specifications.

The paper is organized as follows. In the second section, the model is developed. The one after that provides some basic statistics regarding the model’s variables and the fourth one gives the empirical results. The next section deals with the model’s different specifications and diagnostic testing, with the final section providing a summary and concluding remarks.

2. The Derivation of the Basic Model

The notion of market efficiency is usually affiliated with market expectations’ rationality. Our method of examining this issue is to decide on the possibility of market participants systematically earning an excess profit. In foreign exchange markets, current prices reflect all available information. Therefore, the efficient market approach paired with rational expectations implies that economic agents' expectations about the future values of exchange rate determinants are fully reflected in the forward rates. It follows that, working under these conditions, an investor cannot earn an outsized profit by exploiting this available information.

The assumptions underlying this conclusion are that the conditions of market equilibrium can be stated in terms of expected returns and that equilibrium expected returns are formed on the basis of the full information set II_t such that there exists neither systematic unexploited profits over time nor any irrationality in the market. Following Fama (1970), Mishkin (1983), and Levich (1985), we can write:

$$E[R_{t+1} - R^e_{t+1}|II_t] = 0 \tag{1}$$

where R^e_{t+1} is the expectation derived from the forecast from one period ahead of the actual value of asset returns R_{t+1} and e is the expectations operator conditioned on the information set II_t available at the end of period t. (Note 2)

The hypotheses that the exchange rate follows a random walk and that the forward rate is an unbiased predictor of the future spot rate can be derived from the use of the following international parity conditions:

Purchasing Power Parity

$$s_t = p_t - p_t^* \tag{2}$$

Fisher Effect (Note 3)

$$i_t = r_t + \Delta p_t^e \tag{3}$$

$$i_t^* = r_t^* + \Delta p_t^{*e} \tag{4}$$

Assumption

$$r_t = r_t^* \tag{5}$$

Interest Rate Parity

$$i_t - i_t^* = f_t - s_t \tag{6}$$

International Fisher Parity

$$i_t - i_t^* = s^e_{t+1} - s_t \tag{7}$$

where notations expressed in lowercase letters are natural logarithms, with the only exception being the interest rates; s_t and f_t are the spot and forward exchange rates, respectively; p_t denotes the price level; (Note 4) and i_t and r_t are the nominal and real rates of interest, respectively.

Taking the mathematic expectation of equation (7) and substituting equations (3) and (4), assuming also that $\Delta p_t^e = \Delta p^{*e}_t = 0$ and that equation (5) holds, we have

$$s^e_{t+1} = E(s_{t+1}|II_t) = i_t - i_t^* + s_t = r_t + \Delta p_t^e - (r_t^* + \Delta p_t^{*e}) + s_t = s_t \tag{8}$$

Substituting equation (8) into equation (1), we obtain

$$E[s_{t+1} - s_t|II_t] = 0 \tag{9}$$

or

$$E[s_{t+1} - s_t \mid I_t] \cong 0 \tag{10}$$

Equation (10) suggests that if we have an efficient market then a currency's current price will reflect all available information affecting that currency. The unexpected change in the spot rate, $s_{t+1} - s_t$, is essentially caused by the random shock ε_{t+1} which hits the market between time periods t and t+1. Market rationality suggests that a market participant or investor would discern no particular pattern from studying the history of ε_{t+1}. (Note 5)

By taking equation (2) forward for one period and then taking the mathematic expectation, adding and subtracting r_t, and substituting the relationship into equations (2), (3), and (5), we receive

$$\begin{aligned} E(s_{t+1}) &= p_t + \Delta p_t^e - (p_t^* + \Delta p_t^{*e}) \\ &= p_t + \Delta p_t^e - (p_t^* + \Delta p_t^{*e}) + r_t - r_t^* \\ &= p_t - p_t^* + r_t + \Delta p_t^e - (r_t^* + \Delta p_t^{*e}) \\ &= s_t + i_t - i_t^* \\ &= f_t \end{aligned} \tag{11}$$

Substituting equation (11) into equation (1), we obtain

$$E[s_{t+1} - f_t|II_t] = 0 \tag{12}$$

or

$$E[s_{t+1} - f_t \mid I_t] \cong 0 \tag{13}$$

In equation (13), the notion of rational expectations without a risk premium is formally expressed and is usually called the "simple efficiency" hypothesis. Some people have argued that the forward rate may also contain a risk premium, RP_{t+1}, if the economic agents are assumed to be risk averse; this mathematical relationship (the "general efficiency" hypothesis) (Note 6) can be stated:

$$E[s_{t+1} - f_t \mid I_t] = -RP_{t+1} \tag{14}$$

We are initially testing equations (10), (13), and (14) as the following:

$$s_t = \alpha_0 + \alpha_1 s_{t-1} + \varepsilon_{1t} \tag{15}$$

$$s_t = \beta_0 + \beta_1 f_{t-1} + \varepsilon_{2t} \tag{16}$$

$$s_t = \Upsilon_0 + \Upsilon_1 s_{t-1} + \Upsilon_2 f_{t-1} + \varepsilon_{3t} \tag{17}$$

$$s_t = \delta_0 + \delta_1 f_{t-1} + \delta_2 [(i-i^*)_t - E_{t-1}(i-i^*)_t] + \varepsilon_{4t} \tag{18}$$

The unbiased efficiency hypothesis is assumed to hold if $\alpha_0 = \beta_0 = \Upsilon_0 = \delta_0 = 0$, $\alpha_1 = \beta_1 = \delta_1, \Upsilon_1 + \Upsilon_2 = 1$, and $\delta_2 = 0$; the relationship between s_t and s_{t-1}, f_{t-1} and "news" is linear; the s_t's, f_t's, and "news" are nonrandom variables whose values are fixed, and $\sigma^2_{st} \neq 0$, $\sigma^2_{ft} \neq 0$, $\sigma^2_{\text{"news"}} \neq 0$ and finite; and $E(\varepsilon_t) = 0$, $E(\varepsilon_t^2) = \sigma^2$, and $E(\varepsilon_t, \varepsilon_{t-1}) = 0$, meaning that ε_{1t}, ε_{2t}, ε_{3t}, and $\varepsilon_{4t} \sim N(0, \sigma^2)$.

3. Simple Testing of the Model and Basic Statistics

The data include monthly figures for the spot and forward rates of the U.S. dollar ($) with respect to the Canadian dollar (C$), the British pound (£), and the French franc (FF) as well as to three-month U.S. Treasury bill rates or other interest rates. All the data come from Main Economic Indicators of the Organization for Economic Cooperation and Development (OECD) and cover the period March 1973 through June 1994 inclusive (256 months).

We started out testing the random walk hypothesis by calculating the mean value, the variance, and the coefficient of variation of the error term (ε_t), and these results are in Table 1. As is shown, both the $E(\varepsilon_t)$ and the variance are small but are not constant over time. Then, the general efficiency hypothesis was tested and its results are presented in Table 2. Table 3 shows the exchange rates' correlation matrix. Some basic statistics are next provided in Table 4, (Note 7) namely, mean values, standard deviations, maximum, minimum, skewness, kurtosis, correlation, normality test statistics, autocorrelation and partial autocorrelation, cross correlation, and roots (stationary) tests.

Table 1. Testing of Random Walk Hypothesis: $s_{t+1} - s_t = \varepsilon_{t+1}$, $E(\varepsilon_{t+1}) = 0$, $E(\varepsilon_{t+1}^2) = \sigma^2$

Country	$E(\varepsilon_t)$	$E(\varepsilon_t^2)$	σ^2 (constant)	CV
Canada	-.001	.0002	NO	-14.1421
United Kingdom	-.002	.001	NO	-15.8114
France	-.0007	.001	NO	-45.1753

Note: Data from March 1973 through June 1994.

Table 2. Testing of the "General Efficiency" Hypothesis: Equation (14) $E[s_{t+1} - f_t \mid I_t] = -RP_{t+1}$

	RP_t	σ_{RPt}	RP_{t+1}	σ_{RPt+1}	RP_{t+3}	σ_{RPt+2}
Canada	.003	.00002	.002	.0002	-.0005	.0005
U.K.	-.001	.0001	-.003	.001	-.007	.004
France	.002	.00003	-.0004	.001	-.002	.004

Note: The forward rates are the three-month forward rates.

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-------|------------------|-------------------|-------------------|------------
       0                 1                   2                   3
       Ft               St+1                St+2                St+3
       St
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To predict the S_t, we must use F_t as the best predictor available because σ_{RPt} is small. In these cases, the forward rate cannot predict the future spot rate very well (i.e., there is no efficiency). A negative RP means that the forward rate contains a risk premium, as is the case in all three countries sampled here. A positive RP means that the forward rate does not contain a risk premium and investors are accepting a lower exchange rate in return for the forward market's safety (meaning that they pay for the certainty of the forward market and prefer the forward market over the spot market, e.g., Canada contains a risk and investors therefore require a risk premium). The smallest risk premium in the forward market appears in France (RP_{t+1} = -.0004) and the largest in the United Kingdom, where RP_t = -.00l. A risk premium in the spot market is required in Canada (RP_{t+1} = .002).

The foreign exchange market is not very efficient. The most efficient one (RP→0) is in France (1-month forward) and the least efficient one is in the U.K. because of its large risk premium (3-month forward). The most stable market ($\sigma_{RP}\to 0$) is in Canada (current spot market, σ_{RPt}) and the U.K. and France equally display the most unstable markets (the largest σ_{RPt} at σ_{RPt+2}).

Table 3. Correlation matrix for spot and forward exchange rates

	S_C	f_C	S_{UK}	f_{uk}	S_F	f_{Fa}
Sc	1.000					
f_C	0.999	1.000				
S_{UK}	0.717	0.729	1.000			
f_{uk}	0.695	0.707	0.998	1.000		
S_F	0.680	0.683	0.859	0.853	1.000	
f_{Fa}	0.717	0.721	0.896	0.889	0.999	1.000

Note: a= France's sample range from January 1973 to June 1994.

S=spot exchange rate, f=forward exchange rate, C=Canada, UK= United Kingdom, F=France.

Table 4. Basic statistics of spot and forward exchange rates

	s_c	$D(s_c)$	f_c	$D(f_c)$
Mean	4.439	-.001	4.435	-.001
St. Dev.	.103	.013	.104	.013
Maximum	4.646	.031	4.645	.035
Minimum	4.252	-.063	4.243	-.064
Skewness	.352	-.770	.356	-.875
Kurtosis	2.296	5.360	2.315	5.855
J-B St.	10.568*	84.715*	10.408*	119.619*
B-P Q-St.	2443.32*	19.750*	2437.63*	17.400
L-B Q-St.	2522.41*	20.590*	2516.57*	18.140
D-F t-St.	2.141*	3.461*	1.606*	3.841*

	s_{uk}	$D(s_{uk})$	f_{uk}	$D(f_{uk})$
Mean	5.181	-.002	5.182	-.002
St. Dev.	.182	.034	.178	.034
Maximum	5.554	.131	5.549	.128
Minimum	4.691	-.128	4.694	-.133
Skewness	.060	-.017	.012	-.159
Kurtosis	2.469	4.370	2.487	4.256
J-B St.	3.165	20.037*	2.814	17.903*
B-P Q-St.	2057.41*	11.290	2013.61*	11.260

L-B Q-St.	2120.76*	11.680	2075.17*	11.620
D-F t-St.	2.421*	3.913*	2.457*	4.005*

	s_F	$D(s_F)$	f_F	$D(f_F)$
Mean	2.881	-.001	2.886	-.002
St. Dev.	.222	.034	.252	.034
Maximum	3.222	.092	3.231	.094
Minimum	2.285	-.116	2.281	-.118
Skewness	-.613	-.313	-.621	-.169
Kurtosis	2.708	3.864	2.244	4.177
J-B St.	16.924*	12.135*	17.265*	12.054*
B-P Q-St.	2448.14*	8.20		
L-B Q-St.	2527.05*	8.47		
D-F t-St.	1.606*	3.841*	1.707	3.058

Note: See previous tables; D = the first difference operator.

4. The Empirical Results

We estimate equations (15), (16), (17), and (18) by using Ordinary Least Squares (OLS) and Instrumental Variable (N) methods. As instruments, we use constant, time, time squared, and lagged values of the spot and forward rates. The expected interest rate differential is computed from a regression of the interest differential on a constant, two lagged values of the interest differential, two lagged spot exchange rates, and time. The results from those four equations' estimations are shown in Tables 5, 6, 7, and 8 respectively. The overall results are robust and we also have good statistics.

Table 5. Regression Estimates of equation (15): $s_t = \alpha_0 + \alpha_1 s_{t-1} + \varepsilon_{1t}$

	a_0	a_1	R^2	D-W	SSR	F
Canada						
OLS	.037	.991*	.984	2.091	.043	15838.51
	(.035)	(.008)				
IV	.033	.992*	.984	2.093	.043	15621.66
	(.035)	(.008)				
UK						
OLS	.114*	.978*	.966	1.772	.285	7246.64
	(.060)	(.011)				
IV	.133*	.974*	.966	1.765	.285	6948.99
	(.061)	(.012)				
France						
OLS	.037	.987*	.977	1.946	.286	10931.59
	(.027)	(.009)				
IV	.028	.989*	.982	1.983	.225	10286.56
	(.028)	(.010)				

Note: OLS=Ordinary Least Squares, IV=Instrumental Variables, *=significant at least at the 10 percent level; standard errors in parentheses.

Table 6. Regression estimates of equation (16): $s_t = \beta_0 + \beta_1 f_{t-1} + \varepsilon_{2t}$

	b_0	b_0	R^2	D-W	SSR	F
Canada						
OLS	.030*	.994•	.998	.582	.006	117008.3
	(.013)	(.003)				
IV	.063	.986*	.981	1.833	.051	13066.75
	(.038)	(.009)				
UK						
OLS	-.110*	1.021*	.997	.350	.029	73418.56
	(.020)	(.004)				
IV	.020	.995*	.963	1.645	.309	6393.75
	(.065)	(.012)				
France						
OLS	.019*	.994*	.999	.547	.006	376869.2
	(.005)	(.002)				
IV	.047	.984*	.981	1.887	.232	9738.12
	(.029)	(.010)				

Note: See the previous tables.

Table 7. Regression Estimates of eq. (17): $s_t = \Upsilon_0 + \Upsilon_1 s_{t-1} + \Upsilon_2 f_{t-1} + \varepsilon_{3t}$

	Υ_0	Υ_1	Υ_2	R^2	D-W	SSR	F
Canada							
OLS	.033	1.203*	-.211	.984	2.104	.043	7938.14
	(.035)	(.169)	(.168)				
IV	.034	.984*	.009	.984	2.092	.043	7776.10
	(.036)	(.230)	(.229)				
UK							
OLS	.105	.908*	.071	.966	1.772	.285	3610.91
	(.065)	(.197)	(.201)				
IV	.154*	1.128*	-.158	.966	1.759	.287	3445.01
	(.068)	(.234)	(.240)				
France							
OLS	.020	1.383*	-.391	.982	2.003	.222	5252.04
	(.029)	(.426)	(.424)				
IV	.022	1.285*	-.294	.982	1.991	.221	5092.93
	(.031)	(.598)	(.595)				

Note: See the previous tables.

Table 8. Regression Estimates of eq. (18): st = δ0 + δ1 ft-1 + δ2 [(i-i*)t – Et-1 (i-i*)t] + 4t

	δ_0	δ_1	δ_2	R^2	D-W	SSR	F
Canada							
OLS	.081*	.982*	-.003*	.983	2.084	.046	7398.90
	(.036)	(.008)	(.0006)				
IV	.073*	.984*	-.003*	.983	2.083	.046	7298.73
	(.036)	(.008)	(.0009)				
UK							
OLS	.029	.994*	-.002*	.964	1.679	.302	3400.47
	(.064)	(.012)	(.0009)				
IV	.007	.998*	.001	.962	1.595	.320	3071.89
	(.071)	(.014)	(.003)				
France							
OLS	.050*	.983*	-.004*	.982	1.960	.222	5250.80
	(.028)	(.010)	(.001)				
IV	.051*	.982*	-.004*	.982	1.951	.221	5091.80
	(.028)	(.010)	(.002)				

Note: See the previous tables.

5. Specifications and Diagnostic Tests of the Model

The final equations of the model (Equations (15) through (18)) are subjected to general specification and diagnostic tests so as to determine the statistical specifications' adequacy. We conduct a Wald test to test the hypothesis involving the restriction on the explanatory variables' coefficients and then add an extra variable to the existing equations and ask whether this makes a significant contribution. We next test the residuals of our equations, testing for serial correlation, autocorrelation and partial autocorrelation, autoregressive conditional heteroskedasticity (ARCH), and for white heteroskedasticity. Finally, we did some specification and stability tests, which were: a Ramsey test of specification error; Chow tests by splitting the data into three sets, namely from March 1973 through May 1979, June 1979 through February 1985, and March 1985 through June 1994; a Chow forecast test by estimating the equation with the observations up to March 1991 and predicting the values of the dependent variables in the remaining data points; and Cusum tests to examine the parameters' stability. The results appear below in Tables 9, 10, 11, and 12.

Table 9. Specification and diagnostic tests of Equation (15)

	Canada	UK	France
<u>Coefficient Tests</u>			
Wald Test	F=1.872	F=2.300	F=1.037
(a_0=0, a 1=1)	x^2=3.744	x^2=4.599	x^2=2.074
Add Variable	F=.550	F=3.454*	F=.169
(s_{t-2})	LR=.556	LR=3.472*	LR=.170
<u>Residuals Tests</u>			
Ser. Correlation (12)	F=2.019*	F=1.197	F=.801
$E(\varepsilon_t, \varepsilon_{t-1})=0$	nR^2 =23.296*	nR^2=14.338	nR^2 =9.784
Auto & Partial	B-P=19.82*	B-P=ll.96	B-P=8.94

Correlation $\varepsilon_t(12)$	L-B=20.67*	L-B=12.38	L-B=9.23
Normality of ε_t	S=-.776	S=-.087	S=-.321
	K=5.233	K=4.024	K=3.731
	J-B=78.916*	J-B=11.502*	J-B=10.098*
ARCH Test (12)	F=.925	F=l.ll7	F=.388
	nR^2=11.186	nR^2=13.383	nR^2=4.821
White	F=.040	F=2.329*	F=.953
Heteroskedasticity	nR^2=.081	nR^2=4.629*	nR^2=1.913
Specification & Stability Tests			
Ramsey Test (1)	_____	_____	F=.228
			LR=.230
Chow Test	F=.357	F=4.386*	F=5.829*
Break-Point	LR=l.459	LR=l7.363*	LR=22.828*
79.05, 85.02			
Chow Test	F=1.096	F=1.575*	F=1.327
Forecast	LR=47.721	LR=66.062*	LR=56.730*
91.03			
Cusum Tests	-some instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$	-instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$	-instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$

Note: See the previous tables.

Table 10. Specification and Diagnostic Tests of Equation (16)

	Canada	UK	France
Coefficient Tests			
Wald Test	F=4.319*	F=1.085	F=l.375
(β_0=0, β_1=1)	x^2=8.638*	x^2=2.171	x^2=2.751
Add Variable	F=.917	F=2.209	_____
(f_{t-2})	LR=.926	LR=2.225	
Residuals Tests			
Ser. Correlation (12)	F=2.290*	F=1.930*	F=1.667
$E(\varepsilon_t, \varepsilon_{t-1})=0$	nR^2 =26.107*	nR^2=22.358*	nR^2 =14.000
Auto & Partial	B-P=34.09*	B-P=21.31*	B-P=15.79
Correlation $\varepsilon_t(12)$	L-B=35.38*	L-B=21.95*	L-B=16.31
Normality of ε_t	S=-.460	S=-.236	S=-.289
	K=4.141	K=4.410	K=3.746
	J-B=22.915*	J-B=23.589*	J-B=7.306*
ARCH Test (12)	F=.893	F=1.287	F=.457
	nR^2=10.819	nR^2=15.292	nR^2=5.734
White	F=.269	F=.908	F=.785

Heteroskedasticity	nR^2=.544	nR^2=1.825	nR^2=1.582
Specification &			
Stability Tests			
Ramsey Test (1)	_____	_____	F=.050 LR=.050
Chow Test	F=.357	F=8.205*	LR=7.301*
Break-Point	LR=12.365*	LR=31.579*	F=28.030*
79.05, 85.02			
Chow Test	F=1.023	F=1.662*	F=3.417*
Forecast	LR=44.778	LR=69.250*	LR=10.246*
91.03			
Cusum Tests	- instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$	-instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$	-instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$

Note: See the previous tables.

Table 11. Specification and diagnostic tests of Equation (17)

	Canada	UK	France
Coefficient Tests			
Wald Test	F=2.526*	F=1.902	F=1.191
(γ_0=0, $\gamma_1+\gamma_2$=1)	x^2=5.051*	x^2=3.803	x^2=2.381
Add Variable	F=.788	F=3.383*	F=.002
(s_{t-2})	LR=.799	LR=3.413*	LR=.002
Residuals Tests			
Ser. Correlation (12)	F=2.148*	F=1.196	F=.806
$E(\varepsilon_t, \varepsilon_{t-1})=0$	nR^2 =24.732*	nR^2=14.391	nR^2 =9.944
Auto & Partial	B-P=20.89*	B-P=11.94	B-P=10.66
Correlation ε_t(12)	L-B=21.77*	L-B=12.36	L-B=11.07
Normality of ε_t	S=-.838 K=5.425 J-B=92.640*	S=-.102 K=4.067 J-B=12.602*	S=-.208 K=4.010 J-B=9.786*
ARCH Test (12)	F=.841 nR^2=10.208	F=1.108 nR^2=13.279	F=.409 nR^2=5.150
White	_____	_____	F=1.207
Heteroskedasticity			nR^2=4.831
Specification &			
Stability Tests			
Ramsey Test (1)	_____	_____	F=.235 LR=.238
Chow Test	F=.285	F=3.921*	F=3.411*
Break-Point	LR=l.765	LR=23.288*	LR=20.360*

79.05, 85.02			
Chow Test	F=1.096	F=1.585*	F=4.110*
Forecast	LR=47.915	LR=66.695*	LR=12.324*
91.03			
Cusum Tests	- instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$	-instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$	-instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$

Note: See the previous tables.

Table 12. Specification and diagnostic tests of Equation (18)

	Canada	UK	France
Coefficient Tests			
Wald Test	X^2=10.297*	X^2=2.733	X^2=3.219
($\delta0=\delta2$, $\delta1=1$)			
Add Variable	F=2.229	F=1.667	_____
(f_{t-2})	LR=2.254	LR= 1.688	
Residuals Tests			
Ser. Correlation (12)	F=1.541*	F=2.185*	F= 1.390
$E(\varepsilon_t, \varepsilon_{t-1})=0$	nR^2 =18.248*	nR^2=25.120*	nR^2 =16.542
Auto & Partial	B-P=16.01	B-P=26.02*	B-P=19.63*
Correlation ε_t(12)	L-B=16.74	L-B=26.92*	L-B=20.39*
Normality of ε_t	S=-.861	S=-.327	S=-.138
	K=5.270	K=4.775	K=4.067
	J-B=86.610*	J-B=38.137*	J-B=9.965*
ARCH Test (12)	F= 1.026	F= 1.528	F=.448
	nR^2=12.343	nR^2=17.947	nR^2=5.628
White	F= 1.415	F= 1.257	F=.889
Heteroskedasticity	nR^2=5.645	nR^2=5.027	nR^2=3.582
Specification &			
Stability Tests			
Ramsey Test (1)	_____	_____	_____
Chow Test	F=1.531	F=8.094*	F=4.907*
Break-Point	LR=9.348	LR=45.949*	LR=28.661*
79.05, 85.02			
Chow Test	F= 1.136	F=1.966*	F=3.844*
Forecast	LR=49.503	LR=80.457*	LR=11.549*
91.03			
Cusum Tests	- some instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$	-instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$	-instability in the parameters of the equation $\varepsilon_t \sim N(0,\sigma^2 I)$

Note: See the previous tables.

6. Summary and Concluding Remarks

In this efficiency specification model of spot and forward exchange markets, we argued that the forward rate fully reflects the limited available information about exchange rate expectations and the forward rate because of the lack of complete and correct global knowledge or 'wisdom.' Therefore, the forward rate is usually viewed by the market as an unbiased predictor of the future spot rate. The conventional test of the unbiasedness hypothesis that we used was a regression estimation by fitting the current spot on the one-period lagged spot rate, on the one-period lagged forward rate, on the one-period lagged spot and forward rate, and on the one-period lagged forward rate and the "news" (the difference between actual and expected interest differentials). These tests involve the joint hypothesis that the constant terms do not differ from zero, that the coefficients on the one-period lagged spot and forward rates do not significantly differ from one, that the sum of the coefficients of the one-period lagged spot and forward rates do not significantly differ from one, that the coefficient of the "news" is not different than zero, and that the error terms pass some statistical tests (serial correlation, normality, ARCH, etc.).

We cannot reject the unbiased hypothesis for Canada, but we can do so for the U.K. and France. The results imply that we can use the forward rate as a proxy for the prediction of the spot rate next period. There is some instability in the parameters of almost all the equations of the model, but, from a forecasting point of view, this is consistent with the least cost approach to the economic agents, although it may not yield the minimum forecast error due to interventions, incomplete and partial knowledge (incorrect information), and simplicity in modeling. The overall results show that Canada's, foreign exchange market is fairly efficient whereas the market efficiency of the United Kingdom and France is questionable. France's spot rate also follows a random walk but its variances are not constant.

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Notes

Note 1. By equilibrium, we mean an internal, external, and global balance that exists in markets and societies because we are collectively in balance and live in harmony with ourselves and others, for how could there otherwise be equilibrium? Regarding what we mean by full information, see footnote 2 below.

Note 2. This IIt represents all the information (Πληροφορίαι) that human beings must have in order to make decisions, signifying not merely partial, sectoral, and secular information about market conditions (mere knowledge or facts) but much broader, complete, complex, and correct global information about said markets (i.e., wisdom).

Note 3. Where $\Delta p_t^e = p^e_{t+1} - p_t = p_t^e$

Note 4. An asterisk refers to the foreign country, Δ means a change of the variable, superscript e denotes market expectations, and subscripts t, t+1, and t-1 denote current, future, and past periods, respectively.

Note 5. The well known random walk hypothesis, [$s_{t+1} - s_t = \varepsilon_{t+1}$, $E(\varepsilon_{t+1}) = 0$, $E(\varepsilon^2_{t+1}) = \sigma^2$], provides a good economic explanation for exchange rates' erratic movements. Specifically, exchange rates respond to surprises, news, and human actions because of ignorance of II_t (i.e., knowledge of I_t only). But these surprises are inherently unpredictable and, because exchange rates respond sensitively to such random and unexpected market events, these rates also move randomly. This is the very nature of market efficiency and has unfortunately become second nature to us as well. See Mussa (1979), Rogoff (1983), Huang (1984), and Chiang (1986).

Note 6. This risk premium exists because of the unexpected part of the exchange rate $U(s_{t+1})$, because $s_{t+1} = E(s_{t+1}) + U(s_{t+1})$ is that which we call innovations, surprises, or "news" and is the difference between the actual and expected values of some macro-variables, i.e., $RP_{t+1} = (i-i^*)_{t+1} - E(i-i^*)_{t+1}$. See Frenkel (1981).

Note 7. See Kallianiotis (1991) for a detailed discussion of these statistics and for other formal time series tests.