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RUPEE-DOLLAR EXCHANGE RATE AND MACROECONOMIC FUNDAMENTALS: AN EMPIRICAL ANALYSIS USING FLEXIBLE-PRICE MONETARY MODEL

ABSTRACT

This paper empirically investigates the link between Indian rupee-US dollar exchange rates and a set of macroeconomic fundamentals using flexible-price monetary model (FPMM) for the period 1996 M1 to 2010 M12. The Johanson-Juselius cointegration test result indicates the existence of long run relationship between exchange rate and the macroeconomic variables, implying the validity of FPMM model in Indian context even though there is no short run casual relationship exist in the VECM analysis.

Key Words: flexible-price monetary model, exchange rate, macroeconomic fundamentals, cointegration

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INTRODUCTION

The Indian economy continued to have the features of a closed economy until it started economic reforms in early 1990's. India launched its economic reforms in 1991 under the pressure of a severe balance of payments (BoP) crisis. The economy was opened up through a process of trade and financial liberalization. The thrust of the reforms in all sectors including financial, fiscal and external was to open up India's market to international competition, remove exchange rate controls and trade restrictions, and encourage private investment and to liberalize the access to foreign capital. The major achievement of the reform process has been reflected in India's higher economic growth in the post reform period. Real GDP has grown about 6.0 per cent since the early 1990s, which is far above the 3.5 per cent growth achieved during earlier decades (Wadhva, 1991). The GDP growth rate was more than 8% for the year 2003, 2004 and it crossed the 9% mark in 2005, 2006, 2007 (World Bank, 2010). The increase in growth has been accompanied by a sharp fall in the average inflation rate to 5.75 per cent during 1994-95 to 2006-07 (D'Souza, 2008). The process of opening up of the external sector started with trade liberalization, withdrawal of quantitative restrictions and tariff cuts. This has benefited the international trade in terms of trade and financial openness. For instance, the ratio of trade in goods and services to GDP has increased from 8.59% in 1990 to 12.75% in 2001 and it was 25.40% in 2009 (WDI, World Bank data base). The current account deficit which is an indicator of external sector was on average 0.6 per cent of GDP during 1994-95 to 2003-04 as compared with 1.8% in the 1980s. Current account recorded a surplus-equivalent to 0.3% of GDP in 2001-2002 after a period of 23 years (Government of India, Economic Survey 2002-2003). In 2006, The Prime Minister's Economic Advisory Council presented a report on Balance of Payments to the Prime Minister. According to the report, the Current account deficit (CAD) for 2005-06 was projected at 2.9% of GDP. The report says that at almost 3% of GDP, the CAD may still be in the comfort zone provided it goes to finance productive investment in India. There is also a growing divergence between the trade data as reported by Reserve Bank of India and as compiled by Director General of Commercial Intelligence and Statistics (DGCIS). If the CAD is calculated using the DGCIS trade data, it would amount to only 0.3% of GDP where as it goes up under the RBI data to 2.9% of GDP (Press Information Bureau, Government of India). Moreover, India's foreign exchange reserve recorded US $ 165 billion by end-Sep 2006 compared to foreign exchange reserve of US $ 5.8 billion at end-March 1991(Reserve Bank of India, 2006-07).

One of the major developments in the external sector in the 1990s has been the reform process in the exchange rate management. The movement towards market determined exchange rate system began with the official devaluation of the rupee in July 1991, before that, the exchange rate was fixed by the central bank, the Reserve Bank of India (RBI). In March 1992 a dual exchange rate system was introduced in the form of the Liberalized Exchange Rate Management System (LERMS). Under this system only a portion of export earnings could be converted into the domestic currency at the market determined exchange rates. According to LERMS, 60% of all receipts under current transactions (merchandise exports and invisible receipts) could be converted at the free market exchange rate quoted by the authorized dealers. The rate applicable for the remaining 40% was the official rate fixed by Reserve Bank of India (RBI). In March 1993, India moved from the dual exchange rate system to a single, market determined exchange rate system (Kumar, 2010). However, there were restrictions on the ability of resident individuals and corporate to send capital abroad. Until 1995, the market was not freely allowed to determine the exchange rate of rupee. The capital account was not fully opened up during this period and hence India followed partial capital account convertibility during this period.

The literature provides various models and theories of exchange rate determination. Kanamori and Zhao (2006) review the theories of exchange rate determination and classify them into partial equilibrium models, general equilibrium models and disequilibrium or hybrid models. Partial equilibrium models include absolute and relative purchasing power parity (PPP) and interest rate parity (IRP). While PPP only consider goods market, IRP only consider the asset market. The relative PPP states that the relative change of exchange rate equals the difference of inflation rates of two economies and hence this theory is also called the inflation theory of exchange rate. The interest rate parity condition was developed to link the exchange rate, interest rate and inflation (Kanamori and Zhao, 2006). The interest rate parity theory has two forms, namely, covered interest parity and uncovered interest rate parity (Apte, 2006). According to this theory, the price of assets plays a major role in exchange rate variations. This says that the current spot exchange rate is determined by the expected future spot rate and the interest rate differential. Flexible price monetary model is obtained by combining the monetary equilibrium with the adjustment of price and the adjustment of output toward their long rum equilibrium and is classified as hybrid (Kanamori and Zhao, 2006).

The monetary model of exchange rate determination is a useful theoretical tool for understanding the behavior of bilateral exchange rates over time. The model postulates the existence of a strong link between nominal exchange rates and a set of macroeconomic fundamentals. In this paper, we test the validity of the monetary model of exchange rate determination by applying time series methodology to examine the relationship between the variables included in the monetary model in static and dynamic framework. Since the US Dollar is major currency and USA is the largest trading partner of India, it is important to observe the bilateral exchange rate behavior with respect to both countries' currencies and its relationship with the macroeconomic variable in both the countries. Nominal exchange rate has been taken as rupees per US dollar keeping in view that India's 80 per cent of international trade is invoiced in the US dollar (Kumar, 2010). So we have selected the Rupee-US Dollar exchange rate for this study.

MONETARY MODEL

The monetary models start with the observation that the exchange rate is the price of one nation's currency in terms of another. Based on quantity theory of money, the monetary models argue that the bilateral exchange rate movements can be explained by the changes in supply and demand for national money stocks in the two countries. There are a number of monetary models developed by different authors to explain exchange rate behavior. Among these the 'flexible price' monetary model (FPMM) proposed by Frenkel (1976) is with the assumption that all prices are flexible. The model assumes that PPP holds continuously, so does the International Fisher Effect (IFE) or Uncovered Interest Rate Parity (UIP) (Pilbeam, 1998). The Fisher effect holds that an increase (decrease) in the expected inflation rate in a country will cause a proportionate increase (decrease) in the interest rate in the country. IFE suggests that the nominal interest rate differentials between two countries reflect the expected change in exchange rate (Eun and Resnick, 2010). Other two important versions of monetary model are the 'sticky price' monetary model of Dornbusch (1976) and 'real interest rate differential' model of Frenkel (1979). The major difference between the sticky-price and flexible-price monetary models is that the former assumes that purchasing power parity holds only in the long run, not continuously as assumed in the flexible-price model (Pilbeam, 1998). An important implication of monetarist model is that monetary policy is the only predictable and effective means of influencing the exchange rate. The supply of money in relation to the demand for it is most relevant than the source of creation of the money stock. The flexible-price monetary model further assumes that changes in real income and inflation expectations induce changes in the exchange rate because they affect the demand for money (Pilbeam, 1998). We have chosen the simple flexible price monetary model here for empirical investigation.

Flexible-price monetary model (FPMM)

The flexible –price monetary model was developed by Frenkel (1976); Mussa (1976); and Bilson (1978a). The model postulates the relative money stock as the determinant of relative prices which in turn determine the exchange rate.

Absolute PPP means "that exchange rates are equal to relative price levels" (Krugman and Obstfeld, 2009) and can be written as follows:

$$e = p/p^* \quad (1)$$

Where e is the nominal exchange rate, p and p* are domestic and foreign price levels, respectively. In the monetary approach exchange rate represented as relative demand for money of two countries.

Let the demand for the real money balance (M^d/p) be expressed as:

$$M^d/p = f\ (Y, r) \quad (2)$$

Where M denotes demand for money, p is the price level, 'f' is some function of a real income (Y) and the interest rate (r). Real money demand is positively related to income and negatively related to the interest rate.

The demand for real money balance in equilibrium is equal to real money supply.

$$M^d/p = M^s/p \quad (3)$$

Where M^s is money supply. Equations (2) and (3) can be rewritten as

$$P = M^s/\ f\ (Y, r) \quad (4)$$

Since money supply is equal to money demand, price can be expressed as

$$P = M/\ f\ (Y, r) \quad (5)$$

Where M is equilibrium quantity of money. Price level of the foreign country can be expressed in the same way

$$P = M^*/\ f^*\ (Y^*, r^*) \quad (6)$$

Where * denotes the foreign country.

The flexible-price monetary model (FPMM) attempts to demonstrate how changes in the supply of and demand for money directly and indirectly affect exchange rates. The conventional money demand function is given by:

$$m_t - p_t = \boldsymbol{\beta}\, y_t - \boldsymbol{\gamma}\, r_t \tag{7}$$

Where $\mathbf{m_t}$ is the log of the domestic money stock, p is the log of the domestic price level, y is the log of domestic real income, and r is the domestic interest rate, β and γ are parameters (Sarno and Taylor, 2002). According to equation (7), the demand to hold real money balances (m-p) is positively related to real domestic income (y_t) due to increased transactions demand, and inversely related to the domestic interest rate (r_t).

A similar relationship holds for the foreign money demand function which is given by:

$$m_t^* - p_t^* = \boldsymbol{\beta}^*\, y_t^* - \boldsymbol{\gamma}^*\, r_t^* \tag{8}$$

Where m_t^* is the log of the foreign nominal money stock, p_t^* is the log of the foreign price level, y_t^* is the log of foreign real income, and r_t^* is the foreign interest rate. Asterisk denotes foreign variables.

FPMM model assumes that purchasing power parity (PPP) holds continuously, and this is expressed as follows:

$$e_t = p_t - p_t^* \tag{9}$$

Where e_t is the log of the nominal exchange rate defined as domestic currency units per unit of foreign currency. The model makes a crucial assumption that domestic and foreign bonds are perfect substitutes. This being the case, the uncovered interest parity (UIP) condition holds and expressed as:

$$Ee_t = r_t - r_t^* \tag{10}$$

Where is Ee_t the expected rate of depreciation of the home currency. According to equation (10) the expected rate of depreciation of the home currency is equal to the interest-rate differential between domestic and foreign bonds. Domestic and foreign price levels are derived by rearranging equations (7) and (8) and expressed as follows:

$$p_t = m_t - \boldsymbol{\beta}\, y_t + \boldsymbol{\gamma}\, r_t \tag{11}$$

$$p_t^* = m_t^* - \boldsymbol{\beta}^* y_t^* + \boldsymbol{\gamma}^* r_t^* \tag{12}$$

The flexible price monetary model for the log exchange rate, e_t, is derived by assuming that income elasticity and interest rate semi elasticity of money demand are the same for the domestic and foreign country ($\boldsymbol{\beta} = \boldsymbol{\beta}^*$, $\boldsymbol{\gamma} = \boldsymbol{\gamma}^*$,) (Sarno and Taylor, 2002). By substituting equations (11) and (12) into equation (9) we obtain the following 'reduced form' exchange rate equation.

$$e_t = \delta(m_t - m_t^*) - \beta(y_t - y_t^*) + \gamma(r_t - r_t^*) \qquad (13)$$

Where δ, β and γ are parameters.

This classical flexible price model provides the basic structure of monetary model (Barnet and Kwag, 2005; Pilbeam, 1998). According to equation (13), an increase in the domestic money supply relative to the foreign money stock induces a depreciation of the domestic currency relative to the foreign currency. The relative money supply has positive relationship with long run nominal exchange rate. It means that as the level of money supply increases, the nominal exchange rate also increases. An increase in domestic real income increases the transactions demand for money. The increased demand for money means that if the money stock and interest rates are held constant, the increased demand for real balances can only come about through a fall in domestic prices. Given the PPP, the fall in domestic prices assuming foreign prices constant, suggests an appreciation of the domestic currency relative to the foreign currency (Sarno and Taylor, 2002; Pilbeam, 1998). The relative real income has negative relationship with long run nominal exchange rate. Lastly, an increase in the domestic interest rate leads to a depreciation of the domestic currency. It is because a rise in the domestic interest rate leads to a fall in the demand for money and hence a depreciation of the domestic currency. The interest rate is determined by demand and supply of money. The relative interest rate has positive relationship with long run nominal exchange rate.

REVIEW OF LITERATURE

There are several studies conducted to empirically test the validity of various versions of monetary models of exchange rate determination. An analysis of these studies by classifying them on the basis of methodology used shows that the empirical evidence for the monetary model is mostly depend on the type of model used (Islam and Hasan, 2006).

As noted by Islam and Hasan (2006), "early studies during the late 1970s and the early 1980s employed traditional regression analysis and found mixed evidence" for the validity of monetary model in explaining the exchange rate movements. These studies include Frankel (1976); Bilson (1978a, 1978b); Dornbusch (1979); Dornbusch (1980); Rasula and Wilford (1980); Haynes and Stone (1981); Meese and Rogoff (1983); Frankel (1984), Backus (1984); and Boughton (1988).

The use of earlier version of the cointegration method, Engle and Granger (1987); two-step cointegration methodology provides no evidence for the validity of monetary models. These studies are mostly done in the eighties and early nineties, which includes Meese (1986); Baillie and Selover (1987); Boothe and Glassman (1987); Kearney and MacDonald (1990); McNown and Wallace (1989).

In the nineties most of the studies have used the Johanson (1988), Johansen and Juselius (1990) cointegration methodology. MacDonald and Taylor (1991, 1992, 1993, 1994a, 1994b) have used this methodology to test the validity of the monetary model for the sterling/dollar, the Deutschemark/dollar, the yen/dollar and the French franc/dollar exchange rates and got results in favor of monetary model. Moosa (1994) has analyzed the exchange rate of US dollar with UK pound, German Mark and Japanese Yen for the period January 1975 to December 1986 and found evidence for the validity of the monetary models. Choudhry and Lawler (1997) have done the analysis for the Canadian Dollar-US Dollar exchange rate over the Canadian float period 1950-62 and observed that both the cointegration analysis and Error correction model results supports the monetary model. The other studies in the area includes Husted and MacDonald (1998), Francis et al., (2001), Moersch and Nautz (2001), Goren (2002), and Choudhury and Lawler (1997).

Recently, Liew, Baharumshah, and Puah (2009) examined the validity of the flexible price monetary model for the case of Thailand using the Johansen multivariate cointegration testing framework. The Japanese Yen was chosen as base currency. The study was conducted using monthly data from January 1977 through March 2006 taking real GDP as real income, M2 for money stock, CPI for inflation and money market rate for interest rate. The study shows that there exist cointegrating relationship in the estimated VAR model, indicating the presence of long-run relationship among exchange rate and the monetary variables. In another study, Nwafor (2006) also applied the Johansen-Juselius cointegration methods to investigate whether the flexible price monetary model of exchange rate is consistent with the variability of the Nigerian Naira and US dollar. The study was conducted using quarterly data from 1986 to 2002 on variables such as naira-dollar exchange rate, the differences of the logarithms of national money supplies (M2), real income and expected inflation (CPI). The study found a long-run equilibrium relationship between the naira-dollar exchange rate and the FPMM fundamentals such as money differential, real income differential and expected inflation differential.

Islam and Hasan (2006) validate the monetary model in the determination of the Dollar-Yen exchange rates by applying co integration methodology. They used data from the first quarter of 1974 to the first quarter of 2003. In the empirical model, Japan is regarded as the home country and the US is viewed as the foreign country. Real income is represented by real gross domestic product and the interest rate variable used for the model is one of short-term rate. While the short-term interest rate for US is represented by the 3-month Treasury bill rate, the short-term Japanese interest rate is represented by the 3-month Gensaki interest rate. The Johansen and Juselius (1990) cointegration test is employed to test for cointegration among variables. The results of the study indicate that there exists at least one cointegrating relationship between nominal exchange rate and relative real incomes, money supplies, and interest rates. The paper also studied the short-run dynamics by estimating a vector error-correction model (VECM). Shidong and Thomas (2005) also applied Johansen's cointegration methodology to test whether there exists a long run relationship between the exchange rate and macroeconomic variables for Germany, Japan, the United States, and the United Kingdom, for the 1973 to 1999 period. The macroeconomic variables included in the model are real gross domestic product, short-term interest rates, M1 or M2 for money stocks and expected inflation rate calculated from CPI. Their empirical results are mixed and do not provide evidence in support of the monetary model of exchange rate determination while using US dollar as the base currency. However, for the cases of mark/pound, yen/mark, yen/pound, the results provide strong support for the monetary model of exchange rate determination. Simwaka (2004) examined the monetary model of the Malawi Kwacha –US dollar exchange rate during the floating exchange rate system. The study supports a long run equilibrium relationship as explained by monetary model. The author shows that money supply can be employed as a tool for influencing the exchange rate.

Johnston and Sun (1997) showed the empirical evidence from major industrialized countries for the link between the bilateral nominal exchange rates and the bilateral economic fundamentals such as output, inflation and interest rates. The study showed that the exchange rates of the industrialized countries such as Canada, Germany, Japan, UK and US are determined in the long-run primarily by factors consistent with a monetary approach. Some studies investigated the implications of use of different measures of monetary aggregates. Sarantis (1994), for instance, used both narrow money and broad money in order to investigate the potential sensitivity of the co integration tests to the measure of monetary aggregates. The study employed the Johansen (1988) maximum likelihood framework to investigate three variants of the long-run monetary approach to the exchange rate determination; the flexible price monetary model, the forward-looking-monetary model, and the real interest differential model using quarterly data from 1973 to 1990. The exchange rates are measured by the foreign currency/pound sterling spot exchange rates. The study could not find statistical evidence in support of a long run equilibrium relationship consistent with the flexible price monetary model.

Kumar (2010) attempted to identify the determinants of real exchange rate in India using autoregressive distributed lag modeling approach studying rupee vs. US dollar. The study is based on quarterly data ranging from 2007 Q2 to 2009 Q2. The study shows that productivity differential, net foreign assets, terms of trade and openness are main determinants of real exchange rate in India.

In this study we are analyzing the link among Rupee-Dollar exchange rates and a set of macroeconomic fundamentals in Flexible Price Monetary model for the period 1996 M1 to 2010 M12.

DATA AND METHODOLOGY

We have used monthly data on spot nominal exchange rate rupee/$ from January 1996 to December 2010 for the study. We have chosen rupee as the base currency and dollar as foreign currency. M3 and M2 measures of money supply have been used as measures of stock of money for India and US respectively. Since monthly data for real GDP is not available, we have used monthly data of Index of Industrial Production (IIP) as a proxy for real income of the economy. Call money rates for India and US have been used a proxy for nominal interest rate. The IIP of India and USA, Interest rate of USA are taken from *OECD Stat database*. Rupee-Dollar exchange rate, Money supply (M3) and interest rate of India are taken from *Business Beacon* data base of Centre for Monitoring Indian Economy (CMIE). Money Supply (M2) of USA is provided in the website of Federal Reserve System, USA.

The stationary properties of the study variables have been examined as a first step in the estimation. For this purpose, Augmented Dickey Fuller (hereafter, ADF) test and Phillips and Perron (hereafter, PP) (1988) test have been employed. In all these tests the null hypothesis is that the series is nonstationary (possess a unit root) and if the calculated value exceeds the critical value (based on Mackinnon, 1996 for ADF and PP test), the null hypothesis may be rejected implying the stationary characteristics of the data series. The ADF test is a parametric autoregression to ARIMA structure of the errors in the test regression, but the PP test corrects for serial correlation and heteroskedasticity in the errors. In ADF test Schwarz Information criteria (SIC) have been used to select the appropriate lag length, whereas in PP test we have used the Newey-West using Bartlet kernel method.

Table 1: Augmented Dickey Fuller (ADF) test results

	At level form		At first difference form	
Variables	ADF statistic	PP statistic	ADF statistic	PP statistic
lnExchange rate	-1.639807	-1.933005	-9.679699*	-9.625830*
lnIIP	2.451384	2.459878	-17.71405*	-16.33961*
lnInterest rate	-0.896790	-1.009306	-6.768418*	-6.982767*
InMoney supply	-0.528977	-0.452740	-11.42380*	-11.42380*

As originally shown by Nelson and Plosser (1982), Table I indicates the non stationary characteristics of the macroeconomic study variables at log level form. But the ADF and PP test results at first difference of the log form shows that stationarity can be achieved at first difference form, implying the first order integration of the study variables. Since all study variables are integrated at first order, we are proceeding for co integration analysis since same order of integration is a precondition for the cointegration analysis.

Since the Johansen and Juselius (1990) method (hereafter JJ method) is proved to be more robust than the Engel Granger procedure(based the residual),we prefers the JJ method which uses the VAR model to test the number of cointegrating vectors and the estimation is based on Maximum Likelihood (ML) method. Following Johansen (1988) and Johansen and Juselius (1990) VAR representation of column vector X_t can be written as follows:

$$X_{(t)} = Bz_t + \sum_{i=1}^{k} \Pi_i X_{(t-i)} + \varepsilon_t \qquad (14)$$

Where X_t is column vector of n endogenous variables, z is a (n×1) vector of deterministic variables, ε is a (n×1) vector of white noise error terms and Π_i is a (n×n) matrix of coefficients. Since, most of the macroeconomic time series variables are nonstationary, VAR of such models are generally estimated in first-difference forms.

JJ test provides two Likelihood Ratio (LR) test statistics for cointegration analysis,the trace (λ_{trace}) statistics and the maximum eigenvalue (λ_{max}) statistics. The trace statistics tests the null hypothesis that the number of cointegrating relations is *r* against of *k* cointegration relations, where k is the number of endogenous variables. The maximum eigenvalue test, tests the null hypothesis that there are *r* cointegrating vectors against an alternative of *r+1* cointegrating vectors. To determine the rank of matrix Π, the test values obtained from the two test statistics are compared with the critical value from Mackinnon-Haug-Michelis (1999). For both tests if the test statistic value is greater than the critical value, the null hypothesis of *r* cointegrating vectors is rejected in favor of the corresponding alternative hypothesis. By choosing model 4 and lag interval (1, 1) we have carried out JJ cointegration test.

In table II, the JJ cointegartion trace and Max test results are given. Both the test results indicate the existence of at least one cointegrating vectors in the model at 5% significance level. Even though the Maximum Eigen value test indicates the presence of a second cointegrating vector, following Luintel and Khan (1999)[1] we are accepting the trace statistics results for the presence of one cointegrating vector. The presence of one cointegrating vector implies that the Rupee-Dollar exchange rates is related with the macroeconomic variables like money supply, real income and interest rate in the long run. This shows that the flexible-price monetary model (FPMM) is valid in the determination of Rupee-Dollar exchange rate and the variables such as money supply differential, interest rate differential and real income differential explains the changes in Rupee-Dollar exchange rate.

Table 2: Johansen and Juselius (1990) cointegartion test results

Unrestricted Cointegration Rank Test (Trace)

H_o	H_a	Eigenvalue	Max-Eigen Statistic	5% Critical Value	P value**
None	At most 1	0.204125	29.45246	27.58434	0.0285
At most 1	At most 2	0.147729	20.62071	21.13162	0.0588
At most 2	At most 3	0.052323	6.932628	14.26460	0.4971
At most 3	At most 4	0.023611	3.082412	3.841466	0.0791

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

H_0	H_a	Eigenvalue	Trace Statistic	5% Critical Value	P Value**
None	At most 1	0.204125	60.08821	47.85613	0.0024
At most 1	At most 2	0.147729	30.63575	29.79707	0.0400
At most 2	At most 3	0.052323	10.01504	15.49471	0.2796
At most 3	At most 4	0.023611	3.082412	3.841466	0.0791

**MacKinnon-Haug-Michelis (1999) p-values
Source: Author's calculation

The cointegration analysis result indicates the long run relationship between the variables. It does not explain the short term dynamics between the variables. Since the

[1] Who shown that the trace statistic is more robust than Maximum Eigen value test

variables are integrated at first order and the existence of at least one cointegrating vector among the study variables, we proceed for analyzing the short term dynamics between the variables in Vector Error Correction (VEC) Model framework. In VECM the long run causal relationship is explained through the significance of lagged error correction term (using t-test) and the short run casual relationship is explained through first difference of (using Wald-test, if there are more than one first difference of a particularly variable is used otherwise t-test will be used) explanatory variables.

$$\Delta \ln E_t = \alpha_0 + \alpha_1 ECT_{t-1} + \varphi i \sum_{i=1}^{k} \Delta ln E_{t-1} + \beta_i \sum_{i=1}^{k} \Delta ln IIP_{t-1} + \lambda_i \sum_{i=1}^{k} \Delta ln IN_{t-1} + \gamma_i \sum_{i=1}^{k} \Delta ln MS_{t-1} + \varepsilon t (15)$$ [2]

Where ECT_{t-1} is the lagged error correction term and is the residual from the cointegrating regression equation. It should be noted that the error correction term, ECT ~ I (0), captures the adjustment toward the long-run equilibrium. The coefficient α_1 represents the proportion of the disequilibrium in exchange rate in one period corrected in the next period. The above equation (2) is estimated with a general specified lag structure for all the variables in the equation (1), a constant term and one-lagged error-correction term.

Table 3: VECM test results

Variables	Statistic
Error Correction term	-0.011944**
D(Exchange rate (-1))	0.323984
D(Exchange rate (-2))	-0.135287
D(IIP(-1))	-0.073145
D(IIP(-2))	-0.107800
D(Interest rate(-1))	-0.018038
D(Interest rate (-2))	0.006376
D(Money supply(-1))	0.069206
D(Money supply(-2))	-0.055791
Constant	0.001152
R2	0.184200
S.E of the model	0.009710
AIC	-21.25
SIC	-20.28
LM test statistics	11.38693
Heteroscedasticity Tests	540.746
Joint J-B test 3	62.87

[2] E_t = Exchange rate, ECT_{t-1}=lagged error correction term, E_{t-1}=Exchange rate at lag one,$IIP_{t-1,}$ lagged industrial production index,IN_{t-1}=lagged interest rate ,MS_{t-1}=lagged money supply and ε_t= error term.
[3] Orthogonalization: Residual Covariance (Urzua)

In the VECM test results the Error correction term (ECT), which shows the speed of adjustment in the system is significant. The value of ECT is -0.01, which implies that only 1% of the disequilibrium in the system is getting corrected in one month. Since we are using two lags, Wald test has been used to examine the significance of the coefficients and the results indicate that none of them are significant implying no short term relationship between the variables. The LM test and the Heteroscedasticity test indicate that the residuals of the VECM model are free from the problems of Autocorrelation and Heteroscedasticity.

CONCLUSION

We have examined the relevance of Flexible-Price Monetary Model (FPMM) in the determination of Indian Rupee-US Dollar for the period 1996 to 2010 using monthly data on exchange rate, money supply, Index of Industrial production (IIP) and interest rate. We have used JJ cointegration analysis and VECM, to examine the relationships between the Rupee-Dollar exchange rate and macroeconomics fundamentals. The cointegration results indicate that the exchange rate is related with the macroeconomic fundamentals in the long run, while the VECM results could not find out any short run casual relationship between the variables despite the significant error correction term.

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