RETHINKING FORWARD AND SPOT EXCHANGE RATES IN INTERNATIONSAL TRADING

Guan Jun Wang, Savannah State University

ABSTRACT

This study uses alternative testing methods to re-examines the relation between the forward exchange rate and corresponding future spot rate from both perspectives of the same currency pair traders using both direct and indirect quotations in empirical study as opposed to the conventional logarithm regression method, from one side of traders' (often dollar sellers) perspective, using one way currency pair quotation (often direct quotation). Most of the empirical testing results in this paper indicate that the forward exchange rates are downward biased from the dollar sellers' perspective, and upward biased from the dollar buyers' perspective. The paper further contends that non-risk neutrality assumption may potentially explain the existence of the bias. **JEL Classifications:** F31, F37, C12

INTRODUCTION

Any international transaction involving foreign currency exchange is risky due to economic, technical and political factors which can result in volatile exchange rates thus hamper international trading. The forward exchange contract is an effective hedging tool to lower such risk because it can lock an exchange rate for a specific amount of currency for a future date transaction and thus enables traders to calculate the exact quantity and payment of the import and export prior to the transaction date without considering the future exchange rate fluctuation. However hedging in the forward exchange market is not without cost, and the real costs are the differential between the forward rate and the future spot rate if the future spot rate turns out to be favorable to one party, and otherwise, gain will result. Because of the distinguishing feature of the symmetricity in foreign exchange market, forward rates are expected to neutralize future exchange rate risk for both parties (sellers and buyers of the same currency), and to be fair "unbiased" estimators of corresponding future spot rates. If the forward rate was an unbiased predictor of the future spot rate, the real costs of hedging would be near zero in the long run. Yet, the cost of hedging were often found to differ significantly from zero by the international traders, and these results carry important implications for firms engaged in international trade concerning whether forward contract should be used. And the relation between the forward exchange rate and the corresponding future spot rate is also of equally great concern for academic scholars, portfolio managers, and policy makers. Fama (1984) indicates the forward exchange rate is the market determined certainty equivalent of the future spot exchange rate, and Chiang (1988) indicates that the forward rate is an unbiased predictor of the future spot rate since it fully reflects available information about exchange rate expectations. However, numerous empirical testing results fail to support the unbiasedness forward exchange rate Hypothesis.

Though it is well known that exchange rate between two currencies can be quoted in two ways: direct quotation which measures the value of per unit of US dollar in foreign currency and indirect quotation which measures the value of per unit of foreign currency in US dollar, and the exchange rate expressed in direct quotation is the reciprocal of the exchange rate expressed in indirect quotation, prior empirical research examines the relation between the forward and corresponding future spot exchange rate solely from dollar sellers' perspective from which direct quotations are used, or dollar buyers' perspective from which indirect quotations are used, but not the both, and risk neutrality assumption is imposed on either dollar sellers or dollar buyers. This paper uses alternative testing method to re-examines the relation between the forward exchange rate and corresponding future spot rate from both perspectives of the same currency pair traders using both direct and indirect quotations in empirical testing as opposed to the conventional one side of traders' (often dollar sellers) perspective using one way currency quotation.

The reminder of this paper is organized as follows: the next two sections discuss forward rate determination, spot rate and uncovered interest parity. The fourth Section provides a brief review of the literature on the testing methods for forward exchange rate unbiasedness hypothesis. Section 5 suggests alternative testing methods. Section 6 presents testing results from both conventional testing methods and alternative testing method suggested by this paper. Section 7 discusses forward rate unbiasedness hypothesis from both perspectives of same currency pair traders. Section 8 concludes.

FORWARD EXCHANGE RATE DETERMINATION

The determination of forward rate should depend upon the interest rates between the money markets of the two countries, base country where the base currency is used, and foreign country where the foreign currency is used. Since investors have the choice of earning an annual (continuous) domestic interest rate, r_D, on domestic deposits, or converting their domestic currency at the spot exchange rate, S_0, earning an annual (continuous) foreign interest rate, r_F, on foreign deposits, and then exchanging the foreign currency for domestic currency at the negotiated forward exchange rate, $F_{0,t}$, the returns on the two alternatives should be the same to eliminate the arbitrage opportunities. Therefore, an investor starting with one unit of domestic currency can either accumulate $e^{r_D t}$ units domestic currency at time t, or he or she can exchange one unit of domestic currency now at the spot exchange rate for S_0

units of foreign currency, then depositing in a foreign bank to accumulate $S_0 e^{r_F t}$ units of foreign currency at time t, and then reconverting into domestic currency at the negotiated forward exchange rate $F_{0,t}$, and the following condition must be met:

$$e^{r_D t} = S_0 e^{r_F t} / F_{0,t} \tag{1}$$

If the above condition did not hold, profitable market arbitrage opportunities could be exploited without incurring any risks. Thus forward rate should be determined as

$$F_{0,t} = S_0 e^{(r_F - r_D)t} \tag{2}$$

SPOT EXCHANGE RATE AND UNCOVERED INTEREST PARITY

By an agreement made in 1944 at the Bretton Woods conference, exchange rates between the major currencies were fixed. Since 1970, the central banks have allowed market forces to determine exchange rates. An investor with one unit of domestic currency have the opportunity to leave his/her foreign currency positions uncovered by converting one unit of domestic currency now at the spot rate into S_0 investing in foreign assets to accumulate $S_0 e^{r_F t}$ units of foreign currency at time t, and then reconverting into domestic currency at spot exchange rate S_t. Since the value of S_t is unknown at present and so the attractiveness of holding an uncovered position must be assessed in terms of the probabilities of different outcomes for S_t. The assumption of uncovered interest parity postulates that markets will equilibrate the return on the domestic currency asset with the expected value of spot rate at time t, ES_t, of the yield on an uncovered position in foreign currency, that is,

$$e^{r_D t} = S_0 e^{r_F t} / ES_t \tag{3}$$

This is equivalent to

$$ES_t = S_0 e^{(r_F - r_D)t} \tag{4}$$

Combing (2) and (4) results in

$$F_{0,t} = ES_t \tag{5}$$

One should note that the expected value of domestic currency of uncovered position, $E\dfrac{S_0 e^{r_F t}}{S_t}$, is greater than $e^{r_D t}$, that is,

$$E\frac{F_{0,t}}{S_t} > 1 \quad (6)$$

because risk incurred in uncovered position.
(6) can be generalized to

$$E\frac{F_{t,t+T}}{S_{t+T}} > 1 \quad (7)$$

for any t and T.

The Uncovered Interest Parity suggests that forward exchange rate should be an unbiased estimator of corresponding spot exchange rate. Why do numerous empirical results fail to support unbiased forward exchange rate hypothesis? To answer this question, the first approach of this manuscript is to examine both the conventional testing methods and the assumptions from which the forward unbiasedness hypothesis is derived.

CONVENTIONAL TESTING METHODS

There exists a large body of literature on whether the forward exchange rate is an unbiased predictor of corresponding future spot exchange rate from foreign currency investors (sellers of dollar)' point of view under risk neutrality assumption. The earliest studies (Bradford 1977, Frenkel, 1980, Levich, 1979) often tested the forward unbiasedness hypothesis of (5) by regressing the log of the spot rate at time period n on the one-period lagged log of the forward rate. That is

$$s_n = \alpha + \beta f_{n-1} + \varepsilon_n \quad (8)$$

where $s_n = \log S_{nT}$, $f_{n-1} = \log F_{(n-1)T,nT}$, and T is time interval. This is equivalent to

$$s_{n+1} = \alpha + \beta f_n + \varepsilon_{n+1} \quad (9)$$

The joint hypothesis that the constant term does not differ from zero, the coefficient on the one-period lagged forward rate does not significantly differ from one, and that the error term is free of serial correlation, that is, $\alpha=0$, $\beta=1$, and ε_n white noises, is formulated.

Regression equation (9) has been referred to as the level specification. The results of these studies generally support the forward rate unbiasedness hypothesis in the sense that the regression typically yields a coefficient close to unity.

Due to the non-stationary properties of the log spot and the log forward rates, tests based on a level regression of the log future spot rate on the log forward rate resulted in spurious regression problems. This led later researchers (John 1981, Fama 1984, Frenkel and Froot 1989, Sarno et al 2012) to adopt a "difference" version of the log level regression in which the log current spot rate is subtracted from the one period future log spot and the log forward rate. Thus the regression of the change in the log of the spot exchange rate on the forward discount (expressed in log form) is considered:

$$s_{n+1} - s_n = \alpha + \beta(f_n - s_n) + \varepsilon_{n+1} \quad (10)$$

The test given by either (9) or (10) is equivalent to assuming $Es_{n+1} = f_n$, that is

$$E \log S_{(n+1)T} = \log F_{nT,(n+1)T} \quad (11)$$

Regression based tests of forward unbiasedness hypothesis using equation (10) have performed very poorly ----- the regressions have almost universally shown a negative coefficient which is usually statistically significant, rather than a value of unity. The empirical failure of the forward unbiasedness hypothesis has been a puzzle to economists working in international finance ever since the work of Fama (1984).

As discussed in Section 2, under uncovered interest parity assumption, equation (5) can be derived and generalized to

$$ES_{(n+1)T} = F_{nT,(n+1)T} \quad (12)$$

However, conventional tests are based on equation (11) which differs from equation (12).

ALTERNATIVE TESTING METHODS

As mentioned earlier, forward exchange rate unbiasedness hypothesis should be stated that

$$ES_{t+T} = F_{t,t+T} \quad (13)$$

where S_{t+T} is the spot rate at time $t+T$ and $F_{t,t+T}$ is the lagged T forward rate at time t. The simplest approach to evaluate the validation of $ES_{t+T} = F_{t,t+T}$ is to regress the spot rate at time t+T on the T time lagged forward rate at time t. That is

$$S_{t+T} = \alpha + \beta F_{t,t+T} + \varepsilon_n \quad (14)$$

The joint hypothesis can be formulated as follows: the constant term does not differ from zero, the coefficient on the lgged forward rate does not significantly differ from one, and that the error term is free of serial correlation, that is, $\alpha=0$, $\beta=1$, and ε_n white noises.

However, the variables in the level form (the future spot and current forward exchange rates) are non-stationary I(1), as can be seen in Table 1 which provides descriptive statistics for the spot exchange rate for two currencies, Canadian Dollar and New Zealand Dollar. Obviously the normality assumption for the spot rate is violated, thus, tests based on a regression of the future spot rate on the forward rate can result in spurious regression problems or so-called unit root problem.

To overcome the spurious regression problems, this paper also adopts a “difference” version in which the current spot rate is subtracted from the one period future spot and the forward rate.

$$S_{n+1} - S_n = \alpha + \beta(F_n - S_n) + \varepsilon_{n+1} \quad (15)$$

The test given by (15) is equivalent to assuming $ES_{t+T} = F_{t,t+T}$.
Another 0alternative is to test

$$\frac{S_{t+T}}{F_{t,t+T}} - 1 = \alpha + \varepsilon_t \tag{16}$$

for the null hypothesis $H_0 : \alpha = 0$.

Table 2 provides descriptive statistics for the "difference" of spot exchange rate for two currencies, Canadian Dollar and New Zealand Dollar. The results shown in Table 1 and Table 2 indicate that the "difference" of spot exchange rate is better conformable with normality assumption, which also conformed in Figure 1 showing the histogram of the level spot rate and the "difference" of the spot rate.

EMPIRICAL TESTING RESULTS

The four exchange markets, Canadian dollar, New Zealand dollar, Austria dollar and Euro dollar, are examined in this paper. The data employed is daily data of one month, three months, six months and twelve months forward and spot exchange rates quoted in foreign currency units per U.S. dollar (direct quotation) which spanned from February 1995 to August 2010 with nearly 4000 observations. All data were obtained from Bloomberg.

The regression results of equation (15) were reported in Table 3. As can be seen in Table 3, null hypothesis $H_0 : \alpha = 0$ and $\beta = 1$ of regression (15) is rejected in all cases.

To reinforce these results, the estimation results of the alternative regression equation: $\frac{S_{t+T}}{F_{t,t+T}} - 1 = \alpha + \varepsilon_t$, for the null hypothesis $H_0 : \alpha = 0$, is also reported in Table 6

For comparison purposes, Tables 4 and 5 report regressions of equation (9) and (10). As can be seen in Tables 4 and 5, the tests of the conventional regression equations are consistent with those of previous studies, such as Boothe and Longworth (1986), Cumby and Obstfeld (1984), Fama (1984) Maynard and Phillips (2001), Froot and Thaler (1990) in showing that relation (8) is decisively rejected for all cases.

RISK NEUTRALITY ASSUMPTION

Many financial models, such as option pricing models, are derived under the risk neutrality assumption which is quite reasonable. Does the same assumption hold in foreign exchange markets? Different from other markets, in foreign exchange markets, both sellers of dollar (foreign currency investors) and buyers of dollar (dollar investors) are equally involved and the symmetries of the foreign exchange market are the key feature that distinguishes this market from all others. The analysis conducted in Section 2 is purely from the perspective of sellers of dollar (foreign currency investors). What would be the results if the point of view of the dollar buyers had been taken? To answer this question, the same analysis needs to be conducted from the perspective of dollar buyers.

Assume one unit of country A (domestic country from country A investors' perspective) currency can be exchanged for S_t units of country B (foreign country from country A investors' perspective) currency at time t, then one unit country B (domestic country from country B investors' perspective) currency can be exchanged for $\frac{1}{S_t}$ Country A (foreign country from country A investors' perspective) currency. Assume T time forward rate at time t from country A investors' perspective is $F_{t,t+T}$ which means forward contract insures one unit country A currency to be exchanged to $F_{t,t+T}$ units of country B currency, or one unit of country B currency to be exchanged to $\frac{1}{F_{t,t+T}}$ units of country A currency. As argued earlier, to eliminate arbitrage opportunity from both investors' perspectives, $F_{t,t+T}$ must satisfy the following equation

$$F_{t,t+T} = S_t e^{(r_F - r_D)T} \tag{17}$$

where r_D is country A's annualized interest rate, and country B's annualized interest rate.

Denote $\overline{S_t} = \frac{1}{S_t}$ which is the exchange spot rate expressed as per unit of foreign currency. Thus under Uncovered Interest Parity assumption,

$$\overline{F_{0,t}} = E\overline{S_t} \tag{18}$$

Can be obtained, where $\overline{F_{0,t}} = \frac{1}{F_{0,t}}$ which is the forward rate expressed as per unit of foreign currency. Therefore

$$\frac{1}{F_{0,t}} = E\frac{1}{S_t} \tag{19}$$

can be obtained. It thus has been shown, under risk neutrality assumption for both sellers of dollar (foreign currency investors) and buyers of dollar (dollar investors), that $F_{0,t} = ES_t$ and $\frac{1}{F_{0,t}} = E\frac{1}{S_t}$ hold simultaneously, which violate Jensen's Inequality which states that the expected value of a strictly concave function ($f(x) = \frac{1}{x}$) of a random variable is strictly less than same convave function of expected value of the random variable. Thus one can conclude in foreign exchange markets, the risk-neutral probability measure for both sellers of dollar (foreign currency investors) and buyers of dollar (dollar investors) is not (necessarily) an accurate model for the price processes of traded assets like currencies, rather, it is imposed by the market.

If risk aversion assumption is imposed on both investors, because of risk premium,

$$F_{0,t} < ES_t \tag{20}$$

and

$$\frac{1}{F_{0,t}} < E\frac{1}{S_t} \tag{21}$$

should hold. (20) and (21) can be generated to

$$F_{t,t+T} < ES_{t+T} \tag{22}$$

and

$$\frac{1}{F_{t,t+T}} < E\frac{1}{S_{t+T}} \tag{23}$$

which result in

$$ES_{t+T} > F_{t,t+T} > \frac{1}{E\frac{1}{S_{t+T}}} \tag{24}$$

For any t and T. Thus with the absence of risk neutrality assumption for some participants in foreign exchange market, forward exchange rate should not be expected to be an unbiased estimator of corresponding spot rate. Because of risk premium, the expected future corresponding spot rate should be higher than the forward rate as shown in (20) and (21).

Testing (22) and (23) is equivalent to testing

$$\mu = E\frac{S_{t+T}}{F_{t,t+T}} > 1 \tag{25}$$

and

$$\overline{\mu} = E\frac{\frac{1}{S_{t+T}}}{\frac{1}{F_{t,t+T}}} = E\frac{F_{t,t+T}}{S_{t+T}} > 1 \tag{26}$$

The same four exchange markets which are Canadian Dollar, New Zealand Dollar, Austria Dollar and Euro Dollar are again used for the empirical testing. The dataset consists of spot exchange rate data and one month, three months, six months and twelve months forward exchange rate data covering the period January 1995 to 2010. The following regression test is performed for (25)

$$\frac{S_{t+T}}{F_{t,t+T}} - 1 = \alpha + \varepsilon_t \tag{27}$$

=

$H_0 : \alpha <= 1$ vs. $H_1 : \alpha > 1$

and

$$\frac{F_{t,t+T}}{S_{t+T}} - 1 = \beta + \xi_t \tag{28}$$

For (26) under $H_0 : \alpha >= 1$ vs. $H_1 : \beta < 1$

The regression results are reported in Tables 6 & 7. As can be seen in Tables 6 & 7, the empirical tests produce mixed results: Table 6 shows the results from sellers of dollar's perspective, in which case the exchange rates are expressed as per unit of US dollar, except for Canadian dollar for US dollar (Canadian dollar/US dollar) forward rates and 6-month and 12-month Euro dollar for US dollar (Euro dollar/US dollar) forward rates, forward exchange rates (expressed as per unit of US dollar F_{t+T}) are downward biased estimators of corresponding future spot rates; Canadian dollar/US dollar forward exchange rates are upward biased estimators of corresponding spot rates, and the hypothesis that 1-month and 3-month Euro dollar/US dollar forward rates are unbiased estimators of corresponding future spot rates cannot be rejected.

Table 7 shows the results from the buyers of US dollar's perspective, in which case the exchange rates are expressed as per unit of foreign currency. Except for US dollar for Canadian dollar (US dollar/Canadian dollar) forward rates and US Dollar for Euro dollar (US dollar/Euro dollar) forward rates, forward exchange rates (expressed as per unit of foreign currency $\frac{1}{F_{t+T}}$) are upward biased estimators of corresponding future spot rates; US dollar/Canadian dollar forward exchange rates are downward biased estimators of corresponding spot rates; 3-month US dollar/Euro dollar forward rates are downward biased estimators of corresponding future spot rates and 12-month US dollar/Euro dollar forward rates are upward biased estimators of corresponding future spot rates and we cannot reject that 1-month and 6-month dollar/Euro dollar forward rates are unbiased estimators of corresponding future spot rates hypothesis.

CONCLUSION

This study re-examines the relation between forward and spot exchange rates in international trading. It first shows analytically the forward rate determination and the rationale of the forward exchange rate unbiasedness hypothesis under risk neutral assumption solely from Dollar sellers (foreign currency investors)' perspective. This study uncovers the flaws in conventional formulation of the forward rate unbiasedness hypothesis and its testing methods and proposes two alternative testing methods accounting for non-stationarity, non-normality, and heteroscedasticity for forward exchange rate unbiasedness hypothesis. By using Jensen's inequality, the paper demonstrates that forward exchange rate unbiasedness hypothesis cannot hold simultaneously for both dollar sellers and buyers, and points out the risk-neutral probability measure is not (necessarily) an accurate model for the price processes of traded assets like currencies and forward exchange rate should not be expected to be an unbiased predictor of corresponding future spot rate.

This study uses a long sample period that covers a wide range of major currencies with forward rates over various forecast horizons (one, three, six and twelve months) for the empirical testing to avoid sample specific problems. The testing results show that the forward exchange rate is biased from both dollar sellers and buyers' perspectives which support the theoretical argument that forward exchange rate should not be expected to be an unbiased predictor of corresponding future spot rate because of the unique feature in foreign exchange market: both dollar sellers and buyers are equally involved and risk neutrality assumption does not hold. Most of the testing results indicate the forward exchange rate is downward biased from the foreign currency investors (sellers of dollar)'s perspective, and it is upwards biased from the dollar investors (buyers of dollar)'s perspective. The paper further contends that non-risk neutrality assumption may potentially explain the existence of the bias.

REFERENCES

Aggarwarl, R. Lucey, B. and Mohanty S. (2009) 'The Forward Exchange Rate Bias Puzzle Is Persistent: Evidence from Stochastic and Nonparametric Cointegration Tests.' *Financial Review*, Vol 44, No. 4, pp. 625-645.

Boothe, P. and Longworth, D. (1986) 'Foreign Exchange Market Efficiency Tests:Implications of Recent Empirical Findings' *Journal of International Money and Finance*,Vol 5, pp.135-152.

Chakraborty, A, and Evans, G. W.(2008) 'Can Perpetual Learning Explain the Forward-Premium Puzzle?' *Journal of Monetary Economics*, Vol. 55, No.3, pp. 477-490.

Chakraborty, A. and Stephen, E. H.(2008) 'Econometrics of the Forward Premium Puzzle' Economics Bulletin, Vol. 6, No. 4, pp. 1-17. Chiang, T.C. (1988) 'The Forward Rate as a Predictor of the Future Spot Rate - a Stochastic Coefficient Approach' *Journal of Money, Credit and Banking*, Vol.20, No. 2, pp.212-232.

Cornell, B.(1977) 'Spot Rates, Forward Rates and Exchange Market Efficiency' *Journal of Financial Economics*, Vol.5, No.1, pp. 55-65.

Fama, E., F. (1984) 'Forward and Spot Exchange Rates' *Journal of Monetary Economics*, Vol.14, No. 3, pp. 319-338.

Frenkel, J., A. (1980) 'Exchange Rates, Prices and Money: Lessons from the 1920's' *American Economic Review*, Vol.70, No.2, pp. 235-242.

Goodhart, C. A., McMahon, P. C., and Ngama, Y. L. (1992) 'Does the Forward Premium/Discount Help to Predict the Future Change in the Exchange Rate?' *Scottish Journal of Political Economy*, Vol. 39, No. 2, pp. 129-140.

Han B. and Wang T. Y. (2011) 'Investor Overconfidence and the Forward Premium Puzzle' *Review of Economic Studies*, Vol 78, pp. 523–558

Hodrick L.P. (1987) "The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets' In *Fundamentals of Pure and Applied Economics*,Chur Switzerland: Harwood Academic.

Longworth D. (1981) 'Testing the Efficiency of the Canadian-US Exchange Market Under the Assumption of No Risk Premium' *Journal of Finance*, Vol 36, pp.43-49

Fama, E. F. (1984) 'Forward and spot exchange rates' *Journal of Monetary Economics*, Vol.14, 319-338.

Froot K.A. and Thaler R.H.(1990) 'Foreign Exchange' *Journal of Economic Perspectives*,vol 4. pp.179-192.

Engel C. (1996) 'The Forward Discount Anomaly and the Risk Premium: A Survey of Recent Evidence' *Journal of Empirical Finance*, Vol 3, pp.123-192.

Baillie R.T. and Bollerslev, T. (2000) 'The Forward Premium Anomaly is not as Bad as You Think' *Journal of International Money and Finance*, Vol 19, pp.471-188.

Maynard, A. and Phillips P.C.B. (2001) 'Rethinking an Old Empirical Puzzle: Econometric Evidence on the Forward Discount Anomaly' *Journal of Applied Econometrics*, Vol 16, pp.671-708

Sarno L. and Taylor M.P. (2002) 'The Economics of Exchange Rates' Cambridge

University Press, Cambridge.
Sarno, L., Valente, G. and Leon, H. (2006) 'Nonlinearity in Deviations from Uncovered Interest Parity: An Explanation of the Forward Bias Puzzle' *Review of Finance*, Vol. 10, No.3, pp. 443-482.
Sarno, L., Schneider, P., and Wagner, C. (2012) 'roperties of Foreign Exchange Risk Premiums' *Journal of Financial Economics*, forthcoming
Sercu, P. and Vinaimont, T. (2006) 'The Forward Bias in the ECU: Peso Risks vs. Fads and Fashions' *Journal of Banking and Finance*, Vol. 30, No.8, pp. 2409-2432.

TABLE 1: DESCRIPTIVE STATISTICS

	Canadian Dollar	New Zealand Dollar
Mean	0.609590772	1.32094704
Standard Error	0.001721726	0.002821328
Median	0.637	1.361
Mode	0.691	1.3685
Standard Deviation	0.106788685	0.180013096
Sample Variance	0.011403823	0.032404715
Kurtosis	-0.998415642	-1.114294837
Skewness	-0.356440304	-0.315164131
Range	0.4262	0.6985
Minimum	0.3922	0.9202
Maximum	0.8184	1.6187
Sum	2345.0957	5377.5754
Count	3847	4071
Confidence Level(95.0%)	0.003375584	0.005531346

TABLE 2: DESCRIPTIVE STATISTICS

(Difference between One Period Future Spot Rate and Current Spot Rate)

	Canadian Dollar	New Zealand Dollar
Mean	-3.81141E-05	2.18205E-05
Standard Error	3.69252E-05	8.24575E-05
Median	0	0.0002
Mode	0	0
Standard Deviation	0.002299462	0.005113027
Sample Variance	5.28752E-06	2.6143E-05
Kurtosis	4.625935181	3.184978917
Skewness	0.095204908	-0.286806157
Range	0.031730246	0.0626
Minimum	-0.017363654	-0.0381
Maximum	0.014366592	0.0245
Sum	-0.147806632	0.0839
Count	3878	3845

FIGURE 1: CANADIAN DOLLAR

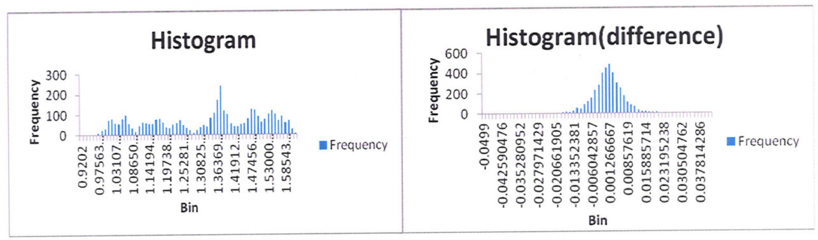

FIGURE 2: NEW ZEALAND DOLLAR

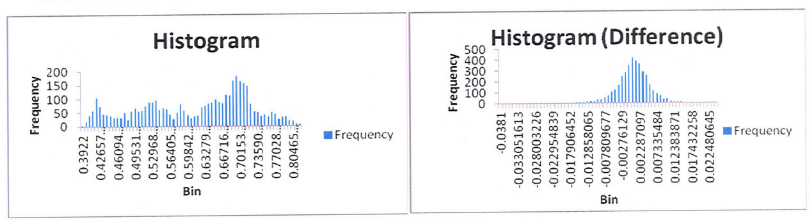

TABLE 3: REGRESSION RESULTS BASED ON $S_{n+1} - S_n = \alpha + \beta(F_n - S_n) + \varepsilon_{n+1}$

Currency		α	**B**	**Adjusted** R^2
Canadian Dollar	1 month	-0.00010165	0.0047622	0.0001593
		(0.338508)	(0.003726)	
	3 months	-0.0003583	0.0013685	-0.0002369
		(0.2051198)	(0.005588)	
	6 months	-0.00035327	0.0002379	-0.000255556
		(0.221376)	(0.0037164)	
	12 months	-0.00035703	0.0023067	-0.000261147
		(0.22096242)	(0.0445624)	
New Zealand Dollar	1 month	2.56E-05	0.0019838	-0.000187
		(0.75667)	(0.003742)	
	3 months	-0.00014727	0.0024164	-0.000192552
		(0.461775)	(0.005016)	
	6 months	4.56E-06	-0.0018752	0.0001352
		(0.9551812)	(0.001513)	
	12 months	2.13E-05	-4.89E-05	-0.00026161
		(0.8007755)	(0.000895)	
Australia Dollar	1 month	3.9543E-05	0.001003701	-0.00023004
		(0.6704102)	(0.00362086)	
	3 months	4.2261E-05	-0.0007135	-0.0002159
		(0.6499182)	(0.00194136)	
	6 months	3.78484E-05	-0.00152174	9.69657E-05
		(0.688464)	(0.00129369)	
	12 months	4.26849E-05	0.000256319	-0.00024275
		(0.665055)	(0.00095076)	
Euro Dollar	1 month	4.1252E-05	-0.0052697	0.0002755
		(0.775122)	(0.0038987)	
	3 months	6.68274E-05	-0.00203438	-0.000166927
		(0.644993)	(0.00286805)	
	6 months	7.37718E-05	0.001330581	-0.000101564
		(0.617058)	(0.00158517)	
	12 months	9.81E-05	0.00044	-0.00031
		(0.523)	(0.00116)	

Hypothesis: α=0 and β=1

Note the numbers in parentheses for α are p-values and for β standard errors

TABLE 4: REGRESSION RESULTS BASED ON $s_{n+1} = \alpha + \beta f_n + \varepsilon_{n+1}$

Currency		α	B	Adjusted R^2
Canadian Dollar	1 month	0.000325	0.991598	0.972186
		(0.354246)	(0.0005)	
	3 months	0.001089	0.974753	0.917805
		(0.07643)	(0.0000)	
	6 months	0.003626111	0.937385212	0.812092717
		(0.0000)	(0.0000)	
	12 months	0.007913	0.875281	0.654166
		(0.0000)	(0.0000)	
New Zealand Dollar	1 month	-0.00231	0.984114	0.959084
		(0.003)	(0.000)	
	3 months	0.007944058	0.948339091	0.872125777
		(0.000)	(0.000)	
	6 months	0.014675795	0.909222791	0.778080618
		(0.000)	(0.000)	
	12 months	0.06523979	0.66750579	0.39633313
		(0.000)	(0.000)	

Hypothesis: α=0 and β=1
Note p-values for all of the tables are in parentheses

TABLE 5: REGRESSION RESULTS BASED ON $s_{n+1} - s_n = \alpha + \beta(f_n - s_n) + \varepsilon_{n+1}$

Currency		α	B	Adjusted R^2
Canadian Dollar	1 month	-3.42E-05	0.004487	0.000115664
		(0.358865)	(0.000)	
	3 months	1.44E-05	-0.0002009	-0.000145243
		(0.859795)	(0.000)	
	6 months	-3.15E-05	0.0009185	-0.00014869
		(0.412566)	(0.000)	
	12 months	-3.96E-05	0.0005796	-0.0001774
		(0.312344)	(0.000)	
New Zealand Dollar	1 month	1.52E-05	0.0005202	-0.000255103
		(0.257)	(0.000)	
	3 months	-0.00014323	0.0008425	-6.20E-07
		(0.476)	(0.000)	
	6 months	-5.43E-06	-0.0018806	0.0001602
		(0.923)	(0.000)	
	12 months	-7.70E-05	0.0019847	7.78E-05
		(0.525)	(0.000)	

Hypothesis: α=0 and β=1
Note p-values for all of the tables are in parentheses

TABLE 6: ESTIMATED EQUATION $\frac{S_{t+T}}{F_{t,t+T}} - 1 = \alpha + \varepsilon_t$

Currency Pair	Forward Length T	α	Adjusted R^2	α=0	α>0	α<0
Canadian Dollar /US Dollar	1 month	-0.0012 (0.001)	0.000	reject	reject	accept
	3 months	-0.0035 (0.000)	0.000	reject	reject	accept
	6 months	-0.0069 (0.000)	0.000	reject	reject	accept
	12 months	-0.0131 (0.000)	0.000	reject	reject	accept
New Zealand Dollar /US Dollar	1 month	0.0036 (0.000)	0.000	reject	accept	reject
	3 months	0.0107 (0.000)	0.000	reject	accept	reject
	6 months	0.018 (0.000)	0.000	reject	accept	reject
	12 months	0.0438 (0.000)	0.000	reject	accept	reject
Austria Dollar /US Dollar	1 month	0.0031 (0.000)	0.000	reject	accept	reject
	3 months	0.0089 (0.000)	0.000	reject	accept	reject
	6 months	0.0189 (0.000)	0.000	reject	accept	reject
	12 months	0.0388 (0.000)	0.000	reject	accept	reject
Euro Dollar /US Dollar	1 month	0.0009 (0.132)	0.000	accept		
	3 months	0.0002 (0.804)	0.000	accept		
	6 months	0.0069 (0.000)	0.000	reject	accept	reject
	12 months	0.0252 (0.000)	0.000	reject	accept	reject

Exchange rates are expressed as per unit of US dollar F_{t+T}

Note p-values for all of the tables are in parentheses

TABLE 7: ESTIMATED EQUATION $\frac{F_{t,t+T}}{S_{t+T}} - 1 = \beta + \xi_t$

Currency Pair	Forward Length T	β	Adjusted R^2	β=0	β>0	β<0
US Dollar /Canadian Dollar	1 month	0.0018 (0.000)	0.000	reject	accept	reject
	3 months	0.0052 (0.000)	0.000	reject	accept	reject
	6 months	0.0109 (0.000)	0.000	reject	accept	reject
	12 months	0.021 (0.000)	0.000	reject	accept	reject
US Dollar /New Zealand Dollar	1 month	-0.0021 (0.000)	0.000	reject	reject	accept
	3 months	-0.0062 (0.000)	0.000	reject	reject	accept
	6 months	-0.0099 (0.000)	0.000	reject	reject	accept
	12 months	-0.018 (0.000)	0.000	reject	reject	accept
US Dollar /Austria Dollar	1 month	-0.0018 (0.002)	0.000	reject	reject	accept
	3 months	-0.0045 (0.000)	0.000	reject	reject	accept
	6 months	-0.0088 (0.000)	0.000	reject	reject	accept
	12 months	-0.0174 (0.000)	0.000	reject	reject	accept
US Dollar /Euro Dollar	1 month	0.0001 (0.833)	0.000	accept		
	3 months	0.0017 (0.033)	0.000	reject	accept	reject
	6 months	-0.001 (0.494)	0.000	accept		
	12 months	-0.0118 (0.000)	0.000	reject	reject	accept

Exchange rate expressed as per unit of foreign dollar $\frac{1}{F_{t+T}}$

Note p-values for all of the tables are in parentheses