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Rupee-Dollar Rate Trends: Co-integration Analysis

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Abstract

The long run dynamics of Indian foreign exchange market with respect to Indian Rupee-US Dollar spot rate can be attributed to interplay of several domestic, foreign and global factors. This paper attempts to identifies whether there exists any long term equilibrium relationship among macroeconomic variables of India and US, Indian Rupee-Euro spot rate, Indian Rupee-Yen spot rate, Indian Rupee-UK Pound spot rate and Indian Rupee-US Dollar spot rate. Time series analysis has been undertaken for ten year period of April, 2005 –March, 2015 using monthly data of these variables. The variables considered are money stock (India and US), nominal long run bond yield (India and US), commodity price levels (India and US), stock prices (India and US), forward premium in Indian rupee-US dollar forward market, foreign exchange reserves with Reserve Bank of India, Indian rupee-euro spot rate, Indian rupee-British pound spot rate and Indian rupee-Japanese yen spot rate. Johansen's co-integration analysis indicates that all Indian and US macroeconomic variables and other currency pairs of rupee are in a long run relationship with rupee-dollar spot rate.

Keywords: *Indian Foreign Exchange Market, Indian Rupee, Johansen's Co-integration, Stationarity.*

INTRODUCTION

The foreign exchange markets across the globe exhibit considerable volatility on account of being market determined under floating rate regime and there arises a challenge to predict exchange rates in these markets. Financial markets are liberalized and inherently dynamic. To study such dynamics in foreign exchange markets, various theories and models have been developed by eminent economists around the world which have been widely employed and tested for evidence in Asian, European, African and US foreign exchange markets.

The paper has been carved to gather deep insights into Indian Rupee- US Dollar spot market to withstand shocks owing to changes

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in macroeconomic variables in Indian and US economy and other significant changes in global factors. In the event of financial crisis in any foreign country, monetary policy changes such as money supply, interest rate changes in US, relative strength of US dollar and Indian Rupee vis-à-vis other major currencies such as Euro, British pound and Japanese Yen, India rupee has exhibited favorable or unfavorable response depending on its resilience which is largely determined by macroeconomic factors and the fundamental strength of Indian economy. To take few instances, events of financial turmoil such as *Euro debt crisis* during which in December, 2011, rupee depreciated against dollar since July, 2011 by 15% as a reflection of global uncertainties and domestic macroeconomic instability. Rupee was the worst performer among major Asian economies. Another such event like exit *decision of Greece from European Union in 2015* through a referendum on 27th June, 2015, euro got weak against many currencies and US dollar strengthened against rupee due to capital pull out from emerging economies by risk-averse investors. In 2013, due to quantitative *easing tapering decision by US Fed Chairman Bernanke,* rupee stumbled 383 points in the same month. The rupee was falling prior to this also but this event aggravated the problem of sell-off by FIIs in emerging market economies including India due to signs of US recovery and rupee began to depreciate sharply. The collapse of Lehman Brothers in September 2008 led to large FII withdrawals from the equity markets and external commercial borrowings which further resulted into pressures in the foreign exchange markets around the world. In October, 2008, rupee depreciated by around 20% with FII outflows and there continued to be a pressure on rupee making it highly volatile. US dollar could sustain against major currencies but rupee suffered. This leads us to the objective of this paper which is to identify long term association among these macroeconomic variables and Indian Rupee- US Dollar spot rate.

The existing literature provides a lead to identify variables which have been found to be influencing exchange rates in foreign exchange markets across all continents. Some of these macroeconomic variables, as identified and highlighted in past studies are money supply, inflation, interest rates, real income, stock indices, foreign direct investment, foreign institutional investment, foreign exchange reserves, central bank intervention, bond yield and forward prices which have been incorporated in the current study. The study has been undertaken to contribute in the area of exchange rate analysis w.r.t rupee-dollar spot exchange rate because of the factors such as growing size of Indian rupee- US dollar market, volatile global markets, lack of consensus on variables influencing rupee-dollar spot rate, need to build understanding of factors or economic mechanisms which govern actual behavior of rupee-dollar spot rate and also of the relationship among rupee-dollar spot rate and other macroeconomic variables.

OBJECTIVES AND HYPOTHESIS OF STUDY

In view of variables identified from the existing literature the paper makes an effort to identify long run association or relationship between rupee-dollar rate and domestic (Indian) macro-economic variables. If any such long run relationship exists among these variables then the domestic monetary and fiscal policies can be employed to target exchange rate management through change in money supply, interest rates, and investing in foreign currency assets. The economy can be said to be more resilient to global shocks depending on the speed at which equilibrium is restored when a deviation takes place. Rupee-dollar is a pair of currency, being influenced by Indian as well as US policies. The currencies euro, pound and yen have been chosen on the basis of the trade flows between Indian, European, UK and Japanese market[1]. Also, US dollar, euro, pound sterling and Japanese yen are used as reserve currency in the foreign exchange markets. The objectives are as stated below:

I. To identify, if any, long term relationship exists between the Indian Rupee- US Dollar spot rate and domestic macroeconomic variables of Indian economy.

II. To investigate whether any long term relationship exists between rupee-dollar spot rate and macroeconomic variables of US economy.

III. To determine, if any, long term relationship exists between the Rupee dollar rate and other currency pairs of rupee i.e. Rupee-Euro spot rate, Rupee-Pound spot rate and Rupee-Yen spot rate.

The aforesaid objectives have been used to establish following hypotheses for data analysis:

Objective	Null Hypothesis	Alternative Hypothesis
I	H_{01}: There is no long term equilibrium relationship among Rupee-dollar spot exchange rate, Indian rate, money supply, foreign exchange reserves in India, RBI intervention through net purchases of dollars, Indian inflation index and Indian stock prices.	H_{11}: There is at least one long term equilibrium relationship among Rupee-dollar spot exchange Indian money supply, foreign exchange reserves, RBI intervention through dollar purchases, Indian inflation index and Indian stock prices.
II	H_{02}: There is no long term equilibrium relationship among rupee-dollar spot rate, US money supply, US inflation index, US stock prices and US 10 year bond yield.	H_{12}: There is at least one long term equilibrium relationship among rupee-dollar spot rate, US money supply, US inflation index, US stock prices and US 10 year bond yield.
III	H_{03}:There is no long term equilibrium relationship among rupee-dollar spot rate, Rupee-Euro spot rate, Rupee-Pound spot rate and Rupee-Yen spot rate.	H_{13}: There is at least one long term equilibrium relationship among rupee-dollar spot rate, Rupee-Euro spot rate, Rupee-Pound spot rate and Rupee-Yen spot rate.

LITERATURE REVIEW

The prior literature by Nagayasu (1998), Sideris (2004) and Cheung & Lai (1993) suggested the existence of long run relationship between consumer prices and nominal exchange rates while studies like Shams and Murad (2010), Shiller, Weliwita (1998), Wickremasinghe and Tiwari (2014) found that purchasing power parity does not hold in the long run and it takes a long time to correct deviations from long run equilibrium among consumer prices and nominal exchange rates.

A few other studies such as Wu & Lin (1992), Jegajeevan (2015), Hunter and Ali (2013), Rapach and Wohar (2001) and Francis et al (2000) supported the hypothesis that money supply and exchange rates are in a long term equilibrium relationship. Monetary models have also outperformed random walk hypothesis in several papers like Bruyn (2012), Messe (1983), Wilson (2009). Financial variables like stock prices, bond yield and forward premium in interbank market have also been found to be significant variables in explaining changes in exchange rates. In earlier studies, multivariate models have been developed or causality has been studied among domestic and foreign stock prices and exchange rates with exchange rate being the endogenous variable. Kutty (2010) found that there is a trigger from stock prices to exchange rates in the short run with no long term association between the two using Granger causality test and co-integration tests. Mishra (2007) stated that there is a long term relation between Indian stock and foreign exchange markets and they move in tandem with each other.

Srikanth (2012) studied that forward premia do affect exchange rates based on both primary and secondary data and Srikanth (2014) found that forward contracts play an important role in addressing the exchange rate risk. Lace (2015) showed that Euro/USD exchange rate is affected by shorter term as well as long term US bond yields in the post crisis period. Patnaik (2003) attributed the use of foreign exchange reserves and monetary policy to liberalization of external sector to achieve traditional goals of exchange rate management. Arunachalam (2010) studied Indian & China markets and found that official international

reserve assets can be used by central banks to purchase the domestic currency which can stabilize the value of domestic currency.

Inoue (2012) found in his study that exchange rate volatility causes central bank intervention through a study of causality in variance.Dua (2011) found that information on intervention by the central bank helps to improve forecasts at the longer end. Neely (2006) has studied the relationship between central bank intervention and exchange rate volatility. Macro-economic announcements and central bank intervention generate jumps and this jump component drives realized volatility of exchange rates between major currencies.

DATA AND METHODOLOGY

In the present paper, M1 measure of money supply has been used to represent money stock variable as data of M2 and M3 variables of US was available as seasonally adjusted figures only and the seasonal parameters had been revised. Therefore, to keep uniformity in India and US data, M1 measure has been used. Tenyear bond yield has been used as proxy variable for interest rate as literature has supported the role of bond spread in currency appreciation or depreciation. Moreover, call money rates in India and effective rate of Federal Reserve as short run interest rates were found to be insignificant in the analysis. Therefore ten year bond yield has been used to represent long run interest rates. Consumer Price Index has been adopted by Reserve Bank of India as key measure of inflation in 2014 to determine real effective exchange rate (REER). Therefore, CPI has been used in the analysis as proxy variable for price levels in India and US.

BSE Sensex is the oldest stock index in India is regarded as pulse of Indian stock markets and S&P500 Index is considered as best index for large capitalization companies of US. 3 month forward premium in interbank market has been found to be a significant predictor variable for exchange rate determination. Literature also suggests foreign Exchange Reserves with Reserve Bank of India as one of the variables affecting value of rupee. Other currency pairs of Indian Rupee - Indian Rupee/ Euro spot rate, Indian Rupee/British pound spot rate and Indian Rupee/Japanese Yen spot rate have also been considered as Japanese Yen, US dollar and euro are three most traded currencies in the foreign exchange market.The choice of methodology has been made keeping in mind the objectives to be accomplished, as stated in section 1.2. Time series analysis has been undertaken for the period of April, 2005 –March, 2015 on monthly data of following variables to attain the objectives of the study:

a) Money stock (India and US) measured as M1 measure of money supply.

b) Nominal long run bond yield (India and US) measured as 10 Year bond yield.

c) Price levels (India and US) measured as Consumer Price Index.

d) Stock Prices (India and US) measured as BSE Sensex and S&P500 Index.

e) Forward Premium in Indian rupee-US dollar forward market measured as 3 month Forward Premia in interbank market in India.

f) Foreign Exchange Reserves with Reserve Bank of India.

g) Foreign Institutional Investment in India.

h) Other currency pairs of Indian Rupee- Indian Rupee/Euro spot rate, Indian Rupee/British pound spot rate and Indian Rupee/Japanese Yen spot rate.

Augmented Dickey fuller (ADF) test has been used to detect unit root process present in all the variables considered in the study. *ADF test* is used if the assumption of error terms not being correlated does not hold true. This is an augmented version of Dickey Fuller (DF) test by adding the lagged values of the dependent variable.

Johansen's cointegration test has been applied to identify the long term relationship among the variables integrated of same order i.e. I(1) in the this paper.

The variables found to be integrated of same order have been tested for long run association among them.Two likelihood ratio (LR) type tests[2]were proposed by Johansen. The two variants are *Maximum eigenvalue test* and *Trace test*.

a) Trace test

Null: There are atmost 'r' cointegrating equations.

Alternative: There atmost 'k'cointegrating equations.

b) Max-Eigen value test

Null: There are atmost 'r' cointegrating equations.

Alternative: There are atmost 'r+1' cointegrating equations.

where 'r' is the number of cointegrating equations and 'k' is (number of variables – 1) i.e. maximum number of cointegrating equations.

DATA ANALYSIS

The order of integration has been determined by using Augmented Dickey Fuller test. For stationarity test results, taken in 1 -1, the variables found to be integrated of same order have been tested for long run association among them. Two likelihood ratio (LR) type tests were proposed by Johansen. The two variants are *Maximum eigenvalue test* and *Trace test*. They are based on Error Correction Mechanism representation. To test whether there exists a long run relationship and to identify the number of cointegrating equations, the optimal lag length is identified by running unrestricted VAR on the variables at level and selecting the lag length at which AIC or SC of the model is least (least positive or highest negative). For results of Johansen cointegration test, take in Table -2, Table -3 and Table -4 for first, second and third objective respectively of present study. Both the tests reveal that there is one cointegrating equation among rupee-dollar spot rate, money supply in India, foreign exchange reserves in India, RBI intervention, stock prices in India and 10 year bond yield in India. The presence of exactly 1 cointegrating equation among rupee-dollar spot rate, US money supply, US inflation index, US stock prices and US 10 year bond yield is also found.

Table 1: Augmented Dickey Fuller Test Result of all Variables

S.no.	Time series	Order of integration	ADF t statistic	p value
a.	Log of rupee-dollar spot exchange rate (LS)	0 1**	-2.145006 -10.27461	0.5157 0.0000*
b.	Log of India money supply (LM1)	0 1**	-1.428386 -3.53122	0.8477 0.0087*
c.	Log of US money supply (LM1F)	0 1**	-2.7599 -10.2281	0.2149 0.0000*
d.	Log of India consumer price index (LCPI)	0 1**	-1.65504 -3.53122	0.7654 0.0087*
e.	Log of US consumer price index (LCPUS)	0 1**	-3.01593 -6.81973	0.1319 0.0000*
f.	Log of India 10 year bond yield (LBOND)	0**	-3.20707	0.0218*
g.	Log of US 10 year bond yield (LBONDF)	0 1**	-2.89962 -11.1785	0.1661 0.0000*
h.	Log of India stock prices (LBSE)	0 1**	-3.11967 -10.2948	0.1061 0.0000*

i.	Log of US stock prices (LSP)	0 1**	-1.30479 -11.1785	0.8824 0.0000*
j.	Foreign institutional investment (FII)	0	-11.67584	0.0000*
k.	Forward premium in Interbank market in India (FP)	0	-4.69775	0.0011*
l.	Log of Rupee-Euro spot exchange rate (LEURO)	0 1**	-1.60609 -9.77899	0.7856 0.0000*
m.	Log of Rupee-Pound spot exchange rate (LPOUND)	0 1**	-2.05103 -11.1886	0.566 0.0000*
n.	Log of Rupee-yen spot exchange rate (LYEN)	0 1**	-2.41402 -11.6449	0.3706 0.0000*
o.	Intervention by RBI (LINTV)	0 1**	-2.22874 -4.95838	0.4694 0.0001*

* indicates rejection of null hypothesis of unit root;

**denotes the order of integration of the corresponding variable.

Table 2: Johansen co-integration test: Trace and Max-Eigen statistic (a)

Null Hypothesis	Max-Eigen statistic	p value	Trace statistic	p value
There is no co-integration among all variables.[3]	35.91223	0.0282*	78.89600	0.0079*
There is at most 1 co-integrating relationship.	19.30477	0.3913	42.98376	0.1330
There are at most 2 co-integrating relationships.	15.66727	0.2449	23.67900	0.2143
There are at most 3 co-integrating relationships.	5.464892	0.6824	8.011731	0.4642
There are at most 4 co-integrating relationships.	2.546838	0.1105	2.546838	0.1105

* indicates rejection of null hypothesis.

Note: the alternative hypothesis is that there is at most one co-integrating equation for Max Eigen test and there are atmost 5 cointegrating equations as per Trace test.

Table 3: Johansen co-integration Test: Trace and Max-Eigen Statistic (b)

Null Hypothesis	Max-Eigen statistic	p value	Trace statistic	p value
There is no co-integration among variables.[4]	35.91223	0.0282*	73.35535	0.0254*
There is at most 1 co-integrating relationship.	19.30477	0.3913	46.81008	0.0625
There are at most 2 co-integrating relationships.	15.66727	0.2449	28.67086	0.0670
There are at most 3 co-integrating relationships.	5.464892	0.6824	12.85827	0.1201
There are at most 4 co-integrating relationships.	2.546838	0.1105	1.059230	0.3034

* indicates rejection of null hypothesis.

Note: the alternative hypothesis is that there is at most one co-integrating equation for Max Eigen test and there are atmost 5 cointegrating equations as per Trace test.

Table 4: Johansen co-integration test-Trace and Max-Eigen Statistic (c)

Null Hypothesis	Max-Eigen statistic	p value	Trace statistic	p value
There is no co-integration among all variables.[5]	26.76328	0.0634	51.00185	**0.0246***
There is at most 1 co-integrating relationship.	16.70960	0.1861	24.23858	0.1905
There are at most 2 co-integrating relationships.	7.512495	0.4304	7.528974	0.5170
There are at most 3 co-integrating relationships.	0.016479	0.8977	0.016479	0.8977

* indicates rejection of null hypothesis.

Note: the alternative hypothesis is that there is at most one co-integrating equation for Max Eigen test and there are atmost 5 cointegrating equations as per Trace test

However for third objective , trace test indicates 1 co-integrating equation at the 0.05 level and Max-eigenvalue test indicates no cointegration at the 0.05 level among Rupee-dollar spot rate, Rupee-Pound spot rate, Rupee-Euro spot rate and Rupee-Yen spot rate.Trace test is the better test, since it appears to be more robust to skewness and excess kurtosis (Sjo, 2008). Trace test gives better results in small samples as it can be adjusted for degrees of freedom. Several papers like Lutkepohl (2000) consider trace test to be a superior test than max-eigenvalue test. However they further state that there is nothing wrong in using both for inferences.

FINDINGS AND CONCLUSION

The rupee-dollar spot rate, money supply in India, inflation in India, foreign exchange reserves in India, stock prices in India, ten year bond yield in India and RBI intervention measures, all have been found to be in a long run equilibrium relationship with each other. This indicates the relevance of domestic policies such as money supply, interest rate changes and purchase or sale of dollars as a check to volatility in rupee-dollar rate. The cointegrating relationship exhibits the tendency of either or all of these variables to help in restoring equilibrium if any deviation takes place. Similarly, rupee-dollar rate is in a long run equilibrium relationship with macroeconomic variables of US economy such as money supply, inflation, stock prices and long term bond yield. Lastly, it is also cointegrated with other currency pairs of rupee i.e. rupee-euro spot rate, rupee-pound spot rate and rupee-yen spot rate. Hence, we may state that the strength of Indian economy and US economy in terms of their macro-economic fundamentals reflect their resilience to shocks in the global economy. However, the strength will be determined by the speed at which adjustment takes place in case occurrence and gravity of the shock. Exchange rate management still plays a crucial role despite increasing speculation in foreign exchange markets and rising importance of microeconomic factors too. Therefore, the study explicitly indicates that there exists a long run equilibrium relationship amongst the macroeconomic variables and the relationship is robust to such an extent that if there is any deviation or short term volatility disturbing the equilibrium, the variables having co integration, in long run, would react in manner to bring back the equilibrium. We may infer that during financial crisis the decisions of holdings in international currency or international markets may not be influenced negatively, if cointegration exists amongst the variables. Further, in fundamentally strong markets, such financial crisis or global shocks with respect to exchange rate may be treated as investment opportunities for long run.

SCOPE OF FUTURE RESEARCH

The analysis can be extended to consider other currency pairs of rupee as dependent variable which form part of Indian foreign market.The daily or weekly data can be used for more insights into the dynamics of exchange

rate.Further, the cointegration analysis can be extended in assessing the speed of adjustment of variables to restore equilibrium.Also, microeconomic variables can be incorporated into the analysis to have deeper insights.

ENDNOTES

1. The European Union is India's second largest trading bloc accounting for around 20% and India has been 9th largest trading partner of EU during 2014-15. EU-India trade mainly takes place between India, France, Germany and UK. Japanese Yen, US dollar and euro are three most traded currencies in the foreign exchange market. (www.wikipedia.com)
2. Likelihood ratio tests are used to test goodness of fit of two models where one model is the null hypothesis and the other model is alternative hypothesis
3. Rupee-dollar spot rate, money supply in India, foreign exchange reserves in India, RBI intervention, stock prices in India and 10 year bond yield in India.
4. Rupee-dollar spot rate, US money supply, US inflation index, US stock prices and US 10 year bond yield
5. Rupee-dollar spot rate, Rupee-Pound spot rate, Rupee-Euro spot rate and Rupee-Yen spot rate

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