Instructor’s Manual

Relationship between Spot and Futures Rate: Role of Risk Premium in the Indian Currency Futures Market

Synopsis
The case explores the relationship between currency futures and realized spot rates for the Indian rupee US dollar exchange rate. Using futures contracts with maturities of one, two and three months, the case examines the unbiasedness of futures quotes as a predictor of the future spot exchange rate as well as the nature of time–varying risk premiums in the Indian market. Empirical estimates, obtained using monthly data, suggest the biasedness of futures quotes as a predictor of the future spot rate for contracts with maturities of two and three months. The results also indicate significant time–varying risk premiums in the considered futures market, while the premium is of greater magnitude and more significant with increasing maturity of the contracts. Additionally, the case provides a glimpse of the Global Currency Markets and Indian Currency Futures Market, and the Trading Mechanism of Currency Futures.

Key Words: Currency Futures Markets; Risk Premiums; Unbiasedness Hypothesis; Forward Premium Anomaly.

Potential Audience
The case has been written for classroom discussion for MBA/MS students as part of the Financial Risk Management/Quantitative Finance students. It can also be used in advanced undergraduate courses when students have good quantitative skills.

Research Method for Case Preparation
The case study has been prepared through secondary research. A rigorous secondary research was done to understand the currency futures market in detail. The case examines the Indian rupee US dollar spot and futures contracts for the time period September 2008 to January 2013. The data for currency futures prices has been taken from the National Stock Exchange of India Limited (NSE) website. Data on spot exchange rates are taken from the central governing body.
for all banks in India, Reserve Bank of India (RBI), website. All exchange rates for spot and futures contracts are denoted as Indian rupees per US dollar.

**Learning Objectives**

This case is designed to enable students to:

- Understand the global currency markets, distribution of currencies traded and the regulatory environment.
- Learn about the currency futures market, its evolution in India and how it is different from the currency spot and forward market.
- Find out the reasons why Indian currency futures market is more liquid than the forward markets through various trading mechanisms.
- Learn about the relationship between spot and futures exchange rates.
- Understand various reasons for the presence of forward premium anomaly.
- Analyze the role played time–varying risk premium and its behavior with varying maturity of the contracts.

**Key highlights of the case**

- The case explores the relationship between currency futures quotes and realized spot rates.
- Currency futures quotes do not provide accurate predictions of realized spot rates.
- The difference between the two rates can be explained by a time-varying risk premium.
- The risk premium becomes larger and more significant for longer maturity contracts.

**Teaching Approach and Strategy**

The case can be used effectively in classroom discussions as well as in distance learning programs. In the classroom mode, the case moderator may distribute the case prior to the discussion for preparation. The case has been designed in a suitable way to explain concepts such as relationship between spot and futures currency rates; the role of risk premium and its time varying nature.
The case moderator can initiate the discussion by asking the students about the relationship between spot and futures rate and their link with the interest rate differentials. After establishing the relationship, the discussion can then move to the determination of currency futures rate using various models. The UIP hypothesis and its link with FRUH can be discussed in detail. The students can be asked to analyze why high interest rate currencies should depreciate. Subsequently, the role of arbitrage opportunities to make futures price to be equal to corresponding future spot price can be examined. The moderator can move further to discuss the behavior of forward premium anomaly and the role of risk premium with the varying maturity of contracts. Finally, the class can be concluded by examining the situations in which the risk premium will be high and the difference between the futures rate and future spot rate will be the largest.

**Discussion Questions**

Following are the main questions to be discussed among the moderator and students:

1. Examine the unbiasedness of the futures rate and the forward premium.
2. Analyze the role played by risk premiums in introducing the forward bias.
3. Discuss the behavior of forward premium anomaly and risk premiums with varying maturity of contracts.

The discussion questions can be taken forward as per the following session plan:

<table>
<thead>
<tr>
<th>Instructor's Questions</th>
<th>Approximate Time for Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>10 min</td>
</tr>
<tr>
<td>Discussion on Question 1</td>
<td>20 min</td>
</tr>
<tr>
<td>Discussion on Question 2</td>
<td>25 min</td>
</tr>
<tr>
<td>Discussion on Question 3</td>
<td>20 min</td>
</tr>
<tr>
<td>Total Session Time</td>
<td>1 hour 15 min</td>
</tr>
</tbody>
</table>

1. **Examine the unbiasedness of the futures rate and the forward premium.**

**Discussion**

According to the unbiasedness hypothesis, the forward rate should be an unbiased predictor of the future spot rate conditional on all the information set \((I_t)\) available at time \(t\). Thus, if the
market for rupee/dollar exchange rate is efficient, i.e., risk neutral and rational agents use all available information in forming expectations about currency spot and futures prices, then the current futures rate, \( f_t^i \), for delivery at period \( i \), would be an unbiased predictor of the future spot rate, \( s_{t+i} \), \( i \) periods from now, i.e.,

\[
E(s_{t+i}|I_t) = f_t^i
\]  

(1)

In the above equation, let \( s_{t+i} \) denote the natural logarithm of the spot rate at time \( t \) for a contract with maturity \( i \) (\( i = 1, 2 \) and 3 months), while \( f_t^i \) denotes the natural logarithm of the current futures rate, for maturity in time \( i \) and \( E \) is the expectations operator. For testing the unbiasedness hypothesis in the currency futures market, the forecasting ability of the futures rate for the future spot rate was initially tested in its level form. In such an analysis, the log of the spot rate at \( t+i \) is regressed upon the log of the futures rate \( f_t^i \):

\[
s_{t+i} = \alpha_i + \beta_i f_t^i + \varepsilon_{t+i}
\]  

(2)

In the following we will refer to Equation (2) as the *Level Regression Equation*. If the unbiasedness hypothesis holds, the coefficient \( \beta_i \) should not be significantly different from one. Hence, generally the null hypothesis \( \beta_i = 1 \) is tested, in order to examine whether the forward rate can be considered as an unbiased predictor of future spot rates. Note that initial tests of forward-rate unbiasedness using equation (2) were soon abandoned due to the non-stationary of both the spot rate \( s_{t+i} \) and forward rate \( f_t^i \). Under these circumstances estimating equation (2) would lead to a spurious regression and any inference drawn about the unbiasedness of the forward rate would be invalid. Therefore, instead of using the level regression equation, researchers soon turned their attention to regression models, where the logarithm of the current spot rate is subtracted from both sides of the original equation (2). Such an approach then leads to testing the typical Fama (1984) UIP equation as:

\[
s_{t+i} - s_t = \Delta s_{t+i} = \alpha'_i + \beta'_i (f_t^i - s_t) + \varepsilon'_{t+i}.
\]  

(3)

The term on the left side in (3) is the future change in the log of the spot exchange rate and \( (f_t^i - s_t) \) is the forward premium or so-called basis. The equation (3) is referred to as the *Forward Premium Regression Equation* that has been examined in various studies testing the unbiasedness of currency forward rates. Again, in equation (3), if the forward premium is an
unbiased predictor of changes in the spot rate from \( t \) up to \( t+i \), the coefficient \( \beta'_i \) should not be significantly different from one under the assumptions of risk neutrality and rational expectations.

2. **Analyze the role played by risk premiums in introducing the forward bias.**

**Discussion**

The unbiasedness of the futures rate or the forward premium is not required to hold when risk-averse investors are present in the market. In that case, the forward rate will differ from the expected spot rate by a risk premium and the rejection of the null hypothesis \( (\beta_i = 1) \) can be attributed to the presence of a time varying risk premium. The risk premium \( (\pi_t) \) is then the difference between the future spot rate at maturity and the currency forward rate today \( (E(s_{t+i}) - f^i_t) \). This definition of risk premium has been used in a number of studies. Hence, assuming the existence of a risk premium in the currency futures market, equation (1) can be modified to

\[
E(s_{t+i}|I_t) = f^i_t + \pi_t\]  

or, alternatively,

\[
E(s_{t+i}|I_t) - f^i_t = (E(s_{t+i}|I_t) - s_t) - (f^i_t - s_t) = \pi_t\]  

where \( \pi_t \) denotes the risk premium on the futures contract that separates the expected change in the spot rate from the forward premium, as indicated by equation (5).

Now, consider the difference between the expected and realized spot rate at \( t+i \). Based on the rational expectations hypothesis, there should be no systematic pattern in the forecast error \( e_{t+i} \) which is the difference between the spot rate at maturity \( s_{t+i} \) and the expected spot rate forecast \( E(s_{t+i}|I_t) \) based upon the information set \( I_t \), i.e.,

\[
s_{t+i} = E(s_{t+i}|I_t) + e_{t+i}\]  

However, assuming that the existence of a time-varying risk premium, combining equation (4) and (6) we get
\[ s_{t+i} = f_t^i + \pi_t + e_{t+i}. \]  \hspace{1cm} (7)

Then subtracting \( s_t \) from both sides of equation (7), yields

\[ \Delta s_{t+i} = (f_t^i - s_t) + \pi_t + e_{t+i}. \]  \hspace{1cm} (8)

From equation (2), the OLS estimator for \( \beta_i \) is:

\[ \hat{\beta}_i = \frac{\text{Cov}(s_{t+i}, f_t^i)}{\text{Var}(f_t^i)}, \]  \hspace{1cm} (9)

while the OLS estimator for \( \beta_{1,i} \) in equation (3) is

\[ \hat{\beta}'_i = \frac{\text{Cov}(\Delta s_{t+i}, f_t^i - s_t)}{\text{Var}(f_t^i - s_t)}. \]  \hspace{1cm} (10)

Based on equation (7), the estimator for \( \beta_i \) in (9) can also be rewritten as

\[ \hat{\beta}_i = 1 + \frac{\text{Cov}(f_t^i, \pi_t)}{\text{Var}(f_t^i)} + \frac{\text{Cov}(f_t^i, e_{t+i})}{\text{Var}(f_t^i)}. \]  \hspace{1cm} (11)

In a similar manner, using equation (8) we can also rewrite the estimator for \( \beta'_{1,i} \) in equation (10) as

\[ \hat{\beta}'_i = 1 + \frac{\text{Cov}(f_t^i - s_t, \pi_t)}{\text{Var}(f_t^i - s_t)} + \frac{\text{Cov}(f_t^i - s_t, e_{t+i})}{\text{Var}(f_t^i - s_t)}. \]  \hspace{1cm} (12)

Hence, equation (11) and (12) provide statistical evidence that the risk premium and non-rationality play an important and significant role in moving the coefficients \( \hat{\beta}_i \) and \( \hat{\beta}'_i \) away from unity. If we assume that there is no risk premium, i.e. the participants are risk neutral, then the second term on the right side of Equation (11) and (12) becomes equal to zero. Further, if the rational expectations hypothesis holds, the third term also becomes zero and the coefficients \( \hat{\beta}_i \) and \( \hat{\beta}'_i \) would be expected to be not significantly different from one. Overall, both time-varying risk premiums and irrational expectations could be the reasons for observing the forward bias anomaly in many currency futures markets.
3. Discuss the behavior of forward premium anomaly and risk premiums with varying maturity of contracts.

Discussion

a. Behavior of forward premium anomaly with maturity

Figure 1 depicts the time-series of the spot exchange rate and futures rates for maturities of one, two and three months. We find that the Indian rupee was initially depreciating against the US dollar from September 2008 to April 2009. Since then the rupee started to appreciate against the US dollar with an exchange rate of 44.14 rupees/US dollar on July 28, 2011.
However, the depreciation phase began again August, 2011 onwards. The figure also shows that for all maturities at any point in time futures quotes are higher than the spot rate what is caused by the higher interest rates for the Indian rupee in comparison to the US dollar. Clearly the difference between the spot and futures prices becomes larger with increasing maturity of the futures contract.

After an initial glance at the data we will now investigate the unbiasedness of futures quotes for realized spot rates during the considered time period based on the suggested Futures Premium Equation (3). Table 1 below shows results for the estimated regression models in order to examine whether the futures premium can be considered as an unbiased predictor of future changes in the spot rate\(^1\).

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\(^1\) Note that we also examined results for the Level Regression Equation (2) yielding results that suggested to reject the unbiasedness of the forward rate at the 5% level for maturities of two and three months, respectively at the 10% level for one-month contracts. However, due to the non-stationarity of the spot and futures rate during the considered time period these results may be spurious and are not reported in detail here.
Table 1
Results for the Futures Premium Regression

\[ s_{t+i} - s_t = \Delta s_{t+i} = \alpha_i' + \beta_i' (f_t^i - s_t) + \varepsilon_{t+i}' \]

<table>
<thead>
<tr>
<th></th>
<th>( \alpha' )</th>
<th>( \beta' )</th>
<th>( R^2 )</th>
<th>( N )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-M</td>
<td>-0.0052 (-1.0094)</td>
<td>1.8758 (1.127)</td>
<td>0.103</td>
<td>53</td>
</tr>
<tr>
<td>2-M</td>
<td>-0.020*** (-3.20)</td>
<td>1.86*** (2.803)</td>
<td>0.425</td>
<td>52</td>
</tr>
<tr>
<td>3-M</td>
<td>-0.027*** (-4.69)</td>
<td>1.84*** (3.96)</td>
<td>0.607</td>
<td>51</td>
</tr>
</tbody>
</table>

**Note:** Figures in parenthesis represent the \( t \)-statistics; \( s_{t+i} \) indicates the natural logarithm of the realized spot rate at \( t+i \); \( f_t^i \) indicates the natural logarithm of the futures rate; 1-M, 2-M, and 3-M respectively represent the future spot rate for contracts with one, two and three months maturity. \( N \) is the number of observations. The sample period is from September 2008 to January 2013. * indicates that the coefficient is significantly different from one at the 10% level, ** at the 5% level and *** at the 1% level.

The results indicate that while the estimated \( \beta' \)'s clearly deviate from one, their level of deviation increases with the maturity of the contract due to decreasing standard errors for the estimated coefficients. Note that for all the contracts, \( \beta' \) is estimated to be positive. Also the explanatory power of the model is very low with values of \( R^2 \) being 0.107 only for the 1-month contract which statistically increases as the maturity of the contract increases (0.607 for the 3-month contract). Thus, the futures premium explains more the longer maturity contracts as compared to the shorter maturity contracts. Therefore, while it is found that the coefficients deviate significantly from one; the results suggest that the unbiasedness hypothesis cannot be rejected for the 1-month contracts, however, for the longer maturity contracts; the unbiasedness hypothesis is significantly rejected.

Similar results with respect to the forward premium as a predictor of changes in the spot rate and the sign of estimated coefficients are reported in a number of studies. Due to the strong results for the futures premium as a predictor of future changes in the spot rate, in the next section, the realized or ex-post risk premiums are investigated in the relatively new Indian rupee US dollar market more thoroughly.
b. Behavior of risk premiums with varying maturities

As mentioned above, theoretically, the basis can be considered as the sum of the expected change in the spot rate and a currency risk premium. Therefore, the failure of the unbiasedness of the futures rate has often been attributed to the existence of a time-varying risk premium. Next, we empirically examine the significance and nature of the risk premium in the Indian rupee US dollar futures market. Since, the ex-ante risk premium is generally unobservable; we consider the realized or ex-post risk premium \((s_{t+i} - f^i_t)\) in the empirical investigation. Thus, we examine the difference between the quote for the one month, two months and three months futures contract on a particular day and the realized spot rate at maturity of the futures contract, i.e. one month, two months and three months later.

Figure 2 exhibits the time series of the ex-post risk premium for the considered Indian rupee US dollar futures contracts. From a first glance we find that the risk premiums for the three different maturities exhibit a similar behavior over the considered time period. For most of the months, during the considered time period, we observe negative risk premiums, i.e. the realized spot exchange rate at maturity is below the futures quote one, two or three months earlier.

![Figure 2: Ex-post risk premium for Indian rupee US dollar futures contracts with maturity of one, two and three months for the considered time period September 2008–November 2012.](image-url)
Table 2 provides the summary statistics for the observed ex-post risk premiums for all maturities. In Table 2, the results of Augmented Dickey-Fuller (ADF) tests for the realized risk premiums are also reported. The results confirm that the observed risk premiums are stationary and reject the null hypothesis of a unit root for all maturities even at the 1% significance level.

Table 2
Summary Statistics for Realized Risk Premiums for Different Maturities

<table>
<thead>
<tr>
<th></th>
<th>1-M Premium</th>
<th>2-M Premium</th>
<th>3-M Premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-0.0014</td>
<td>-0.0082*</td>
<td>-0.012**</td>
</tr>
<tr>
<td></td>
<td>(-0.3524)</td>
<td>(-1.7053)</td>
<td>(-2.4164)</td>
</tr>
<tr>
<td>Max</td>
<td>0.0733</td>
<td>0.0562</td>
<td>0.0508</td>
</tr>
<tr>
<td>Min.</td>
<td>-0.0781</td>
<td>-0.0954</td>
<td>-0.0723</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.0284</td>
<td>0.0349</td>
<td>0.0350</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.2324</td>
<td>0.1406</td>
<td>0.1261</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>3.7235</td>
<td>2.4286</td>
<td>1.8811</td>
</tr>
<tr>
<td>J-B</td>
<td>1.6332</td>
<td>0.8788</td>
<td>2.7953</td>
</tr>
<tr>
<td>ADF Test</td>
<td>-6.82***</td>
<td>-6.86***</td>
<td>-6.05***</td>
</tr>
</tbody>
</table>

Note: Figures in parenthesis represent the t-statistic for the estimated mean parameter of the realized risk premium \( \left( r_{t+i} - f_t \right) \) for different maturities. ADF provides results on the Augmented Dickey-Fuller test for stationarity of the risk premium. J-B is the Jarque-Bera test statistic that is approximately \( \chi^2 \)-distributed with two degrees of freedom. The data is from September, 2008 to January 2013. * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level.

The mean of the risk premium is negative for all maturities and is also increasing with maturity of the futures contract. These results are in line with other studies. The results further suggest that risk premiums are a reward for taking short positions in the futures market. The results suggest that the magnitude of the risk premium is increasing with maturity, i.e. returns from futures contracts are decreasing for longer maturity contracts. Further, the hypothesis that the mean of the risk premium is zero, can be rejected for the 2- and 3-month futures contracts at the 10% and 5% significance level respectively, while for 1-month contracts the mean of the risk premium is not significantly different from zero. These results are also coherent with the literature on risk premiums in currency markets suggesting that the premium becomes more significant for contracts with longer maturities.
Many studies argue that for longer maturities risk premiums in the futures market start to play a more important role and lead to a rejection of the unbiasedness hypothesis. Since the economic rationale for the existence of futures markets is the possibility to transfer the exchange rate risk from risk-averse investors to those most willing or able to take it, the risk premium could be interpreted as a compensation for taking on these risks. Another reason for this maturity effect in the risk premium may be that for shorter maturity contracts bank loans are easily available which is not the case for longer maturities. Therefore, interest rate risk becomes more important for futures contracts with longer maturities and might lead to lower returns for such contracts.

The finding that the risk premium is less significant for contracts with shorter maturity can probably be explained by two reasons: the first explanation is based on the notion that the relationship between hedging and speculation activities plays a more important role in longer maturity contracts. Hedging activities become more prevalent on contracts with longer maturity and decline for shorter maturity contracts. Therefore, the pricing of longer maturity contracts will be more affected by risk premiums. Hedgers in currency markets typically hold positions in the cash market and use futures contracts to hedge against undesirable long-term exchange rate movements in the cash market. On the other hand speculators do usually not hold positions in the cash market but only operate in the forward market. As a consequence, in case there are a lot of hedging activities relative to speculating activities, we expect to observe more significant risk premiums in currency futures markets such that the risk premium will be an important determinant of the futures rate. The risk premium can be expected to be more pronounced as the maturity of the contract gets longer.

A second explanation can be related to covered interest parity (CIP) that states that the futures-spot basis is equivalent to the interest rate differential between two countries’ currencies. Generally, short-term interest rates are set by central banks and are, therefore, not affected by market risk premiums. However, as the maturity increases, the risk premium starts to play a more important role in the determination of interest rates, as these rates are set by market forces. This means that the risk premium may not be an important component of the future-spot basis for short maturity contracts where UIP and the unbiasedness of the futures rate are likely to hold.
However, for the same reason, UIP may not hold for longer-term contracts such that we can expect to find significant risk premiums in currency forward markets with longer maturities.

**Conclusion**

This case explores the relationship between currency futures rates and realized spot rates for the Indian rupee US dollar exchange rate. Using futures contracts with maturities of one, two and three months, the unbiasedness of the futures rate as a predictor of the spot exchange rate as well as the nature of realized time-varying risk premiums are examined in this relatively new market. Like several studies on more mature foreign exchange markets, this case finds that the futures premium cannot be considered as an unbiased predictor of changes in the spot rate for the Indian rupee US dollar. In particular for contracts with maturities of two and three months, estimated coefficients in a model regressing realized changes in the spot exchange rate on the forward premium deviate significantly from their expected coefficients under the null hypothesis of unbiasedness. Results also become more significant for contracts with longer maturities. In other words, the unbiasedness hypothesis possibly holds for futures contracts with a short maturity, but it is unlikely to hold for contracts with longer maturities of two and three months. Thus, the results confirm the relationship between bias and maturity in other currency futures markets.

One of the reasons for the poor performance of the futures premium as an unbiased predictor of changes in the spot exchange rate is the presence of a time-varying risk premium in the Indian rupee US dollar futures market. The risk premiums start playing a more important role with increasing maturity of the currency futures contracts. To further investigate this assumption empirically, tests on observed risk premiums’ significance for different maturities are conducted. It is found that realized risk premiums for one month futures contracts are not significant, while realized risk premiums for the two-month and three month contracts are negative and significantly different from zero.

Overall, the results suggest that the relationship between currency spot and futures rates in the Indian rupee US dollar market shows dynamics that are similar to more established currency futures markets.