Advances in Applied Economics and Finance (AAEF)
Vol. 1, No. 4, 2012, ISSN 2167-6348

www.worldsciencepublisher.org

Testing the Validity of Uncovered Interest Rate Parity in India

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Abstract: One vital potential issue determining the exchange rate is the uncovered interest rate parity (UIP). Uncovered interest parity (UIP) is a typical subject of international finance, a critical building block of most theoretical models, and a miserable empirical failure. Uncovered interest rate parity (UIP) states that the nominal interest rate differential between two countries must be equal to expected change in the exchange rate. In other words, if UIP condition holds, then high yield currencies should be expected to depreciate. The article attempts to test the validity of uncovered interest rate parity based on a theoretical formulation in line with economic theory. Although KPSS test suggest that excess return series are in stationary process, excess return curve shows erratic behaviour during some months of our study period (showing negative trend) which automatically excludes the possibility for the UIP to hold. The UIP regression estimate indicates that there is no statistically significant evidence that suggests the uncovered interest rate parity to hold during January, 2006 –July, 2010 for domestic interest rate (weighted average call money rate).This indicates that interest rate spread is a very poor predictor of exchange rate yields. Thus, the UIP hypothesis fails in India.

Keywords: Uncovered interest rate parity; UIP regression; India; excess return; exchange rate; interest rate.

1. Introduction

One vital potential issue determining the exchange rate is the uncovered interest rate parity (UIP). The UIP theory asserts forward market efficiency and states that a country's currency is expected to depreciate against a foreign currency when its interest rate is higher than the foreign country's interest rate due to international capital arbitrage. Uncovered interest parity (UIP) is a typical subject of international finance, a critical building block of most theoretical models, and a miserable empirical failure. Uncovered interest rate parity (UIP) states that the nominal interest rate differential between two countries must be equal to expected change in the exchange rate. In other words, if UIP condition holds, then high yield currencies should be expected to depreciate. UIP affirms that the interest differential is, on average, equal to the *ex post* exchange rate change. A well-built agreement has developed in the literature that UIP works unsuccessfully; it predicts that countries with high interest rates should, on average, have depreciating currencies. Instead, such currencies have tended to appreciate. Thus, any finding reflecting exchange rate appreciation rather than depreciation is called Forward Premium Puzzle. UIP also postulates that, if covered interest rate parity holds, then the interest rate differential is an unbiased predictor of the *ex post* change in the spot exchange rate, assuming rational expectations (Chinn, 2007). This is called unbiased ness hypothesis in the UIP literature. The basic assumption underlying UIP is the efficient market hypothesis where the price should fully reflect all the information available to the market participants and thus no profitable opportunities will be possible in the market. This means that exchange rates will quickly adjust to any new information, which should immediately be reflected in the exchange rate. In addition, it can be considered as a joint hypothesis that the market participants have rational expectations and that they are risk neutral. If these assumptions are legitimate and UIP holds, then the expected return from holding one currency rather than another is cancelled out by the opportunity cost of holding funds in that currency versus another(Foy, 2005). If UIP holds, investors cannot gain an arbitrage opportunity due to high yield currency which is anticipated to depreciate by an amount roughly equal to the interest rate differential between two countries. A violation of this relationship indicates that capital markets are not efficient and there is a possibility of arbitrage opportunity.

In view of the above discussion, the article attempts to test the validity of uncovered interest rate parity in India over the period, 2006:January-2010:July based on a theoretical formulation in line with economic theory.

This paper is organized as follows. In the next section, we examine existing literature regarding the conventional empirical studies used to test UIP. In section 3, we describe the data set and sources and methodology. Section 4 contains empirical results in order to see whether or not UIP holds for India. Section 5 presents summary and conclusion.

2. Review of existing literature

There exists a bulky literature of theoretical and empirical papers examining the interest parity condition in the economics literature, of which most papers also fail to give evidence in favour of the UIP hypothesis. Uncovered Interest Parity has become infamous as a favorite theoretical abstraction which is intensely rejected by data. Part of the reason is that it cannot be tested directly, and therefore has to be tested in conjunction with rational expectations, as the unbiasedness hypothesis.

Froot and Thaler (1990) in a famous survey, reported an average estimated value of β for industrialized countries to be -0.88 for data of maturity more than one day and less than one year. They report few cases where the sign of the coefficient on interest rate differentials in exchange rate prediction equations is consistent with the un-biased-ness hypothesis and not a single case where it exceeds the theoretical value of unity. This resonant unanimity on the failure of the predictive power of interest differentials is practically unique in the empirical literature of economics.

The enormous literature on UIP uses data drawn from low-inflation, floating exchange rate regimes (Flood and Rose, 1997). UIP may work differently for countries in crisis, whose exchange and interest rates both display considerably more volatility. This volatility raises the stakes for financial markets and central banks; it also may provide a more statistically powerful test for the UIP hypothesis. UIP may also work differently over time as financial markets deepen; UIP deviations may also vary across countries for the same reason. Surveys by Macdonald and Taylor (1992) and Isard (1996) came to similar conclusions. Similar results can be found in Fama (1984) and Bilson (1981).

Chinn and Meredith (2004) use data from 1980-2000 at 3, 6 and 12 month horizons for 6 major currencies and find an average coefficient also of -0.8, with four of the estimated coefficients having the wrong sign and being significantly different from unity. Another important finding is that estimates from the arbitrage equations tend to be highly unclear, so even where one cannot reject the null of unity coefficient, one can often also not reject the null of zero coefficient.

Several explanations have been forwarded for this failure of unbiasedness to hold at horizons less than a year and more than a few hours. These basically fall into three categories: Risk Premium, Forecast Errors, and Non-Linearities. Meredith and Chinn (1998) and Chinn (2006) obtained panel estimates for UIP at 5 and 10 year horizons for 4 countries and obtained betas close to 1, although these were imprecisely estimated.

Lothian and Simaan (1998) used time averaged long-horizon data to obtain evidence in favor of UIP for 1974-1994. Cheung et. al (2005) also note more evidence of UIP at long, rather than at short horizons.

Liu and Maddala (1992) tested the unbiased expectations theory and concluded that the predictor is biased, so covered interest parity doesn't hold and that the efficiency of the major currency markets of Japan, Germany, Great Britain, and Switzerland is questionable.

Bakaert and Hodrick (1993) observed that uncovered interest rate parity did not hold through the early 1990s as high-interest-rate countries provided a higher net return, taking account of exchange rate changes, than did low interest rate countries. In other words, currency values of high interest rate countries did not depreciate fast enough to offset their yield advantages.

Van Horne (1998) summarized evidence of test of uncovered IRP in the mid 1990s as being "less clear", where the IRP equality "more nearly prevailed".

Varma (1997), in the Indian context, has carried out an exploration of the covered interest parity. He posits a structural break in the money market in India in September 1995, with CIP become effective from that point on for the first time in the Indian money market. The structural break itself is attributed to interplay between the money market and the foreign exchange market. The period after 1995 witnesses to several deviations from the CIP. Varma has used rates on Treasury bills, certificates of deposit and commercial paper and call money rate to analyze the Indian money market. For the foreign rate, he has calculated an implicit euro-rupee rate for six, three and overnight maturity. Thus, he uses a mix of actual and constructed rates of different maturity. A rigorous test requires use of interest rates on identical instruments (e.g. maturity, risk) and a consistent forward rate (period of forwards should be identical to that of instruments).

The uncovered interest parity (UIP) theory states that differences between interest rates across countries can be explained by expected changes in currencies. Empirically, the UIP theory is generally rejected assuming rational expectations, and explanations for this rejection include that expectations are irrational, [Frankel and Froot (1990) and Mark and Wu (1998)], or that time-varying risk premia are present, [Domowitz and Hakkio (1985) and Nieuwland et al. (1998)], respectively.

McCallum (1994) observes that regressing the change in spot exchange rates on the forward premium, one typically finds a negative regression parameter of -4 to -3 contrary to the expected parameter of +1. McCallum argues that this finding may be consistent with the UIP theory, if one introduces policy behavior. Assuming policymakers adjust interest rates in order to keep exchange rates stable, and that they are interested in smoothing interest rate movements, McCallum derives a reduced form equation for the spot exchange rate under rational expectations. In fact, this results in a negative theoretical relationship between the change in the spot exchange rate and the forward premium consistent with his empirical findings. Christensen, M. (2000) extend the data set used by McCallum to include the recent 8 years and find that $/DM,

$/£ and $/Yen for the period 1978.01m to 1999.03m behave remarkably well according to the modified UIP theory developed by McCallum. However, when he estimates the policy reaction function, its structural parameters are inconsistent with the UIP relationships estimated. Nevertheless, there appears to be overwhelming empirical evidence against UIRP, at least at frequencies less than one year [Hodrick (1987), Engel (1996) and Froot and Thaler (1990)].Christensen (2000) attributes the rejection of the UIP theory to both the lack of assuming rational expectations and the existence of time-varying risk premia.

Fama (1984) focuses on statistical properties of this relation. He finds that from the end of August 1973 to the end of 1982, the variance of the exchange risk premium has been large, exceeding the variance of expected future spot rates changes of the dollar against each of ten other major currencies (over monthly intervals).

On the other hand, Frankel and Froot (1987), among others, suggest an explanation of UIP deviations based on the existence of asymmetries between currencies. Using survey data to estimate the exchange rates' behaviour, they demonstrate that agents were expecting a 10% depreciation of the Dollar against the Mark over 1981-85 whereas the differential in corresponding interest rates was only around 4%. Given that this empirical evidence has not stopped theorists from relying on UIRP, it is fortunate that recent evidence is more favorable.

Bekaert and Hodrick (2001) and Baillie and Bollerslev (2000) argue that suspicious statistical inference may have contributed to the strong rejections of UIRP at higher frequencies.

Chinn and Meredith (2001) marshal evidence that UIRP holds much better at long horizons. They test this hypothesis using interest rates on longer-maturity bonds for the U.S., Germany, Japan and Canada. The results of these long horizon regressions are much more positive — the coefficients on interest differentials are of the correct sign, and most are closer to the predicted value of unity than to zero.

Ravi Bansal and Magnus Dahlquist (2000) conclude that **t**he frequently found negative correlation between the expected currency depreciation and interest rate differential is, contrary to popular belief, not a persistent phenomenon. It is restricted to developed economies, and here only to states where the U.S. interest rate exceeds foreign interest rates.

Flood and Rose (2002) argue that although the UIP theorem predicts that countries with high interest rates should, on average, have depreciating currencies, much empirical papers indicate that such currencies in general have tended to appreciate. Such findings in general are attributed to that the forward rate is a biased predictor of the future spot rate.

Bruggemann and Lutkepohl (2005) conduct an empirical study based on unit root test and univariate analysis for the monthly market and 10 year bond rate for the period 1985-2004. They show evidence of EMH and UIP to hold jointly for the U.S. and Europe.

Meredith and Chinn (2002) examine unbiasedness hypothesis as well as UIP. Their short horizon study indicates that the unbiasedness hypothesis does not hold and UIP condition fails over short horizon. On the other hand, they find correct sign and hence do not reject the null of unity over long horizons.

Sachsida et al. (2001) investigated that the so-called peso problem can be considered one of the main reasons of empirical lack of the UIP theorem since most countries do not work with a pure floating exchange rate regime. In a fixed rate regime, due to a small probability of large alteration in the exchange rate within the period covered by the analysis, one can be misled to the conclusion that agents are showing systematic errors in their short-run predictions, i.e. they are not rational, and this can lead to biased estimates of slope parameters of the UIP equations in samples that are too short to accurately reflect the small probability of large events (Chinn and Meredith, 2004). Since the rational expectations assumption is one of the fundamental building blocks of the UIP theorem, the failure of the empirical tests applied can be a result of apparent lack of rationality in the exchange rate expectation Beyaert et al. (2007) in a recent paper state that regime shifts stemming from institutional, political, and economic changes subject to modern world economies are responsible for the UIP puzzle estimated by researchers. Since regimes switch 'infrequently' at dates that are unknown, economic agents make rational forecast errors that are correlated with the forward premium or the interest rate spreads.

Kool (2006) found that the estimated slope coefficient is negative for each of the ten countries. Flood and Rose (1997) argues that whether or not UIP holds depends on the exchange rate regime. For this purpose, they perform an empirical study by estimating the same conventional equation and conclude that UIP does not hold. Moreover, forward discount puzzle vanishes for fixed exchange rates. Chinn (2006) examines UIP and unbiasedness hypothesis over both short and long horizons. His empirical results suggest that the unbiasedness hypothesis as well as UIP appear to work much better over long horizon indicating zero intercept and unity cannot be rejected. On the other hand, Chaboud and Wright (2003) perform a high frequency data study. By using ordinary UIP regression, they could not find evidence to reject unity for shorter horizons. Flood and Rose (2002) found an interesting result that UIP works systematically worse for fixed and flexible exchange rate countries than for crisis. The empirical results of Bekaert, Wei and Xing (2005) present that UIP depends on the currency pair, not horizon. Furthermore, a random walk model for both interest rates and exchange rates fits the data marginally better than UIP model.

Weber (2010) examined US, European relationship based on long run interest rate equilibrium over a period of January, 1990 to June, 2006 and found that since the middle of 1990s, the UIP condition does not hold any more which is explained by the Central banks' reactions on interest rate volatility, intended to establish a common currency in Euro area.

3 Models and Methodology:

3.1. Data Description:

Domestic interest rates are weighted average call money rates [monthly].The same maturity foreign interest rate is measured in terms of 4-week Treasury bill secondary market rate on discount basis of US govt. security rate collected from Board of Governors of the Federal Reserve System[Source: http://www.publicdebt.treas.gov/of/ofrespr.htm.].Exchange rates are end of month rates, measured by one unit of SDR, USD, Euro, Sterling, Japanese yen in Indian rupee. All the data used are taken from Handbook of Statistics on Indian Economy, 2009-10.The time horizon of the study is from January, 2006 till July, 2010.

3.2. Uncovered interest rate parity:

It has been assumed that individuals are risk neutral. With no capital controls and perfect capital markets, the interest differential between two countries is equal to change in exchange rate:

$i_t - i_t^* = S_{t+1} - S_t$.
where i_t is domestic interest rate,
i_t^* is foreign interest rate on similar asset ,
S_t is the spot exchange rate.

A risk neutral person would replace S_{t+1} by his expectation about future exchange rate. So we get:
$i_t - i_t^* = E(S_{t+1}) - S_t$
Any deviation from UIP can be attributed to currency associated risks in the absence of hedging agreements- namely currency premium and expectation bias.

The UIP hypothesis assumes that if capital is perfectly mobile, then investors around the world will be indifferent between holding their portfolios in domestic or foreign securities, because they obtain the same return from these assets.

In a regime of fixed exchange rate and perfect capital mobility, nominal interest rates will be equal across markets. If the exchange rates are flexible and the capital market is imperfect, interest rate difference will persist. Two versions of interest rate parity -covered interest parity (CIP) and uncovered interest parity (UIP) - are usually used to explain the difference between interest rates.

$$i_{t+n} - i_{t+n}^* = (F_{t+n} - S_t)/S_t \qquad \text{CIP}$$

$$i_{t+n} - i_{t+n}^* = [E(S_{t+n}) - S_t]/S_t \qquad \text{UIP}$$

where i_{t+n}, i_{t+n}^* are the nominal interest of domestic and foreign countries; F_{t+n} and S_t are the n-month forward and the spot rate. The exchange rate is defined as domestic currency value of the foreign currency.

Uncovered interest parity is based on the assertion that the expected rate of appreciation of the spot exchange rate value of a currency is equal to the difference in interest rates. Uncovered international investments involve investing in foreign currency denominated financial assets without hedging in futures markets. That is, the investment proceeds in a future time are converted back to the domestic currency at the prevailing spot currency exchange rates in the future. Therefore, the investment is exposed to exchange rate risk.
The Uncovered interest rate parity[UIP] ruled out the arbitrage opportunity by equalizing domestic(i_t) and foreign interest rate (i^*_t) spread with exchange rate yield .The simplest UIP equation under the assumption of risk neutrality is as follows:

$$\Delta S^e_{t,t+k} = (i_{t,k} - i^*_{t,k}) \text{----------------(1)}$$

Where $\Delta S^e_{t,K}$ defines expected percentage change in exchange rate and i_t , i^*_t represents domestic (Indian) and foreign (US govt. security rate) interest rate respectively, t is the spot period and k is the future period. The equation (1) assumes no arbitrage opportunity between countries, which implies that the changes in the exchange rate and interest rate spread are in equilibrium and there is no room for earning extra money by investing across countries.
If investors are risk averse, equation (1) does not hold any more. Hence, the forward discount rate ($i_{t,k} - i^*_{t,k}$) can be different from the future spot rate ($\Delta S^e_{t,t+k}$) depending upon the perceived risk of domestic vs foreign asset(Chin, Meredith,2005).
The inequality between domestic and foreign interest rate differential and the expected exchange rate yield, leads the equation taking the form as follows:

$$\Delta S^e_{t,t+k} = (i_{t,k} - i^*_{t,k}) + \eta_{t,t+k} \text{------------------(2)}$$

Where the term $\eta_{t,t+k}$ refer to the risk premium demanded from risk averse investors, in order to compensate for the risk of given financial instrument.However,expected exchange rate yields are not observable, hence equation (2) can not be tested. Engel (1995) suggested to test the UIP condition together with the rational expectations, where investors efficiently use all the information at time t,to predict the market movement at time t+k and came up with the equation for future spot rate:

$$S_{t,t+k} = S^e_{t,t+k} + \zeta_{t,t+k} \text{---------------------------(3)}$$

Where the term $S^e_{t,t+k}$ refers to the future expected exchange rate under the rational expectation, and $\zeta_{t,t+k}$ is a white nose process,uncorellated with the exchange rate differential and the spot exchange rate at time t.
Combining equation (2) and (3), we get the future realized change in exchange rate as:

$$\Delta S_{t,t+k} = (i_{t,k} - i^*_{t,k}) + \eta_{t,t+k} - \zeta_{t,t+k} \text{----------(4)}$$

Which can be transformed into Uncovered Interest rate parity (UIP) equation, under the assumption that $\eta_{t,t+k}$, $\zeta_{t,t+k}$ terms are orthogonal to the interest rate spread(Chin, Meredith,2005) and the risk premium is stable over time. The equation (5) represents the final UIP regression:

$$\Delta S_{t,t+k} = \acute{\alpha} + \beta(i_{t,k} - i^*_{t,k}) + \varepsilon_{t,t+k} \text{-------------(5)}$$

Where $\varepsilon_{t,t+k}$ is the white nose process and the null hypothesis of the UIP is β=1.In case $\beta \neq 1$,the null hypothesis fails, this implies that the interest rate differential is a biased estimator of the future spot exchange rate. For Uncovered Interest Parity we would expect ά to be 0 and β to be equal to 1.

If $\Delta S_{t,t+k}$ follows the stationary process(I(0)) and the domestic and foreign interest rates behaves like non stationary process I(1),equation (5) implies that domestic and foreign interest rates are cointegrated with the co integration vectors (1,-1).

To test the basic relation of interest rate parity, we can think of a linear regression of the following type:

Equation 6: $\Delta S_t = \acute{\alpha} + \beta(it - it^*) + \varepsilon_t$

For Uncovered Interest Parity we would expect ά to be 0 and β to be equal to 1.

The problem with using Ordinary Least Square as an estimation technique relates to the issue of non-stationarity of the time series involved in the above equation. In case of non-stationary times series the estimate of β would be spurious and biased. However if we can show that the two variables in question are cointegrated, then the OLS estimates are super consistent and would converge to their true value faster . Therefore, before drawing inferences based on the results of ordinary least squares, it is imperative to check the variables namely F (1 month,3-month ,6 months forward premium) and IRDIFF (Interest rate differential between India and U.S). In case the two series are integrated of the same order, we can then test for cointegartion between the two non-stationary variables.

4. Analysis of results:

To test stationary process of different series taken into our consideration for testing the validity of uncovered interest rate parity(UIP),we have conducted the unit root test by Augmented Dickey Fuller(ADF) and KPSS for domestic interest rates(i_t), foreign interest rates(i_t^*),interest rate differential($i_t - i_t^*$),exchange rates(St), exchange rate yield($\Delta S_{t,t+k}$) with the null hypothesis of presence of unit root and alternative hypothesis with stationarity respectively. To avoid spurious results, it is essential that domestic interest rates(i_t) , foreign interest rates(i_t^*), exchange rates(St) to be integrated of order I(1) and interest rate differential and exchange rate yield follow stationary process I(0).

Second, graphical analysis has been done to informally check whether exchange rate changes minus domestic and foreign interest rate differential ($\Delta S_{t,t+k} - i_{t,k} - i_{t,k}^*$) is stable over time.

Another way of testing the validity of uncovered interest rate parity (UIP) is through UIP regression equation (6) with the null hypothesis β=1 .If the null hypothesis holds, domestic and foreign interest rate differential is an unbiased estimator of the exchange rate yield, consequently, the interest rate spread is equalized with the exchange rate yield and the uncovered interest rate parity holds.

Table: 1: Summary Statistics, using the observations 2006: 01 - 2010: 07 for the variables- Domestic Interest Rate(domintrate) and Foreign Interest Rate(forintrate) (55 valid observations)

India	Mean	Median	Minimum	Maximum
	5.84382	6.06000	0.730000	14.0700
	Std. Dev.	C.V.	Skewness	Ex. kurtosis
	2.38196	0.407604	0.616573	1.18057
USA	Mean	Median	Minimum	Maximum
	2.26727	1.69000	0.0200000	5.13000
	Std. Dev.	C.V.	Skewness	Ex. kurtosis
	2.08485	0.919541	0.157929	-1.74410

- Weighted average Indian call money rate is treated as Domestic Interest Rate (domintrate) .
- 4-week Treasury bill secondary market rate on discount basis (US govt. security rate) is treated as Foreign Interest Rate (forintrate) .

Source: Author's own estimate

Table: 2: Summary Statistics of Exchange Rate: Indian Rupee vs SDR, USD, Sterling, Euro, Yen using the observations 2006:01 - 2010:07 for the variable exSDR,exUSD,exSTER,exEURO,exYEN (55 valid observations)

Exchange rate of SDR	Mean	Median	Minimum	Maximum
	68.6151	68.6153	61.6189	76.5492
	Std. Dev.	C.V.	Skewness	Ex. kurtosis
	4.58854	0.0668737	0.0869168	-1.21252
Exchange rate of USD	Mean	Median	Minimum	Maximum
	44.8543	45.0250	39.3200	50.9450
	Std. Dev.	C.V.	Skewness	Ex. kurtosis

	3.26560	0.0728047	-0.162518	-0.906749
Exchange rate of Sterling	Mean	Median	Minimum	Maximum
	79.3214	79.7550	67.3100	88.7450
	Std. Dev.	C.V.	Skewness	Ex. kurtosis
	5.68193	0.0716317	-0.369802	-0.696914
Exchange rate of Euro	Mean	Median	Minimum	Maximum
	61.3293	59.8088	52.6925	70.2275
	Std. Dev.	C.V.	Skewness	Ex. kurtosis
	4.96539	0.0809628	0.234802	-1.17375
Exchange rate of Yen	Mean	Median	Minimum	Maximum
	43.3206	40.1663	33.0263	54.8413
	Std. Dev.	C.V.	Skewness	Ex. kurtosis
	7.17556	0.165639	0.255237	-1.55701

Source: Author's own estimate

Table:3: Unit root test for Domestic interest rate &Foreign interest rate through Augmented Dickey-Fuller (ADF) Test

ADF-Domestic Interest Rate												
Countries	Levels						First Differences					
	Intercept			Intercept&Trend			Intercept			Intercept&Trend		
	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2
India(Home Country)	-2.87	-2.60	-2.55	-3.23	-2.97	-3.01	-8.28	-5.60	-4.44	-8.20	-5.54	-4.40
ADF-Foreign Interest Rate												
Countries	Levels						First Differences					
	Intercept			Intercept&Trend			Intercept			Intercept&Trend		
	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2
USA(Foreign Country)	-0.357	-0.637	-0.621	-1.66	-1.58	-1.31	-6.06	-5.16	-2.97	-5.99	-5.10	-2.92
Critical Values												
1%	-3.5572			-4.1348			-3.5572			-4.1383		
5%	-2.9157			-3.4935			-2.9178			-3.4952		
10%	-2.5953			-3.1753			-2.5970			-3.1762		

Ho: series has unit root; H_1: series is trend stationary.

Source: Author's own estimate

Table:4: Unit root test for Domestic interest rate &Foreign interest rate through (KPSS) test

KPSS- Domestic Interest Rate												
Countries	KPSS level						KPSS First Difference					
	Without Trend			With trend			Without Trend			With trend		
India	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2
	1.46	0.85	0.63	0.30	0.18	0.14	0.03	0.036	0.039	0.031	0.036	0.039
KPSS- Foreign Interest Rate												
Countries	KPSS level						KPSS First Differences					
	Without Trend			With trend			Without Trend			With trend		
USA												
	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2
	5.15	2.61	1.76	0.619	0.329	0.231	0.277	0.237	0.236	0.277	0.236	0.235

Source: Source: Author's own estimate

Ho: series has unit root; H_1: series is trend stationary

Note: 1%, 5% and 10% critical values for KPSS are 0.739, 0.463 and 0.347 for *without trend.*

1%, 5% and 10% critical values for KPSS *with trend* are 0.216, 0.146 and 0.1199.

Table 3 and 4 suggest that for domestic and foreign interest rate, although ADF test rejects null hypothesis of the presence of unit root in case of domestic interest rate but ADF test fails to reject null hypothesis in case of foreign interest rate and finally, both domestic and foreign interest rate are in stationary process using KPSS at I(1) for both the cases.

Table:5: Unit root test for Exchange rate&Exchange rate yield through Augmented Dickey-Fuller (ADF) Test

ADF-Exchange rate		
Exchange rate	Levels	First Differences

	Intercept			Intercept&Trend			Intercept			Intercept&Trend		
	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2
Re/SDR	-1.36	-1.53	-1.37	-1.33	-1.64	-1.42	-6.04	-3.11	-3.11	-6.00	-5.03	-2.99
Re/USD	-1.12	-1.57	-1.24	-1.29	-1.79	-1.46	-5.22	-5.15	-3.88	-5.18	-5.10	-3.85
Re/Euro	-1.92	-2.00	-1.78	-1.60	-1.52	-1.13	-7.27	-5.47	-2.63	-7.42	-5.65	-2.55
Re/Sterling	-1.47	-1.69	-1.67	-3.09	-3.73	-4.10	-6.55	-4.80	-3.94	-6.56	-4.82	-3.87
Re/Yen	-0.52	-0.70	-0.74	-1.66	-1.98	-1.99	-6.08	-4.48	-3.34	-6.06	-4.48	-3.36
ADF- Exchange rate yield												
Exchange rate yield	Levels						First Differences					
	Intercept			Intercept&Trend			Intercept			Intercept&Trend		
	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2	Lag0	Lag1	Lag2
ΔRe/SDR	-5.88	-3.18	-2.79	-6.28	-3.41	-3.98	-14.2	-7.52	-6.20	-14.1	-7.44	-6.13
ΔRe/USD	-4.47	-3.16	-2.49	-4.85	-3.39	-3.63	-11.0	-7.76	-5.69	-10.9	-7.69	-5.64
ΔRe/Euro	-4.00	-2.27	-1.73	-4.32	-2.51	-3.90	-12.34	-8.07	-5.37	-12.19	-7.97	-5.28
ΔRe/Sterling	-3.99	-2.96	-2.34	-4.03	-3.03	-3.82	-10.19	-7.67	-5.40	-10.09	-7.60	-5.32
ΔRe/Yen	-4.93	-3.87	-2.93	-5.91	-4.96	-3.98	-10.25	-7.95	-7.31	-10.15	-7.86	-7.23
Critical Values												
1%	-3.5547			-4.1420			-3.5625			-4.1383		
5%	-2.9157			-3.4969			-2.919			-3.4952		
10%	-2.5953			-3.1772			-2.597			-3.1762		

Source: Author's own estimate

Ho: series has unit root; H_1: series is trend stationary

Table:6: Unit root test for exchange rate& exchange rate yield through (KPSS) test

KPSS- Exchange rate												
Exchange rate	KPSS level						KPSS First Difference					
	Without Trend			With trend			Without Trend			With trend		
	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2
Re/SDR	2.81	1.45	0.99	0.549	0.287	0.199	0.142	0.123	0.125	0.13	0.11	0.115
Re/USD	1.66	0.856	0.587	0.675	0.348	0.240	0.162	0.124	0.121	0.153	0.118	0.115
Re/Euro	2.92	1.53	1.06	0.481	0.261	0.187	0.168	0.176	0.193	0.481	0.261	0.187
Re/Sterling	3.16	1.67	1.18	0.241	0.138	0.106	0.107	0.10	0.099	0.054	0.051	0.052
Re/Yen	4.12	2.12	1.45	0.687	0.360	0.252	0.142	0.122	0.115	0.097	0.085	0.08
KPSS- Exchange rate yield												
Exchange rate yield	KPSS level						KPSS First Differences					
	Without Trend			With trend			Without Trend			With trend		
	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2
ΔRe/SDR	0.831	0.688	0.548	0.207	0.185	0.153	0.013	0.0327	0.037	0.0103	0.026	0.029
ΔRe/USD	1.236	0.851	0.671	0.245	0.182	0.151	0.026	0.0446	0.063	0.0144	0.025	0.035
ΔRe/Euro	1.099	0.738	0.549	0.360	0.249	0.188	0.022	0.0434	0.059	0.0218	0.043	0.059
ΔRe/Sterling	0.558	0.365	0.284	0.289	0.190	0.149	0.019	0.0294	0.043	0.0188	0.028	0.041
ΔRe/Yen	1.493	1.092	0.932	0.122	0.104	0.104	0.014	0.0216	0.033	0.0120	0.018	0.028

Source: Source: Author's own estimate

Ho: series has unit root; H_1: series is trend stationary

Note: 1%, 5% and 10% critical values for KPSS are 0.739, 0.463 and 0.347 for *without trend.*

1%, 5% and 10% critical values for KPSS *with trend* are 0.216, 0.146 and 0.1199.

Table 5 and 6 showing the unit root tests for exchange rate and exchange rate yield depicts that KPSS test rejects null hypothesis of all exchange rate and exchange rate yields at I(1) although ADF test rejects null hypothesis of the presence of unit root partially .

Table:7: Stationarity test for Interest Rate Differential through ADF &KPSS test

ADF- Interest Rate Differential												
Interest Rate Differential(H-USA)	ADF level						ADF First Difference					
	Intercept			Intercept&Trend			Intercept			Intercept&Trend		
	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2
	-2.84	-2.53	-2.41	-3.06	-2.75	-2.61	-8.36	-5.84	-4.37	-8.28	-8.29	-4.33
	Critical value											
1%	-3.5547			-4.1420			-3.5625			-4.1383		
5%	-2.9157			-3.4969			-2.919			-3.4952		
10%	-2.5953			-3.1772			-2.597			-3.1762		
KPSS- Interest Rate Differential												

Interest Rate Differential(H-USA)	KPSS level						KPSS First Differences					
	Without Trend			With trend			Without Trend			With trend		
	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2
	1.047	0.608	0.452	0.382	0.226	0.171	0.0312	0.0370	0.041	0.0321	0.0382	0.0431

Ho: series has unit root; H_1: series is trend stationary.
Note: 1%, 5% and 10% critical values for KPSS are 0.739, 0.463 and 0.347 for *without trend.*
1%, 5% and 10% critical values for KPSS *with trend* are 0.216, 0.146 and 0.1199.
Source: Author's own estimate

Table 7 presents the domestic (H) and foreign interest rate(USA) differential ($i_t - i_t^*$).Both ADF and KPSS Test suggest the stationary process in India versus USA. It is expected the uncovered interest rate parity (UIP) condition to hold for domestic interest rate (weighted average call money rate) with respect to USA(US govt. security rate).

Informal Test:
Informal way of examining the validity of the UIP condition is to test whether excess return ($i_{t,k} - i_{t,k}^* - \Delta S_{t,t+k}$) is stable over time.The hypothesis suggests that if the excess return is stable over time , there is an implication for UIP condition to hold.

Figure:1

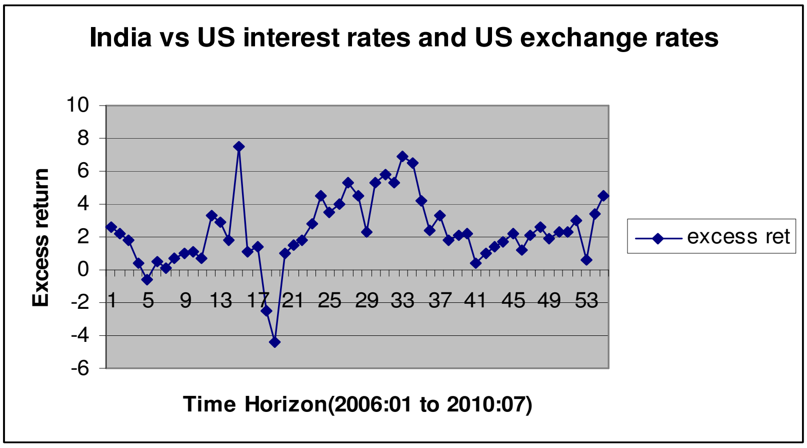

Table:8: Unit root test for Excess Return ($i_{t,k} - i_{t,k}^* - \Delta S_{t,t+k}$): India vs US Interest rates and US exchange rates through (KPSS) test

KPSS- **Excess Return : ($i_{t,k} - i_{t,k}^* - \Delta S_{t,t+k}$)**												
Excess Return	KPSS level						KPSS First Difference					
	Without Trend			With trend			Without Trend			With trend		
	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2	Lag 0	Lag 1	Lag 2
($i_{t,k} - i_{t,k}^* - \Delta S_{t,t+k}$)	0.582	0.364	0.278	0.297	0.188	0.145	0.0297	0.0427	0.0463	0.0272	0.0392	0.0463

Ho: series has unit root; H_1: series is trend stationary
Note: 1%, 5% and 10% critical values for KPSS are 0.739, 0.463 and 0.347 for *without trend.*
1%, 5% and 10% critical values for KPSS *with trend* are 0.216, 0.146 and 0.1199.
Source: Author's own estimate

Although KPSS test suggest that excess return series are in stationary process, excess return curve shows erratic behaviour during some months of our study period (showing negative trend) which automatically excludes the possibility for the UIP to hold.

Table 9: Johansen Cointegration Test:

Included observations: 52 Test assumption: Linear deterministic trend in the data Series: Series: IRDIFF, FORPRE1, FORPRE3 ,FORPRE6 Lags interval: 1 to 1				
Hypothesized No. of CE(s)	Eigen value	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value
None **	0.524004	62.85687	47.21	54.46
At most 1	0.225758	24.25483	29.68	35.65
At most 2	0.178092	10.94956	15.41	20.04
At most 3	0.014337	0.750942	3.76	6.65

Ho: has no co-integration; H1: has co-integration

*(**) denotes rejection of the hypothesis at 5%(1%) significance level .
L.R. test indicates 1 cointegrating equation at 5% significance level.
Source: Source: Author's own estimate

The next step is to test for Co-integration between IRDIFF (Interest rate differential) and FORPRE(Forward Premia) using Johansen's procedures. The maximum eigen value statistics strongly suggest that there is one cointegrating relation between the variables. Hence, using least squares would yield super-consistent estimators.

Figure:2

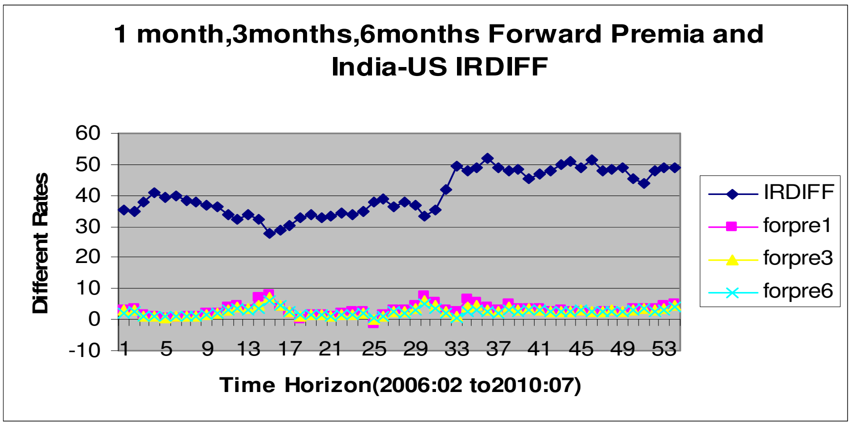

Figure:3

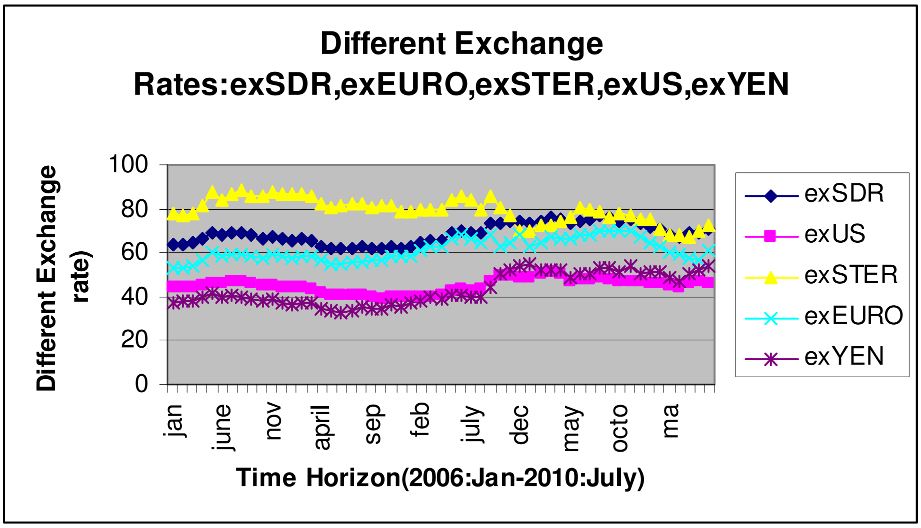

Table 10: Testing Uncovered interest rate parity :OLS estimates using the 54 observations 2006:02-2010:07
Dependent variable: EDIFF

Variable	Coefficient	Std. Error	t-statistic	p-value
const	-0.410693	0.219951	-1.8672	0.06752*
IRDIFF	0.058262	0.033082	1.761152	0.0840*

Mean of dependent variable = 0.0440741
Standard deviation of dep. var. = 1.05094
Sum of squared residuals = 52.0553
Standard error of residuals = 1.00053
Unadjusted R^2 = 0.110738
Adjusted R^2 = 0.0936368
Degrees of freedom = 52

Durbin-Watson statistic = 1.45646
First-order autocorrelation coeff. = 0.271581
Log-likelihood = -75.6324
Akaike information criterion = 155.265
Schwarz Bayesian criterion = 159.243
Hannan-Quinn criterion = 156.799

Source: Source: Author's own estimate

The interest rate parity hypothesis postulates that with flexible exchange rates and non-frictionless capital markets the difference between the yields on identical assets in two countries could be explained by expected change in the exchange rate. Assuming perfect foresight, we can test for uncovered interest rate parity by regressing change in spot exchange rate on interest rate differential and testing for the coefficient of interest rate differential being equal to 1. The estimated equation is as follows.

Equation: EDIFF = -0.410693 + 0.058262* IRDIFF

The evidence from India shows that the slope coefficient of interest rate differential is positive and insignificantly close to 0(which is different from β=1).

For Uncovered Interest Parity, we would expect α to be 0 and β to be equal to 1.The conclusion that can be done from Table 10 is that there is no statistically significant evidence that suggests the uncovered interest rate parity to hold during January,2006 –July,2010 for domestic interest rate (weighted average call money rate).This indicates that interest rate spread is a very poor predictor of exchange rate yields. Thus, the UIP hypothesis fails in India.

5. Conclusion:

The result shows ambiguous picture in favour of uncovered interest rate parity conditions in India. Excess return criteria($i_{t,k} - i_{t,k}^{*} - \Delta S_{t,t+k}$) during the sample period for domestic interest rate indicates whether exchange rate yield($\Delta S_{t,t+k}$)and forward premia differential($i_{t,k} - i_{t,k}^{*}$) follow stationary process. Although KPSS test suggest that excess return series are in stationary process, excess return curve shows erratic behaviour during some months of our study period (showing negative trend) which automatically excludes the possibility for the UIP to hold. The UIP regression estimate indicates that there is no statistically significant evidence that suggests the uncovered interest rate parity to hold during January, 2006 –July, 2010 for domestic interest rate (weighted average call money rate).This indicates that interest rate spread is a very poor predictor of exchange rate yields. Thus, the UIP hypothesis fails in India.

General impression for uncovered interest rate parity puzzle is that the UIP condition is more likely to hold in the long run than in the short run. The deviation from the UIP condition in the short run is the exchange rate risk premium in the country, however, in the long run , consistent results for the UIP condition are controlled by the fact that the exchange rates are determined by the economic fundamentals. Therefore, further research work needs to be done on this UIP issues in India as well as other emerging economies taking into account more larger sample period.

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