Forward rate unbiased hypothesis, risk premium and exchange rate expectations: estimates on Pakistan Rupee-US Dollar

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Abstract

In this paper, forward market unbiasedness hypothesis (FRUH) is tested and its underline assumptions of rationally formed expectations and non existence of time varying risk premium is examined empirically in case of Rupee/US$. Taking in to account the non-stationarity of the spot and forward rates series, we tested this hypothesis by two approaches. First approach relates the changes in spot rates to the forward premium. The results overwhelmingly reject the hypothesis of forward rate unbiasedness hypothesis. In fact, the estimate is significantly negative and away from 1. This confirms the existence of forward discount anomaly or forward discount puzzle for 1-month forward market. Following the recent literature, we also tested forward rate unbiasedness hypothesis using the tests of cointegration. The result suggests the presence of the cointegration relation between spot and forward rates. However, it fails the restriction that this relation is (1,-1). This therefore implies that cointegration test too fail to accept the forward rate unbiasedness hypothesis. We also found that forward rate unbiased hypothesis fails due to fact that market's expectation regarding exchange rate movements were not rational and also due to presence of time varying risk premium.

1.1: Introduction

The assumption that forward exchange rate is an unbiased predictor of future spot rate is widely used in both theoretical and empirical studies. Useful surveys of the literature include Froot and Thaler (1990) and Engel (1996). More recent contributions to the literature include Bacchetta and van Wincoop (2005), Frankel and Poonawala (2006).

The primary objective of this paper is to examine the forward rate unbiasedness hypothesis (FRUH) in Rupee-US$ market. We also examined its underlying assumptions that the agents form expectations regarding exchange rate changes rationally and that there does not exist any risk premium in the forward premium. Several reasons motivated this research. One is that there is no such study available using Pakistan data that have tested this hypothesis and its underlying assumptions. These assumptions of FRUH have implications for the conduct of monetary policy in Pakistan, which experienced large foreign exchange inflows from 2001 to 2007 and likely to experience significant foreign inflows in coming years too. For instance presence of risk premium has implications for the success of sterilized interventions by the central bank in the foreign exchange market. This view relates to the portfolio balance theory channel for the effectiveness of sterilized foreign exchange intervention. If domestic and foreign assets are re-garded by agents as perfect substitutes, sterilized intervention may have no significant result on the exchange rate. This is because people will be uninterested regarding the relative amounts of domestic and foreign assets, they are holding. They would only care about the total amount and therefore no change in the relative quantities of domestic and foreign assets in their portfolios. Consequently, there will be no change in market clearing prices. And for domestic and foreign assets to be imperfect substitutes; there must be some kind of risk premium. That means if central bank is pursuing a policy of complete sterilization of its intervention and if sterilized intervention do influence the exchange rate, then it could be considered as a second policy instrument along with the domestic credit policy, through which monetary authority can simultaneously achieve its internal and external targets in short run. We also explored the factors that determine the changes in exchange rate and the risk premium in the market and draw policy implications. For instance we empirically explored the assertion that monetary policy defense of the exchange rate is credible in Pakistan.

In first part of empirical investigation, we tested the forward rate unbiased hypothesis (FRUH) exploiting the perceived long run relation between s_t and f_t using Engle-Granger and Johenson multivariate cointegration techniques. In this context, this paper investigated whether the forward rate unbiased hypothesis (FRUH) is maintained in the context of Rupee-US$ exchange rate, using monthly data on spot and 1-month forward exchange rates from January 2002 to May 2007. We found out that FRUH is not accepted for Rupee-US$ market. This result is consistent with the results available in the literature [Froot and Thaler (1990) and Engel (1996)]. We discussed the policy implication in later part of the chapter.

As literature suggests FRUH could be rejected either due to the reason that expectations of agents regarding the exchange rate changes are not rational and/or due to the presence of risk premium in the forward premium. Therefore, we further tested two hypotheses. One is that in foreign exchange market, agents form expectations rationally; acceptance of which would have implied that market is efficient. Other is that there exists no risk premium in the forward premium. If accepted that would have implied that agents in the market are risk neutral. To test these assumptions, we used the empirical methodology developed by Liederman (1980) and Londan and Smith (2003). We first build an exchange rate determination model and explored the relevant factors that influence the exchange rate. To test the rational expectations and nonexistence of risk premium assumptions, we estimated the forward premium equation using exchange rate changes, and factors that determine the risk premium. Later by imposing cross equation restrictions, we tested both the underlying assumption—rationally formed exchange rate expectations and non-existence of risk premium. The results and policy implications are discussed in the later part 2.3 of this chapter.

The rest of the chapter is organized as following. Next section discusses the theoretical background literature review regarding FRUH. Section 2.2.1 focuses on the data issues and empirical results on the FRUH. Section 2.3 and its subsections focus on the testing the underlying assumptions of rationally formed expectations regarding exchange rate changes and the absence of risk premium in forward premium. Section 2.4 concludes the chapter.

1.2: Theoretical Background and Literature Review on FRUH

There is ample of literature on the analysis whether the forward exchange rate is an unbiased predictor of future spot exchange rate. To investigate this, forward rate unbiased condition (FRUC) is the starting point. Two interest rate parity conditions provide the back ground. First, the interest rate parity condition which set up the linkages across the spot and forward currency markets simultaneously with the domestic and foreign security markets.

$$\frac{f_{t,1}-s_t}{s_t} = \frac{i-i_*}{1+i_*} \tag{1}$$

Where s_t is the spot exchange rate at period t while $f_{t,1}$ is the one period forward exchange rate. This condition states that percentage of one period forward premium is equal to percentage of interest rate differential between two countries for the same time period. Second condition is the uncovered interest rate parity[1].

$$\frac{E(s_{t+1})-s_t}{s_t} = \frac{i-i_*}{1+i_*} \qquad (2)$$

Equation (2) looks much like the equation (1) barring one significant difference. In equation (1) all four variables can be observed at the time of contract while in equation (2) only three variables can be observed at the time of contract. The fourth variable $E(s_{t+1})$ is expectation and not realized until the conclusion of investment after one period. So in real world, the foreign investment mentioned in uncovered interest rate parity contains an exchange rate risk. This exchange risk is hedged by using a forward contract. It follows from (1) and (2) that expected change in exchange rate will equal to forward exchange premium.

$$\frac{E(s_{t+1})-s_t}{s_t} = \frac{f_{t,1}-s_t}{s_t} \qquad (3)$$

Equation (3) is forward rate unbiased condition (FRUC). It says that if average deviation between today's one period forward rate ($f_{t,1}$) and the actual one period ahead spot rate (s_{t+1}) is small and near zero, then forward rate is unbiased predictor of future spot rate.

The initial studies on this subject [Cornell (1977), Frenkel (1980)] were based on the level regression of the log of the future spot rate, st+1, on the log of the current forward rate, ft.

$$s_{t+1} = \mu + \beta f_{t,1} + u_{t+1} \qquad (4)$$

Where s_{t+1} = log of the spot exchange rate at time t+1 (defined as domestic units per foreign), and $f_{t,1}$ = log of the one period forward exchange rate at time t. The null hypothesis that forward rate unbiased hypothesis (FRUH) is true, imposes the restriction that $\mu = 0$,$\beta = 1$ and

[1] It is some time referred to as the international Fisher effect.

$E(u_{t+1}) = 0$. The results of these studies generally supported the forward rate unbiased hypothesis (FRUH) for level equation (4). The basic assumption in these studies was that rejection of the hypothesis if happens would be due to irrationality of the agents. In addition, these studies assume the non existence of risk premium in forward rates.

Later on Bilson (1981), Fama (1984) and Froot and Frankel (1989), Levich (1989); concentrated on the regression of the change in the log spot rate, Δs_{t+1} , on the forward premium, $(f_{t,1} - s_t) \equiv fp_t$ due to the unit root behavior of exchange rates and the concern about the spurious regression phenomenon illustrated by Granger and Newbold (1974). These studies focused on the presence of time varying risk premium, conditional on the assumption that forward markets are rational.

Algebraically, the regression equation is:

$$\Delta s_{t+1} = \mu^* + \alpha(fp_t) + u^*_{t+1} \qquad (5)$$

Where Δs_{t+1} is ex post future percentage depreciation, defined as $(s_{t+1} - s_t)$, while $(f_{t,1} - s_t)$ is the forward premium fp_t of a maturity matching that of the ex post depreciation, s_t = log of the spot exchange rate at time t (defined as domestic units per foreign), and $f_{t,1}$ = log of the 1 period forward exchange rate at time t. The null hypothesis of unbiasedness is $\alpha = 1$. The null would imply that there is no systematic time-varying component to the prediction error:

$$E_t\Delta s_{t+1} - fp_t = \mu^*$$

The forward rate unbiased condition is monitored by speculators, who trade in forward contracts only at prices equal to expected future spot rate. In essence this forward rate unbiased condition (FRUC) depends on two assumptions. First is that the speculators are able to form unbiased expectations of future spot rates;

$$E_t(s_{t+1}) = s_{t+1}$$

While second states that speculators choose to trade forward contracts at price equal to their expectations of future spot rates

$$f_{t,1} = E(s_{t+1})$$

Failure of the any results in the forward rate being a biased predictor of future spot rate. If former is violated, a forward rate bias signifies the market inefficiency. Therefore exploiting the pattern of bias offers a profit opportunity for the players. Similarly, forward bias could occur because of the failure of the pricing rule for setting the forward rates. Specifically forward prices could reflect a risk premium (rp) such that $f_{t,1} = E(s_{t+1}) + rp_t$. Here under the rational expectation, the presence of risk premium can be modeled as

$$\Delta s_{t+1} = \mu^* + \alpha(fp_t + rp_t) + \epsilon_{t+1} \qquad (6)$$

Therefore, the null hypothesis in (5) is actually a joint hypothesis, comprising of two distinct conditions:

Rational expectations: $E_t \Delta s_{t+1} = \Delta s_t^e$

No time-varying risk premium: $rp_t = E_t \Delta s_{t+1} - fp_t - \mu^* = 0$

Where $E_t \Delta s_{t+1}$ is the mathematical expectation of sample, and Δs_t^e is the expectation held by investors. Under the null hypothesis the error term in (5) u_{t+1}^* would be equal to the forward market prediction error. But the null hypothesis is almost always rejected statistically in these studies using various samples and exchange rates, and often the finding is $\alpha < 1$ and even negative. These results were puzzling because for the forward exchange rate to be unbiased predictor of future spot rate, α should be equal to 1. This result is referred to as forward discount anomaly, or forward discount puzzle.

The statistical explanation for this result is that the error term in (5) is correlated with the risk premium($\mathrm{rp_t}$). Fama (1984) concludes that the negative estimates of $\alpha's$ are consistent with rational expectations and imply certain restrictions on the risk premium ($\mathrm{rp_t}$). If risk neutrality fails, then the regression (5) is mis-specified. If the risk premium is correlated with the forward premium then the OLS estimate of $\alpha's$ in the regression (5), which omits the risk premium, will be biased away from the true value of 1. Hence the negative estimates of $\alpha's$ from (5) can be interpreted as resulting from omitted variables bias. As discussed in Fama (1984), for omitted variables bias to account for negative estimates of $\alpha's$, it must be true that $\mathrm{cov}[\mathrm{rp_t}, \mathrm{E_t}(\Delta \mathrm{s_{t+1}})] < 0$ and is larger in absolute value than $\mathrm{var}[\mathrm{E_t}(\Delta \mathrm{s_{t+1}})]$. Furthermore, it is required that $\mathrm{var}(\mathrm{rp_t}) > var[\mathrm{E_t}(\Delta \mathrm{s_{t+1}})]$.

Later studies like, Hakkio and Rush (1989), Barnhart and Szakmary (1991), Naka and Whitney (1995), Hai, Mark and Wu (1997), Norrbin and Reffett (1996), Clarida and Taylor (1997), Zivot (1997) and Luintel and Paudyal (1998); Jung and Albarano (1998), Haitham et al,(2006) have focused on FRUH using the tests of cointegration. Accordingly, the FRUH requires that $\mathrm{s_{t+1}}$ and $\mathrm{f_t}$ be cointegrated and that the cointegrating vector be (1,-1). An extensive set of studies have utilized models of cointegration between $\mathrm{s_{t+1}}$ and $\mathrm{f_t}$. Results of these studies are mixed and according to Engel (1996), a rejection of the FRUH is usually interpreted as evidence for the existence of a time varying risk premium.

Engel (1996) also points out that it is also true that the FRUH requires $\mathrm{s_t}$ and $\mathrm{f_t}$ to be cointegrated with cointegrating vector (1,-1) however only a few authors have based their analysis on models of cointegration between $\mathrm{s_t}$ and $\mathrm{f_t}$. Since

$$\mathrm{s_{t+1}} - \mathrm{f_t} = \mathrm{s_{t+1}} - \mathrm{s_t} + \mathrm{s_t} - \mathrm{f_t}$$

$$s_{t+1} - f_t = \Delta s_{t+1} - (f_t - s_t)$$

It is easy to see that under the assumption that s_t and f_t are I(1); (a) if s_t and f_t are cointegrated with cointegrating vector (1,-1), then s_{t+1} and f_t must be cointegrated with cointegrating vector (1,-1); and (b) if s_{t+1} and f_t are cointegrated with cointegrating vector (1,-1) then s_t and f_t must be cointegrated with cointegrating vector (1,-1). Zivot (1997) too emphasized this point and argues that simple models of cointegration between s_t and f_t more easily capture the stylized facts of typical exchange rate data than the models between s_{t+1} and f_t. Instead of finding cointegrating relation between s_{t+1} and f_t, we too followed Zivot (1997) and focused on the test of cointegration between s_t and f_t.

The main idea in above mentioned studies is that all of them test the FRUH after imposing either the rationality of expectations or the non existence of the risk premium assumption, but not both. For example, a large portion of the such literature employs empirical tests that are conditional on the assumption of rational expectation [Cornell (1977), Frenkel (1980),Bilson (1981), Fama (1984); Froot and Thaler (1990)]. Taylor (1989), and Froot and Frankel (1989b) used survey data to test the rationality of exchange rate expectations. A useful survey on this account is given by Takagi (1991). Hai et al. (1997) used an estimating equation to derive expectations of the future spot exchange rate. Another path of this literature used the survey data on exchange rate expectations and then determines whether there exists a risk premium, where the risk premium is calculated as the difference between the forward premium and the forecast change in the exchange rate e.g.; Frankel and Froot (1987), Taylor (1989). Although these studies suggested the presence of risk premium, Froot and Frankel (1989b) tested whether the risk premium is significant and if it is correlated with forward premium fp. While these studies often find the evidence of risk premium, they never attempt to model it as a function of economic variables.

Still other studies including [Frankel (1982), Lewis (1988), Bansal and Dahlquist (2000), and Francis et al (2002)] have examined whether movements in the risk premium vary systematically with observed variables. The variables employed include asset stocks, and uncertainty in the form of changes in the variances of exogenous variables such as government spending, monetary policy, or the rate of technological change, financial liberalization, etc. In the empirical implementation of these studies, rational exchange rate expectations are imposed by setting the predicted future exchange rate equal to the actual future exchange rate plus a random error. Dominguez and Frankel (1993) attempt to model the risk premium as a function of observed economic variables without imposing rational expectations. To do this, they first generate an estimate of the forward exchange rate risk premium using data on the forward premium and forecasts of exchange rate changes from survey data. They then estimate the impact of central bank intervention on the generated risk premium and found that this type of intervention had a significant impact on the risk premium associated with the dollar–mark forward exchange rate.

1.2.1: Data and Empirical Results for FRUH

To investigate the forward rate unbiased hypothesis, 1-month forward rate data on Rupee-US$ is used for the period of January 2002 to May 2007. Data on spot exchange rate s_t and forward rates $f_{t,1}$ are arranged in monthly fashion and are in log form. The range of data is limited due to its non availability. We restricted this study to explore the 1-month forward rate as anecdotal evidence suggest that this is the most liquid segment of the market in Pakistan. The similar studies to explore the FRUH at longer tenors can be considered as future agenda.

We start with the examination of the time series properties of the data on spot and forward exchange rates. Several tests are available in literature to test the stationarity of the series. The augmented Dicky-Fuller test is one such test that we have used. The Dickey-Fuller test, as with other unit root tests, has its own weaknesses. Although, the test seems to give a precise answer about stationarity or non stationarity, however, in actual this is not the case. The test is weak in its ability to detect a false null hypothesis. Enders (2004: 229) mentioned the low power of this test to distinguish between a unit root process and near unit root process. That means the unit root tests have low power if the process is stationary but with a root close to the non stationary boundary. This lack of power means that the Dickey-Fuller test fails to detect stationarity when the series follows a stationary process. This could occur either because the null hypothesis was correct or because there is insufficient information in the sample to enable rejection. There are several ways of solving this problem, including increasing the sample size and using a test with stationarity as a null hypothesis among others. The former solution could be limited by data unavailability, while the latter could be a good alternative without changing the sample size.

This study therefore utilizes the Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS) test of stationarity test in addition to the test of non-stationarity. The (KPSS) test stationarity under the null hypothesis, thus reversing the null and alternative hypotheses under unit root tests, such as the ADF discussed above. Under stationarity tests, therefore, the data will appear stationary by default if there is little information in the sample. The KPSS (1992) differs from other tests in that the series is assumed to be trend-stationary under the null hypothesis.

The graph of data is depicted in Figure 1.1. The results regarding time series properties of the two variable are reported in **Table 1.1**, and these two tests clearly show that both variables are I(1), i.e., non-stationary at levels.

Figure 1.1: Plot of Spot Exchange Rate (S) and Forward Exchange Rate (F)

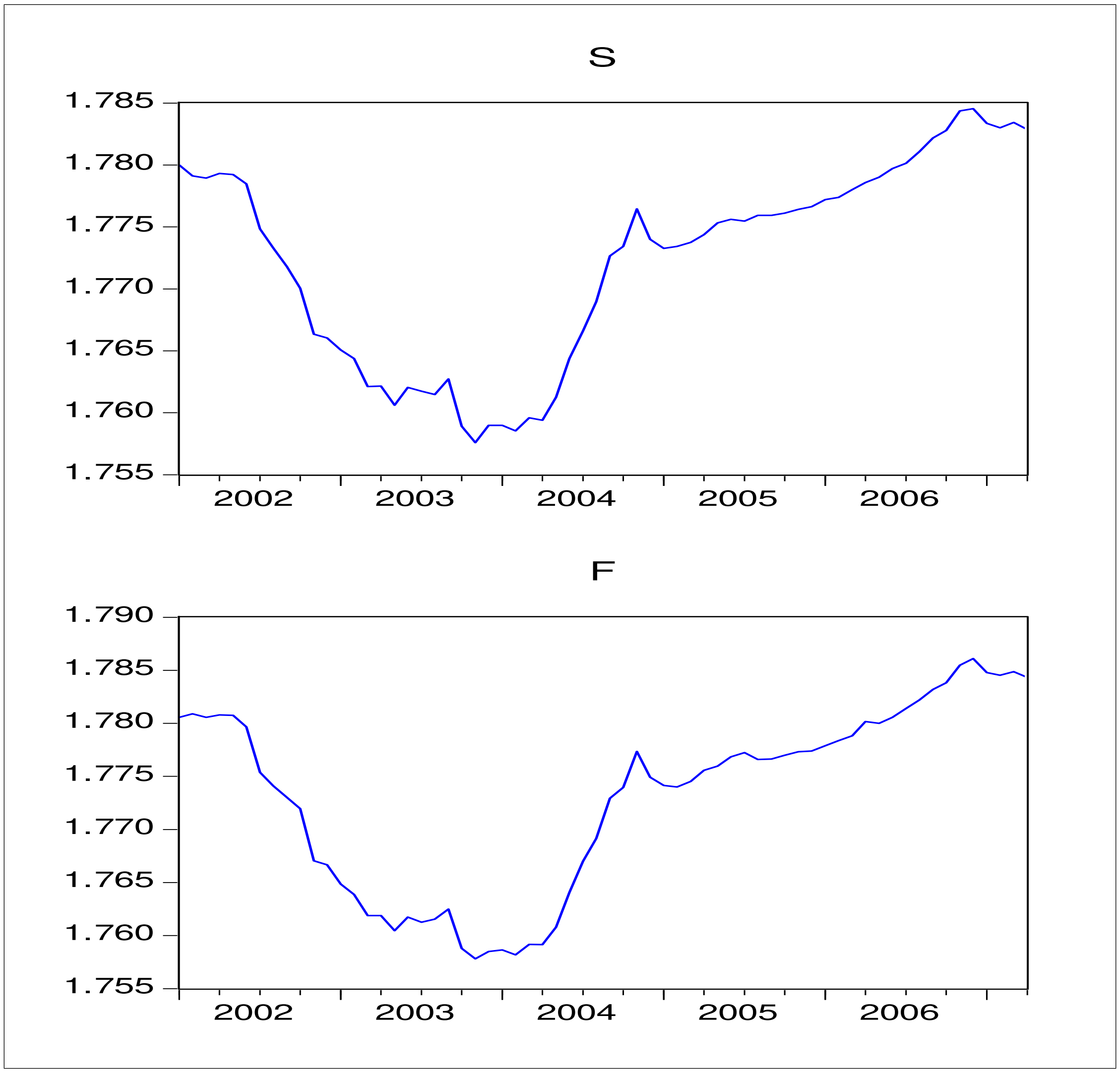

Table 1.1: Unit Root Test Results

Hypothesis in ADF: Series has a unit root
Hypothesis in KPSS: Series is stationary

Variables	ADF(p)	[p]	KPSS	Result
s	-1.21538	[2]	0.475856	non-stationary
f	-1.3177	[2]	0.466166	non-stationary
Δs	-5.22033	[0]	0.407613	Stationary
Δf	-3.06425	[1]	0.387519	Stationary
Asymptotic critical values				
1% level	-3.5421		0.739	
5% level	-2.91002		0.463	
10% level	-2.59265		0.347	

1.2.1.1: Test of FRUH using the Depreciation of Spot Exchange Rate and Forward Premium

Research on foreign exchange market efficiency was originally persuaded by estimating equation (4) [e.g. Cornell (1977), Frenkel (1980)]. But later studies recognized the fact that since both spot and forward rates are I(1), equation (4) suffers from the problem of spurious regression phenomenon illustrated by Granger and Newbold (1974). Therefore later studies used equation (5) for estimation purposes. Our results for equation (5) are mentioned in **Table 1.2**.

Table 1.2: Results of Regression $\Delta s_{t+1} = \boldsymbol{\mu}^* + \boldsymbol{\alpha}(\boldsymbol{f}_{t,1} - \boldsymbol{s}_t) + \boldsymbol{u}^*_{t+1}$

	Coefficient	Std. Error	t-Statistic	Prob.
μ^*	0.000176	0.000256	0.688361	0.4938
α	-0.19764	0.268145	-0.73706	0.4639

The null hypothesis that forward rate unbiased hypothesis is true imposes the restriction that $\mu^* = 0, \alpha = 1$ and $E(u_{t+1}) = 0$. The restrictions are tested using Wald coefficient test and we are able to reject the restriction on $\alpha = 1$. In fact the estimate of α is negative and significantly different from 1. This result is line with the large amount of literature developed in the other countries and often referred to as forward discount anomaly, forward discount bias or forward discount puzzle. According to Fama (1984), the negative estimates of α in **Table 1.2** can be interpreted as resulting from omitted variables bias because non inclusion of risk premium in equation (5). For omitted variables bias to account for negative estimates of $\alpha's$ it must be true that $cov[rp_t, E_t(\Delta s_{t+1})] < 0$ and is larger in absolute value than $var[E_t(\Delta s_{t+1})]$. Furthermore, it is required that $var(rp_t) > var[E_t(\Delta s_{t+1})]$.

1.2.1.2: Test of FRUH using cointegration between s_t and f_t

Table 1.3 represents the results of cointegration test between spot exchange rate and forward exchange rate. Accordingly, the FRUH requires that s_{t+1} and f_t be cointegrated and that the cointegrating vector be (1,-1). Lot of the studies have utilized models of cointegration between s_{t+1} and f_t. Engel (1996) points out that it is also true that the FRUH requires s_t and f_t to be cointegrated with cointegrating vector (1,-1). Also Zivot (1997) emphasis this point and showed that test of cointegration between s_t and f_t produce better results. Therefore, we also test the cointegration relation between s_t and f_t. As mentioned in Zivot (1997), forward rate unbiased hypothesis places testable restrictions on the system. These are that s_t and f_t are cointegrated and the cointegrating vector be (1,-1).We have used Engle-Granger (1987) single equation approach to test the cointegration between s_t and f_t.

We begin by estimating equation (4). The results are shown in **Table 1.3**.

Table 1.3: Engle-Granger approach $s = \mu + \beta f_t + u_{t+1}$

	Coefficient	Std. Error	t-Statistic	Prob.
C	0.120646	0.008674	13.90857	0.0000
F	0.931581	0.004892	190.4149	0.0000
ADF Unit root test (Residual)	-5.967974*			0.0000
*1% level				

The residuals generated from this regression are tested for unit root using the critical values by Phillips and Ouliaris (1990) to establish long-run co-integrating relationship. These residuals are stationary, as reflected by the results of unit root test reported in the bottom of **Table 1.3**, confirming that the above regression is showing a long-run cointegrating relationship between spot exchange rate and forward exchange rate. We also test the restriction $\beta = 1$ on the step 1 regression using Wald restriction test but fail to accept it. To check the validity of restriction that β=1, we bootstrap the sample 1000 times and found out that value of β would yield between 0.932 and 0.942. Histogram is shown in footnote.[2]

This implies the rejection of forward rate unbiased hypothesis. This failure can be a result of violation of the underlying assumptions of rationally formed expectations regarding exchange rate changes and/or presence of risk premium. We will look into this issue in later section.

1.3: Testing the Underlying Assumptions of FRUH

As already discussed that the failure of FRUH stems from two facts; the expectations formation may be irrational and/or the assumption of risk neutrality fails; implying the presence of risk premium in the forward exchange rates. In the following section we will investigate these two assumptions.

To test these prepositions, we assumed that Rupee-US$ forward premium is decomposed into two components: a risk premium and the expected change in the exchange rate. Following Landon and Smith (2003), we modeled risk premium as a function of observed economic variables such as money supplies, current account balance, portfolio investment flows, interest rate differentials etc. However, the second component of the forward-premium, the expected exchange rate change, is generated from a forecasting equation. This is done because of non availability of survey data on expectation on exchange rate changes in Pakistan. The exchange rate forecasting equation and the equation describing the forward premium are estimated jointly,

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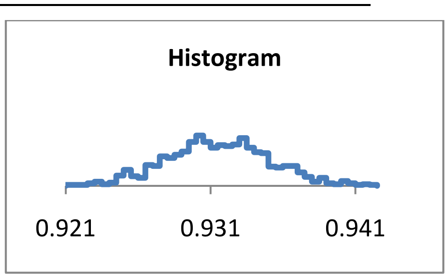
2 

with the variables in exchange rate forecasting equation were used to replace the expected exchange rate change in the forward-premium equation. This methodology is similar to that used by Leiderman (1980) to test monetary neutrality and rational expectations. The joint estimation of the exchange-rate and forward-premium equations makes it possible to test the cross-equation restrictions implied by the rational-expectations hypothesis and to test for the non existence of time varying risk premium. We restricted this study to explore the 1-month forward rate as anecdotal evidence suggest that this is the most liquid segment of the market in Pakistan. The similar studies to explore the FRUH at longer tenors can be considered as future agenda. As discussed in previous section, the FRUH involves two assumptions: that expectations are rational in the sense that the forecast of the changes in the exchange rate utilizes all information that is useful in forecasting the exchange rate, and that there is no risk premium. Following Landon and Smith (2003) consider the following version of the forward premium equation,

$$\mathrm{fp}_t = \mu + \Delta s^e_{t+1} + \emptyset' R_t + \varepsilon_t \qquad (7)$$

Where μ is a constant, R_t is a vector of variables that determine the time-varying risk premium, $\emptyset$ is a vector of parameters, ε_t is a random error. To estimate equation (7) and test the rational expectations hypothesis, it is necessary to specify an equation describing the expected changes in the exchange rate Δs^e_{t+1}. Suppose the actual change in the exchange rate from period t to period t + 1 can be expressed as:

$$\Delta s_{t+1} = a' V_t + \varepsilon^s_{t+1} \qquad (8)$$

Where V is a vector of variables known at time t that can forecast the future value of the exchange rate, a is a vector of parameters, and ε^s_{t+1} is a random error with mean zero. The expected exchange rate change is obtained by taking the expectation at time t of equation (8).

This expectation is then substituted into the forward rate equation (7), to yield an equation for the forward premium that is a function of observable variables only.

$$\mathrm{fp}_t = \mu + \alpha' V_t + \emptyset' R_t + \varepsilon_t \qquad (9)$$

The rational-expectations hypothesis implies that the parameter vector a that enters the exchange rate equation (8) is the same as the parameter vector α in the forward premium equation (9). Hence, rational expectations can be tested by estimating (8) and (9) jointly and testing the cross-equation restrictions: $a = \alpha$

If this restriction is rejected, the expected exchange rate that enters the forward premium equation is not consistent with the process determining the exchange rate and forward market participants will be making systematic expectation errors. The rational-expectations hypothesis also requires that the expectation error ε_{t+1}^{s}, be orthogonal to all information available in period t. If the cross-equation restriction is not rejected, but this orthogonality condition is violated, market behavior is again not consistent with rational expectations.

The hypothesis of no time-varying risk premium implies that the forward premium is not affected by the variables included in the vector R_t. In other words; this hypothesis imposes the following restrictions on (9): $\emptyset = \theta 0$, where θ is a vector of ones. The hypothesis of no risk premium, either constant or time-varying, imposes the joint restrictions: $\emptyset = \theta 0,\ \mu = 0$. This rejection of this hypothesis would imply that one reason for the failure of FRUH is the presence of risk premium. In other words, economic agents are risk averse rather than risk neutral.

To estimate forward premium equation (9), it is important to choose a specification for the exchange rate equation (8) and the determinants of risk premium need to be decided. The risk premium can be influenced by changes in the external current account balance of the country, foreign short term inflows proxy by foreign portfolio flows, interest rate changes etc. The exchange rate forecasting model was obtained by considering for possible inclusion in the vector Vt of the forecasting equation (8), a number of variables that theoretical and empirical studies suggest may be important determinants of the exchange rate. These variables include the lagged changes in the exchange rate (s_t), interest rate differential (idiff) calculated by subtracting 1-month Karachi interbank offer rate (KIBOR) from the 1-month London interbank offer rate (LIBOR), the log of domestic relative to US real income proxied by log of ratio of tradable to non-tradable between Pakistan and United States (tnt)[3], log of domestic relative to US money supply (mdiff), log of monthly inflation rate differential between domestic and US (infd).

All these variables have theoretical relationship with the exchange rate. For instance if current value of exchange rate is explained by its past values, we can infer that the exchange rate is exhibiting inertia. In their seminal paper, Messe and Rogoff (1983) found that the exchange rate is best depicted by the random walk behavior. Similarly, the theory of uncovered interest rate parity proposes that domestic interest rates should equal to sum of foreign interest rate and expected depreciation of domestic currency. That is, the interest rate differential between domestic and foreign assets (idiff) should equal to expected exchange rate depreciation/appreciation. We can therefore expect that higher interest rate differential would cause capital inflows and therefore exchange rate should appreciate in short run. However, in

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[3] There is a vast literature in determination of real exchange rate, where this ratio is used as a proxy for output differential. Since data on real sector is not available below yearly frequency in case of Pakistan, we are forced to use this variable as proxy.

$$tnt = ln\left[\frac{\left({}^{wpi}/_{cpi}\right) Pak}{\left({}^{wpi}/_{cpi}\right) US}\right]$$

long run exchange rate should depreciate for uncovered interest rate parity condition to hold. Therefore the sign of the idiff coefficient in exchange rate equation should be positive. According to monetarist view, higher the interest rate the less would be the demand for money. A lower demand for real balances would imply an excess money supply that would cause exchange rate to depreciate as domestic agents demand foreign assets. So sign of mdiff coefficient would be positive with respect to exchange rate changes. Inflation differential infd between countries can also explain the exchange rate movement between two countries through purchasing power parity condition. For instance higher prices in a country would cause its exchange rate to depreciate. The plausible sign of infd with respect to exchange rate movement is positive. Another plausible determinant for exchange rate movement is the productivity differential between two countries. This phenomenon is popularly known as the Balassa-Samuelson effect. This effect presupposes that productivity differences in the production of tradable goods across countries can introduce a bias into the overall real exchange rate, because productivity advances tend to be concentrated in the tradable goods sector; the possibility of such advances in the nontradable goods sector is limited. To restore equilibrium the nominal exchange rate has to appreciate. In the absence of output data on monthly basis, we use the ratio of tradable to non-tradable tnt as proxy. The plausible sign of tnt would be negative with respect to changes in the exchange rate. Data is taken from IFS CD-ROM, State Bank of Pakistan's various publications and a local brokerage house.

Before estimation, we check at graphical presentation and the unit root properties of all the variables as mentioned in **Table 1.4**. This is important as the unit root behavior of variables could result in the spurious regression phenomenon illustrated by Granger and Newbold (1974).

Figure 1.2: Plot of Data

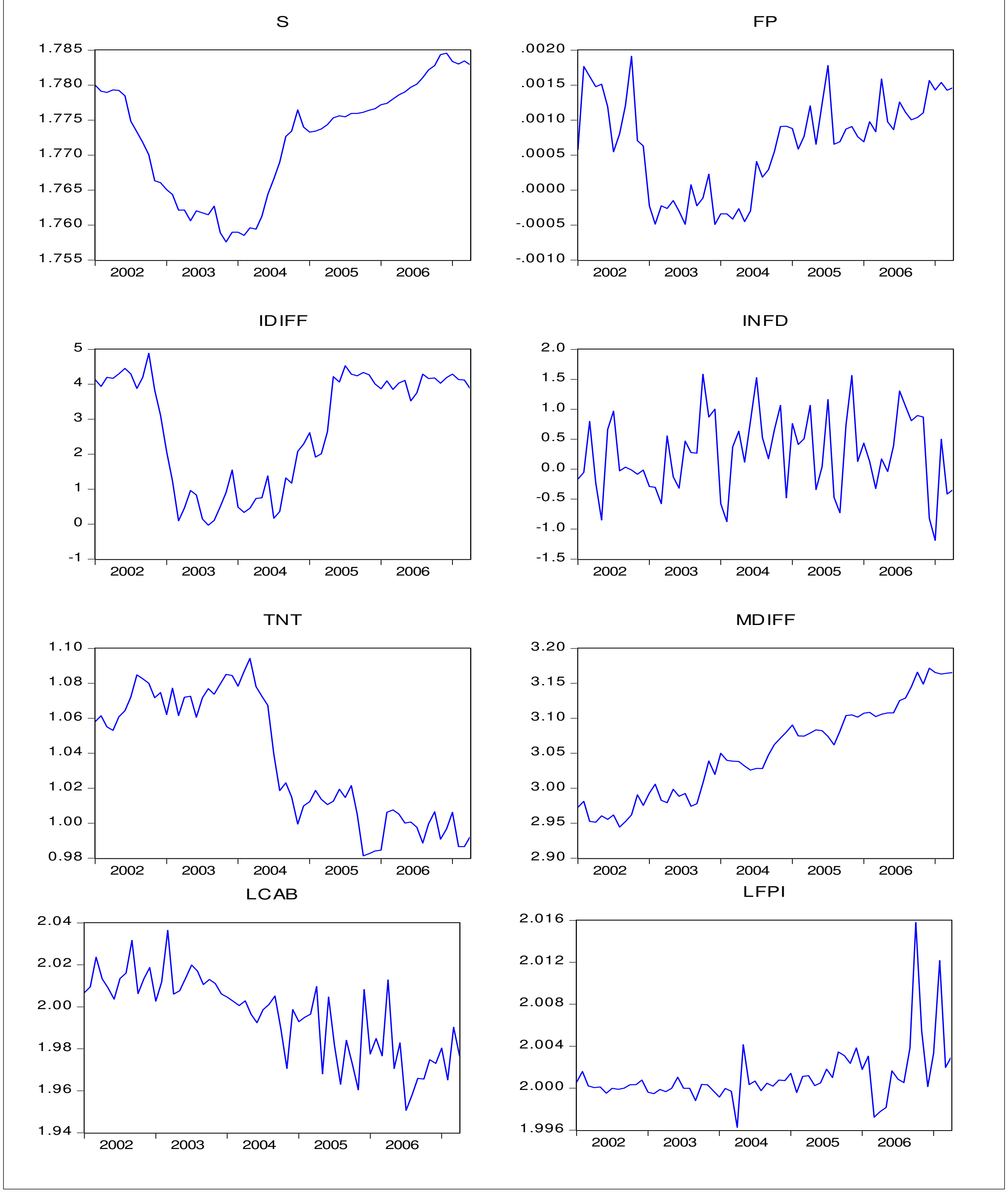


Table 1.4: Unit Root Test

		ADF(p)	[p]	KPSS	Result
Log of exchange rate s	C	-1.215	[2]	0.476	non-stationary
Forward premium fp	C	-2.364	[0]	0.330	stationary
Log of CAB $lcab$	C, t	-1.507	[2]	0.917	non-stationary

Interest rate differential $\boldsymbol{idiff}$	C, t	-4.217	[9]	0.190	stationary
Inflation differential $\boldsymbol{infd}$	C	-6.302	[0]	0.156	stationary
Log of Foreign portfolio investment $\boldsymbol{lfpi}$	C	-5.346	[0]	0.644	stationary
Ratio of tradable to non-tradable (proxy for output differential) $\boldsymbol{tnt}$	C	-0.833	[0]	0.840	non-stationary
Money growth differential $\boldsymbol{mdiff}$	C, t	-4.340	[0]	0.071	stationary
Asymptotic critical values			ADF	KPSS	
		C	C, t	C	C, t
1% level		-3.542	-4.110	0.739	0.216
5% level		-2.910	-3.483	0.463	0.146
10% level		-2.593	-3.169	0.347	0.119

The estimate able form for equation (8) would be

$$\Delta s_t = a_0 + \sum_{t=0}^{k} a_{1i}\,(\Delta s)_{t-i} + \sum_{t=0}^{k} a_{2i}\,(\text{tnt})_{t-i} + \sum_{t=0}^{k} a_{3i}\,(\text{mdiff})_{t-i} + \sum_{t=0}^{k} a_{4t}\,(\text{idiff})_{t-i} + \sum_{t=0}^{k} a_{5i}\,(\text{infd}) + u_t$$

Equation is estimated using 4 lags for each variable. We estimated two equations with similar variables and same lag lengths. In one case, we omitted all those lags from the estimated equation, which turned out to be insignificant. The other case, we let the insignificant lags stay in the model. The results were almost similar. However, we choose the second model on the basis of lower mean squared errors. **Table 1.5** presents the results of exchange rate forecasting equation. Signs of the coefficient are plausible. The model seems to fit the data fairly well.

Table 1.5: Exchange Rate Forecast Model Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(S(-1))	0.223	0.114	1.964	0.055
D(TNT)	-0.080	0.037	-2.126	0.039
D(TNT(-1))	-0.098	0.037	-2.622	0.012
D(TNT(-2))	-0.005	0.037	-0.139	0.890
D(TNT(-3))	-0.082	0.040	-2.035	0.047
MDIFF	-0.038	0.012	-3.179	0.003
MDIFF(-1)	0.038	0.012	3.180	0.003
IDIFF	0.001	0.000	2.151	0.037
IDIFF(-1)	-0.001	0.000	-2.379	0.021
INFD	0.015	0.062	0.237	0.814
INFD(-1)	0.017	0.057	0.305	0.761

INFD(-2)	0.138	0.059	2.333	0.024

The significant coefficient of first difference of the exchange rate implies that the previous period exchange rate explains the changes in the current period exchange rate. The sign of productivity differential proxy ***tnt*** is correct and significant. As explained above, the changes in productivity differential has opposite effect on the exchanges rate changes. For instance any improvement in relative productivity of Pakistan in comparison to USA would cause exchange rate to appreciate. This implies that real sector shocks would have implication for the changes in nominal exchange rate.

The sign of money growth differential should be positive with respect to changes in the exchange rate. That means if Pakistan is experiencing relatively higher monetary growth than the USA, the exchange rate ought to depreciate. This is because of the fact that an excess money supply would cause domestic agents demand foreign assets thereby causing exchange rate to depreciate. Our result reveals that this channel works with one period lag as sign of ***mdiff(-1)*** is significant and has correct sign. The impact of current period money growth differential is significant but with negative sign. This implies that any defense of exchange rate by monetary authority by tightening money growth would work with a lag. The opposite relationship between contemporaneous changes in money growth differentials and exchange rate could be explained by uncovered interest rate parity condition. As monetary authority tightens its stance in t-1 period, interest rates are jacked up. If this can cause inflows of foreign exchange in to county, then domestic currency would appreciate in period t-1. This causes the positive relation between changes in money growth differential and changes in the exchange rate in t-1 period. However, in accordance with the uncovered interest parity (UIP), exchange rate has to depreciate in the later periods (for instance period t) thereby causing negative relation between $mdiff$ and exchange rate. The reason cited here turns more explicit when we look at the interest rate differentials. The one period lag interest rate differential ***idiff(-1)*** has negative sign; implying that higher interest rate differential has caused inflows which resulted the exchange rate to appreciate. However, after a period, the sign of coefficient turned positive in accordance with the uncovered interest parity. Here we are not claiming that UIP hold perfectly, as that would have implied the coefficient of interest differential to be equal to 1. We are just pointing to the conclusion that signs of coefficients of money growth differential and interest rate differential imply that exchange rate defense using monetary policy can at best, have a short lived effect.

The sign of all the lags of inflation differential ***infd*** have correct signs. According to purchasing power parity condition, if Pakistan is experiencing high inflation than USA, the exchange rate has to depreciate. However, importantly, as the significant coefficient of ***infd(-2)*** reveals that it impacts the exchange rate after the two lags. This means that authorities should peruse inflation fighting policies to keep the exchange rate stable. This is more important for countries like Pakistan where it has to import large quantities of goods to fulfill domestic demand. If inflation causes the exchange rate to depreciate then it would cause the prices of imported goods to rise further thereby adding to already prevalent inflationary pressures and a further depreciation in exchange rate.

Table 1.6 shows the diagnostics carried out on the residuals which imply that errors are serially uncorrelated.

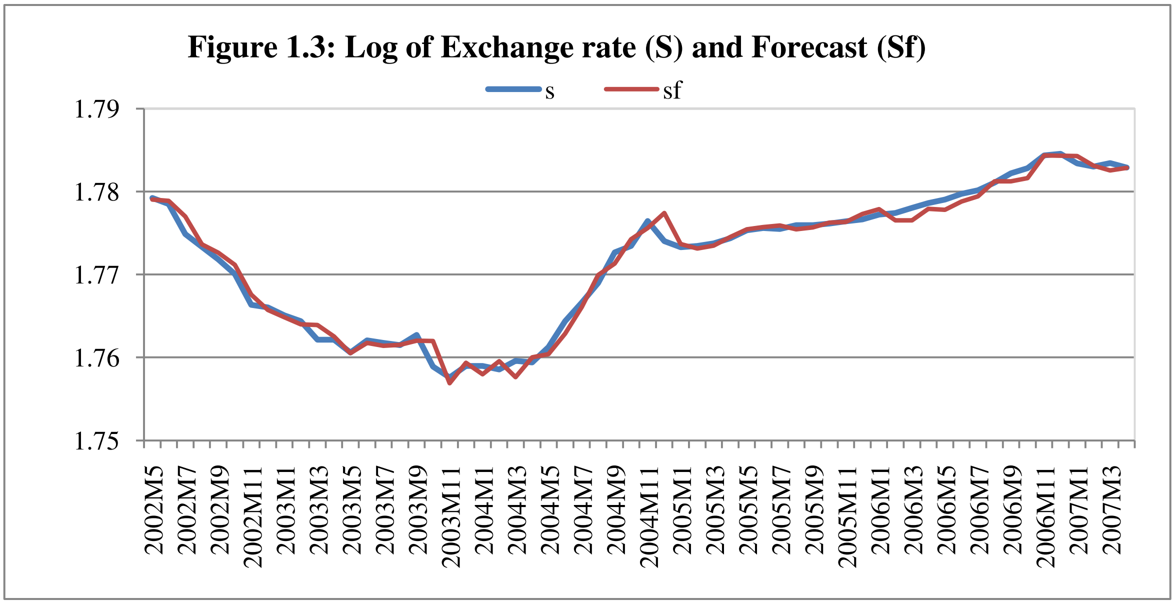
Table 1.6: Residual Diagnostics of Exchange Rate Forecast Equation

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.41566	Prob. F(2,46)	0.2531
Obs*R-squared	3.47725	Prob. Chi-Square(2)	0.1758

ARCH Test:			
F-statistic	0.28173	Prob. F(1,57)	0.5976
Obs*R-squared	0.29018	Prob. Chi-Square(1)	0.5901

Figure 1.3 shows the exchange rate forecast using above model.

Equation (9) has two set of variables, one that are used for exchange rate forecast and the other that determines the risk premium. Before estimating equation (9) of forward premium, we need



to set up the possible determinants of risk premium. To do this we consider some theoretical possible determinants of risk premium. We estimated an equation of forward premium using the current and lagged values of spot exchange rate (s) and other potential variables that could explain risk premium. Those may include, contemporaneous, lead and lagged values of log of current account balance ($lcab$) as market can take note of the external current account balance to make an opinion of the likely pressures on the exchange rate; the amount of short term inflows in to country—proxy by log of foreign portfolio investment $lfpi$, lead and lag values of interest rate differential between 1-month KIBOR and 1-month-LIBOR ($idiff$), current, lead and lagged values of monthly inflation differential between Pakistan and US ($infd$). We also assumed that forward premium has inertia like exchange rate, therefore we also included the lagged values of forward premium (fp). We assumed that all the variables other than changes in exchange rate, which explain the changes in forward premium represent the factors determining the risk premium. To estimate a parsimonious and efficient equation, a sequential reduction procedure was employed to eliminate the many variables in the initial specification of the forward premium equation that did not contribute significantly. **Table 1.7** depicts the result of the estimation.

Table 1.7: Forward premium determinants

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FP(-1)	0.3133	0.1233	2.5416	0.0141
D(S(-2))	0.0875	0.0269	3.2515	0.0020
IDIFF	0.0106	0.0147	0.7243	0.4721
INFD(-1)	-0.0245	0.0148	-1.6572	0.1035
INFD(-2)	0.0325	0.0154	2.1052	0.0401
INFD(-3)	-0.0001	0.0000	-2.8475	0.0063
LFPI(-1)	-0.0070	0.0022	-3.1361	0.0028
DLCAB(1)	0.0002	0.0001	4.6838	0.0000

The fit is reasonably good with R-square of 0.83. Residuals are also normal with no-serial correlation. Results reveal that forward premium is largely explained by the two factors. Those are forward premium's own lag and the lagged changes in exchange rate. We believe that remaining factors represents the risk premium component in the forward premium. For instance we see that risk premium is dependent on the current account balance position, short term inflows represented by portfolio investment, interest and inflation differentials. For instance, an improvement in current account balance reflects a lower forward premium due to investors' perception of lower risk. Similarly, we see that an inflow in portfolio investment also reduce forward premium through lowering of risk premium.

As discussed previously, it is possible to test the hypothesis of rational expectations and no time varying risk premium by testing the restrictions on the parameters of the equation (8) and equation (9). To do this it is necessary to estimate the equations jointly. Therefore, we estimate the equation (8) and (9) jointly and test the restrictions and results are reported in **Table 1.8**.

Table 1.8: System Estimation of Equations (8) and (9)					
Variable	Parameter	Coefficient	Std. Error	t-Statistic	Prob.
D(S(-1))	C(11)	0.2233	0.1137	1.9640	0.0527
D(TNT)	C(12)	-0.0797	0.0375	-2.1255	0.0363
D(TNT(-1))	C(13)	-0.0976	0.0372	-2.6223	0.0103
D(TNT(-2))	C(14)	-0.0051	0.0369	-0.1387	0.8900
D(TNT(-3))	C(15)	-0.0820	0.0403	-2.0348	0.0448
MDIFF	C(16)	-0.0376	0.0118	-3.1794	0.0020
MDIFF(-1)	C(17)	0.0376	0.0118	3.1801	0.0020
IDIFF	C(18)	0.0006	0.0003	2.1508	0.0342
IDIFF(-1)	C(19)	-0.0007	0.0003	-2.3786	0.0195
INFD	C(20)	0.0147	0.0619	0.2369	0.8133
INFD(-1)	C(21)	0.0173	0.0567	0.3055	0.7607
INFD(-2)	C(22)	0.1382	0.0593	2.3326	0.0219
D(S(-1))	C(31)	0.0076	0.0369	0.2071	0.8364
D(TNT)	C(32)	-0.0055	0.0110	-0.5021	0.6169
D(TNT(-1))	C(33)	0.0071	0.0112	0.6362	0.5263
D(TNT(-2))	C(34)	0.0104	0.0113	0.9214	0.3594
D(TNT(-3))	C(35)	0.0055	0.0122	0.4509	0.6532
MDIFF	C(36)	0.0000	0.0036	0.0126	0.9899
MDIFF(-1)	C(37)	-0.0002	0.0036	-0.0629	0.9500
IDIFF	C(38)	0.0003	0.0001	3.0392	0.0031
IDIFF(-1)	C(39)	-0.0001	0.0001	-0.8388	0.4038
INFD	C(40)	0.0053	0.0181	0.2939	0.7695
INFD(-1)	C(41)	0.0065	0.0181	0.3613	0.7188
INFD(-2)	C(42)	-0.0196	0.0176	-1.1128	0.2688
FP(-1)	C(51)	0.3203	0.1395	2.2954	0.0241
D(S(-2))	C(52)	0.0949	0.0367	2.5890	0.0112
INFD(-3)	C(53)	0.0288	0.0199	1.4515	0.1502
LFPI(-1)	C(54)	0.0051	0.0179	0.2881	0.7739
DLCAB(1)	C(55)	-0.0071	0.0025	-2.8756	0.0050
CONSTANT	C(100)	-0.0100	0.0347	-0.2878	0.7742

Test of cross equation restriction $a = \alpha$ in context of equation (8) and equation (9) is tantamount to testing the assumption that agents while setting forward premium, form their exchange rate expectations rationally. These restrictions imply that elements of the parameter vector a in exchange rate forecasting equation (8), are equal to the elements of the parameter vector α in the forward premium equation (9). However, as can be seen, cross equation restriction implied by the rational expectation hypothesis could not be accepted (**Table 1.9**).[4] The result implies that some information useful in predicting the exchange rate is not incorporated in

[4] To test the restrictions, we also estimated a restricted model and used likelihood ratio to test the restriction. We found that we cannot accept the hypothesis that $a = \alpha$.

the forward premium equation. If the market participants had used that information, it would have been reflected in forward premium and cross equation restrictions should not have been rejected. In other word, we may assert that foreign exchange market in Pakistan is inefficient and may provide some arbitrage opportunity for investors.

Table 1.9: Wald Test: $\boldsymbol{a = \alpha}$			
Test Statistic	Value	df	Probability
Chi-square	62.23591	12	0.000

The hypothesis of no time varying risk premium is also tested (**Table 1.10**). To do this, we test the restrictions on equation (9): $\gamma = \theta 0$, where θ is a vector of ones. As can be seen from the Table 2.11, this restriction could not be accepted implying that we are unable to accept the hypothesis of no-time varying risk premium in forward premium. This suggests that current account balance, portfolio investment inflows, inflation and interest rate differentials have an important influence on forward premium. This also implies that domestic and foreign assets are imperfect substitutes. That would result in the efficacy of the central bank intervention in the foreign exchange market, even if the intervention is completely sterilized through portfolio balance channel. If domestic and foreign assets are regarded by agents as perfect substitutes, sterilized intervention may have no significant effect on the exchange rate. This follows because agents will be indifferent as to the relative amounts of domestic and foreign assets they are holding—they will care only about the total amount and hence no change in market-clearing prices or quantities is required [Dominguez and Frankel (1993), Sarno and Taylor (2001)]. That would mean that over a shorter horizon, sterilized intervention could be preferred policy option for the central bank.

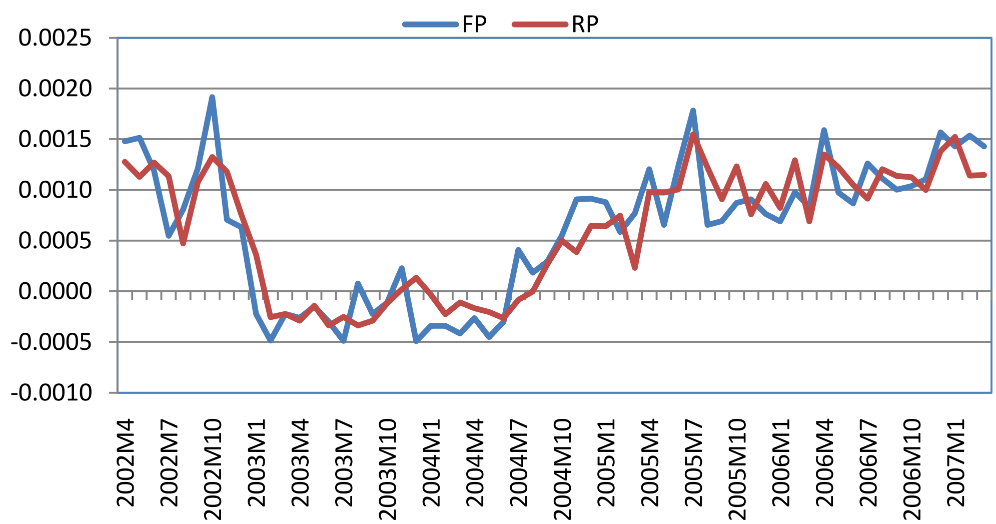
Table 1.10: Wald Test: $\boldsymbol{\gamma = \theta 0,}$			
Test Statistic	Value	df	Probability
Chi-square	20.25875	4	0.0004

The hypothesis of no risk premium, either constant or time-varying, imposes the joint restrictions: $\emptyset = \theta 0,\ \mu = 0$. Like previous case, we are unable to accept the no-risk premium hypothesis—either constant or time varying (**Table 1.11**).

Table 1.11: Wald Test: $\gamma = \theta 0, \alpha = 0$			
Test Statistic	Value	df	Probability
Chi-square	20.62203	5	0.001

The results discussed above indicate the presence of time varying risk premium that depends upon the current account balance, portfolio investment inflows, and inflation and interest rate differentials. **Figure 1.4** illustrate the importance of risk premium in the determination of the forward premium, where latter is calculated by regressing the variables in vector Z— the determinants of risk premium, on the forward premium. It can be seen that there is close association between forward premium and the risk premium. In other word, risk premium is a significant part of the forward premium and its presence means that domestic and foreign assets of same characteristics cannot perfectly substitute each other.

Figure 1.4: Relationship between Forward Premium (FP) and FP explained by Risk Premium (RP)



1.4: Conclusion

The forward market unbiasedness hypothesis is subject to extensive research in the developed countries. However, owing to lack to data availability, there is very small amount of literature for the developing countries. This was also true for Pakistan as there was no attempt to test this hypothesis and its underlying assumptions. In this paper, we attempted to test the hypothesis that 1-month forward premium is an unbiased predictor of 1-month forward spot rate.

Due to non-stationarity of the spot and forward rates series, we tested this hypothesis by two approaches. First approach was to use difference equation (5) that relates the changes in spot rates to the forward premium. The results fail to accept the hypothesis of forward rate unbiasedness hypothesis. In fact, the estimate is significantly negative and away from 1. This confirms the existence of forward discount anomaly or forward discount puzzle for 1-month forward market. Following the recent literature and taking into account the non-stationary nature of exchange rate and corresponding forward rate, we also tested forward rate unbiasedness hypothesis using the tests of cointegration. Accordingly, the FRUH requires that s_{t+1} and f_t be cointegrated and that the cointegrating vector be (1,-1). Zivot (1997) argues that simple models of cointegration between $\mathrm{s_t}$ and $\mathrm{f_t}$ more easily capture the stylized facts of typical exchange rate data than the models between $\mathrm{s_{t+1}}$ and $\mathrm{f_t}$. Therefore following Zivot (1997), we also focused on the test of cointegration between $\mathrm{s_t}$ and $\mathrm{f_t}$. To this end, we used Engle-Granger two step procedures and Johansen cointegration procedure. The results of both suggests the presence of the cointegration relation between $\mathrm{s_t}$ and $\mathrm{f_t}$. However, both fail the restriction that this relation be (1,-1). This therefore implies that these tests too fail to accept the forward rate unbiasedness hypothesis.

The FRUH depends on assumptions of rational expectations and non-existence of time varying risk premium. In the later part of the paper we tested these assumptions. The finding provides evidence that may explain the empirical rejection of the forward rate unbiasedness hypothesis. We first build an exchange rate determination model and explored the relevant factors that influence the changes in the exchange rate. We found out that in case of Rupee-US$ exchange rate, relative productivity differentials and relative money growth between the Pakistan and USA, inflation and interest rate differentials and exchange rate's own lags are important determinant.

To test the rational expectations and nonexistence of risk premium assumptions, we estimated the forward premium equation using exchange rate changes, and factors that determine the risk premium. We found that external current account balance position, foreign portfolio investment and inflation and interest rate are determinants of the risk premium. Later by imposing cross equation restrictions, we found that we are unable to accept FRUH due to violation of both the underlying assumption—rationally formed exchange rate expectations and non-existence of risk premium. This indicated towards the inefficiency of the foreign exchange market. The result implied that some information useful in predicting the exchange rate was not incorporated in the forward premium equation. If the market participants had used that information, it would have been reflected in forward premium and cross equation restrictions should not have been rejected. The existence of risk premium imply that if central bank follow a policy of total sterilization of its foreign exchange interventions, there is high probability that it will succeed in influencing the exchange rate.

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