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Testing the Empirical Validity of Flexible Price Monetary Model of exchange rate determination between Indian Rs and US $

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Abstract
March 1993 marks the beginning of flexible rate regime in India i.e. forex rate determined by demand and supply factors. This paper tries to fill in the gap in economic literature that has till on focused on testing the empirical validity of Flexible Price Monetary model which incorporates money demand and supply into the determining exchange rates between developed economies. We do it for developing and emerging economies. Our finding is in support of the model when we look it in long run horizon.
Keywords: Flexible Price monetary model; Stationarity test; Johnson Cointegration; Granger Causality; Engel Granger method.

Introduction
March 1993 marks the beginning of flexible exchange rate regime in India. It was done as a corrective measure after India had faced the Balance of Payment crisis after oil price increase; suspension of remittances from Gulf countries, etc. Therefore, the foreign exchange rate today is determined by demand and supply of forex in the market with central bank intervening to prevent high volatility in the rates. Movement in forex rate can have critical implication for trade, capital flows and other financial developments. Timely prediction can help by giving useful information for decision makers and participants in internation finance circles.
There is a large number of research work on the monetary approach of determining the exchange rate. There are various monetary models. The three major forms are the 'Flexible Price Monetary model', (hereafter FPM), the 'Sticky Price monetary model' and the 'Real Interest differential monetary model'. Pioneering work are done by Frankel (1976) which confirms the 'sticky prices model' for mark-dollar and Bilson (1978) which confirms FLM model for pound-dollar. These researches were largely done for developed countries. Very little empirical work is found on monetary models that pertains to developing and emerging economies like India.

We focus here on the FPM model. This model, like the other two monetary models, introduces money demand and money supply in determining the exchange rate. As the name suggests, flexible price means that prices of goods and services, wages and exchange rate are perfectly flexible and can move up and down in both long and short run. The model assumes that there is perfect capital mobility; that purchasing power parity and uncovered interest parity holds all the time. According to Umoru (2013) the model assumes the money market is always in equilibrium and it further postulates that spot exchange rate is influenced by money supplies, national income and rate of interest in domestic and foreign economies.

The Model

Following the description given by (Pilbeam, 1992) the model is expressed as follows-

The demand for real money balance (money demand) in the domestic economy depends on income level, price level and interest rate. Money demand is a positive function income but a negative function of rate of interest. It can be expressed as

M/P = L(Y,i).

In log form it can be written as m-p = ϕ y- λ i

where m is log of money stock, determined by the monetary authority i.e. the central bank; p is log of price level; y is log of real income and i is the interest rate.

More formally it can be written as $m_t = p_t + \phi y_t - \lambda i_t$ – (1)

where t denote time period attached to the variable. A similar equation can be formulated for the foreign country' demand for money as $m *_t = p *_t + \phi y *_t - \lambda i *_t$ – (2)

where asterisk denote the variables for the foreign country.

As already stated above FPMM assumes PPP and UIP to hold all the time. Expressing these conditions mathematically in the log form as ($s_t = p_t - p *_t$) – (3) and ($\dot{S}_t = r_t - r_t^*$.) –(4)

Using equation 1 and 2, manipulating it in terms of p & p* and substituting it in the PPP condition, equation 3, we get $s_t = -\phi(y_t^* - y_t) + \lambda(i_t^* - i_t) - (m_t^* - m_t)$ – (5). This is called the reduced form.

We know from Fischer's equation that nominal interest rate is the sum of real interest rate and expected inflation (Dornbusch & Fischer, 1994). If real interest rate is same in two countries then the difference between nominal interest rate is equal to expected inflation differential, Pilbeam (1992) then $i_t - i_t^* = \pi_t^e - \pi_t^{e^*}$.

Substituting expected inflation differential into the reduced form equation we get

$s_t = -\phi(y_t - y *_t) + \lambda(\pi_t^e - \pi_t^{e*}) + (m_t - m *_t)$ –(6).

Three implications can be derived from this equation. (1)- If money supply in the domestic economy increases then prices will also increase. When prices increase the domestic currency will depreciate because we are assuming that the PPP holds continuously. (2)- When income increases transaction demand for money increases. To get back to the equilibrium real money balance ($M^d/P=M^s/P$) prices must fall if interest rates and money stock is held constant. Since domestic prices fall, our exports will rise and through PPP the exchange rate will appreciate. (3)- Lastly from equation 5, increase in nominal interest rate at home will lead to depreciation of the currency because UIP condition is assumed to holds.

Literature Review

Hsieh starts his paper by discussing the monetary nature in Indonesia such as the foreign exchange restrictions, the introduction of the new rupiah because of inflationary pressures and various other steps taken to safeguard the country from the Asian Financial crisis, which led to 508% depreciation of the rupiah (Hsieh, 2009). His paper tries to model the behaviour of exchange rate and use four models. One of them is the monetary model Within monetary model he uses many versions developed by Dornbusch, Frankel and Bilson.

He uses quarterly data from 1997Q1 to 2007 Q4, collected from International Financial Statistics on exchange rate, call money rate, M2 money supply, CPI and uses one lagged value of inflation as a proxy of expected inflation. He concludes that the model developed by Frankel, which is a FPM fits the data well. He defines FPM as e= f (M-M*, Y-Y*, $\pi^e - \pi^{*e}$) which is how we have defined our model in the introduction section above.

Yong and Ling in their work start by discussing that PPP and monetary models are among the many models that are discussed at length in literature (Yong & Ling). There are studies in support and against both PPP and the monetary model. The authors then go on to discuss the PPP and Monetary model in detail. In monetary model authors discuss two versions: Real Interest differential model and the FPM model. They claim that FLM is a long run model. Real interest differential model considers short term interest rates and thus will not have a long run relationship. Using quarterly data from 1978 Q1 to 1993 Q4 from the International financial Statistics for Singapore Yong & Lee test for cointegration in the FPM model. Here they use Engle-Granger two step method and found that cointegration exist in the FPM. Since cointegration was found to exists an error correction model was then developed to look for short run dynamics. They concluded that FPM did not match with the predictions made, as there were wrong signs and statistical insignificant. Further, ECM of FPM did not give satisfactory results because coefficient had wrong signs. The error correction coefficient however, in ECM of FLPM was found to be statistically significant.

Umoru (2013) in his paper discussed exchange rate management and the monetary developments in Nigeria. In 1986 due oil glut Nigerian revenue fell to very low levels and Nigeria was about to exhaust its reserves if it had continued with the fixed exchange rate regime. Under the Structural Adjustment Programme Nigeria moved to flexible exchange rate system. In light of the above he discusses various monetary models such as flexible price model and others.

Using annual data from 1975 to 2010 from the International Financial Statistics maintained by the IMF on exchange rate, real interest rate, money supply, expected inflation and national income, the author tested for the models. Using the ADF test and Phillips Peron test, it concluded that variables trended at level. He then used Johansen test for cointegration instead of Engle Granger two step giving the reason that multivariate long run relationship can be established simultaneously in this method. Cointegration test supported the existence of long run relationship. Error correction model was then tested and found to be statistically significant and signs were as expected. Paper concludes with the claim that flexible price model gives better forecast of the exchange rate compared with any other model that was estimated in the work.

Bhargavi Karamcheti, Padake, & Geetha (2018) adopts the Johansen cointegration methodology and use a VAR framework to estimate the model. Their findings on the empirical validation of the FPM model between the Indian Rupee and the US dollar that there exist cointegration between exchange rate and other variables of the FPM model i.e. there exist long run relationship between the variables. The Granger causality test also confirmed causality. It further clarifies that the variables of the model, in the short run, does not have significant impact on exchange rate movements. Though, in the long run, the impact is significant. It concludes with the assertion that the FPM model for the long run does hold true in determining exchange rate.

Erdal (2018) analyses FPM model for Turkey currency against the US dollar for the period between quarter 1 2002 to quarter 4 2013. As is the case with other literature on monetary models, this paper adopts a similar empirical testing procedure. It checks for stationarity; cointegration for long run relation, Error correction model for short run effect. It concludes with the outcome that money supply and nominal interest rate does play an effective role in the long run. However, its only the nominal exchange rate that has effect on exchange rate in the short run.

Data and methodology

This paper uses Quarterly data from 1997 Q1 to Q1 2019 to analyse the FPM model. Data on quarterly exchange rate, real income, inflation and money supply have been collected from St. Louis Fed website [1]. For real income we have used real GDP data. M1 has been used in our analysis as money supply variable. As consistent Real GDP data was not available before 2013Q1 we derived it using GDP deflator and nominal GDP expressed in national currency units from Q1 1997 that is available on St. Louis website.

For Real GDP derivation we first converted national currency units into dollar value by dividing Nominal GDP and Money supply (expressed in rupee) by the exchange rate prevailing in their respective quarters. Using the GDP deflator formula, we generated real GDP and used it as a proxy for real income. Expected inflation is substituted by one lagged period actual inflation. We follow the methodology adopted by (Dua & Ranjan, 2011) i.e. we test for stationarity, cointegration and Granger Causality and (Yong & Ling). However, in this paper we do not take in consideration impact of forward premium, capital inflows, volatility of capital flows and central bank intervention as taken by Dua & Ranjan (2011)

FPM model is a long run model. Thus, cointegration must exist between the variables of the model. We first check for Integration level I(.) of the series that is at what level the series becomes stationary. If we don't check for stationarity and simply estimate a model then there are high chances that regression results will be spurious and hence not reliable. We will use the 'Augmented

[1] Data on exchange rate, real income, inflation and money supply collected from https://fred.stlouisfed.org/series/DEXINUS

Dickey-Fuller' (hereafter ADF) test to examine whether the series is stationary or not. The common method is to test for unit root. The null hypothesis is – presence of unit root, indicating that the series is not stationary. The alternative hypothesis- no presence of unit root, meaning the series is stationary. If the series is stationary at its level, it is written as I(0). If the series becomes stationary after taking the first difference, then it is written as I(1).

If we find that series are I(0) we simply estimate the model using the least square method. If all the series are I(1) we will look at the variables and try establish long run relationship between them. This is done through cointegration test. Since the model at hand is a single equation model, we use 2 step Engle granger method to check for cointegration. This is done by running least square regression on I(1) series, then generate residual series and test for stationarity of the residual series. If residual series is I(0) then we conclude that variables does have a long run relationship. The cointegration is present simply means that a linear combination of variables in a model is stationary. We express that linear combination in terms of the residual. Thus, if the residual series is stationary then the linear combination is also stationary. If cointegration exist then there must an error correction mechanism that will take into consideration short run shocks. If the integration level of the series are different, some are I(0) and others are I(1) then we use Auto regressive distributive Lag model (ARDL).

We use $s_t = -\phi(y_t^* - y_t) + \lambda(i_t^* - i_t\ ) - (m_t^* - m_t)$ since real GDP differential and money supply differential cannot be calculated in log terms for India-USA. When money supply increases in USA then prices in USA will also increase (from the quantitative theory of money) i.e. P* increases. Since PPP is assumed to hold Rupee will appreciate. Thus, a negative sign. When interest rate in USA will be higher than interest rate in India, liquid capital will flow out of India to get better returns from abroad. And thus, demand for US dollar will increase and hence India rupee must depreciate. Therefore, a positive sign.

RESULTS

We begin by checking for stationarity of all the variables. We use the Augmented Dicky fuller method to test for unit root. Our results for the unit root test at level are shown in the table 1 and table 2 in appendix. The Level of significance chosen is 1%.

From the stationarity test we may conclude that all the variables are I(1). Since all the series in this paper are I(1) it is expected that there exist a long run relationship between the variables. We check this using Johnson cointegration test. The Null hypothesis H_o:- nonexistence cointegration and alternative hypothesis H_1:- presence of cointegration. We test this using Engle-Granger 2 step method. The corresponding equation used is $s_t = -\phi(y_t^* - y_t) + \lambda(i_t^* - i_t\ ) - (m_t^* - m_t)$.

From table 3 and table 4, shown in appendix, we can reject the null hypothesis since the residual series is stationary at level i.e cointegration is present thus there exist a long run relation between exchange rate and other variables of the FPM model. It is also confirmed using the Granger causality test that money supply does granger causes the exchange rate

CONCLUSION

This paper tries to bridge the gaps in economic literature concerned with testing the empirical validation of FLM model of determining the exchange rate for developing and emerging economies. We follow a similar methodology of testing the model that are followed in the empirical researches conducted on this same model in developed economies. We tested for stationarity, followed by Johnson cointegration and Granger causality. We find that there exists long run relationship between the exchange rate and the variables i.e. money supply, interest rate of FLM model and that these granger causes the exchange rate. We have not investigated the short run effect. Further research can be done using a vector autoregressive model and error correction model to test for short run effects.

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APPENDIX

(Table 1)

Result of Unit Root test for Stationarity of each Time series variable at Level using Augmented Dicky Fuller method

Variable	Test	Type	P value	Interpretation
E	ADF	Trend & Intercept	0.012	Unit root present
		Intercept	0.04	Unit root present
		Without intercept and trend	0.99	Unit root present
M_t*-M_t	ADF	Trend & Intercept	0.83	Unit root present
		Intercept	0.99	Unit root present
		Without intercept and trend	0.99	Unit root present
Y_t*-Y_t	ADF	Trend & Intercept	0.21	Unit root present
		Intercept	0.43	Unit root present
		Without intercept and trend	1.00	Unit root present
$\pi_t^{e*} - \pi_t^e$	ADF	Trend & Intercept	0.14	Unit root present
		Intercept	0.09	Unit root present
		Without intercept and trend	0.07	Unit root present

Source: Author's calculation using Eviews's student version

(Table 2)
Result of Unit Root test for Stationarity of each Time series variable at Level using Augmented Dicky Fuller method

Variable	Test	Type	P value	Interpretation
E	ADF	Trend & Intercept	0.0000	No unit root present
		Intercept	0.0000	No unit root present
		Without intercept and trend	0.0000	No unit root present
M_t*-M_t	ADF	Trend & Intercept	0.0001	No unit root present
		Intercept	0.0000	No unit root present
		Without intercept and trend	0.0089	No unit root present
Y_t*-Y_t	ADF	Trend & Intercept	0.0000	No unit root present
		Intercept	0.0000	No unit root present
	ADF	Without intercept and trend	0.0060	No unit root present
$\pi_t^{e*} - \pi_t^e$	ADF	Trend & Intercept	0.0000	No unit root present
		Intercept	0.0001	No unit root present
		Without intercept and trend	0.0000	No unit root present

Source: Author's calculation using Eviews's student version

TABLE 3

Least Square Estimate of FPM model

LOG_ST = C(1)*LOG_REAL INCOME DIFF+C(2)*INT DIFF-C(3)*LOG_MS DIFF

		Standard Error	t-stat	Probability
COEFFICIENT_1	0340625	0.022232	15.32163	0.0000
COEFFICIENT_ 2	0.000708	0.001787	0.396124	0.6930
COEFFICIENT_3	-0.50787	0.024061	-21.108	0.0000
R^2	0.863175			
Adj R^2	0.859993			
Regression' S.E	0.029486			

Source: Author’s calculation of Regression using Eviews’s student version

TABLE 4

Residual Series Unit root test result

Null Hypothesis: RESID01 has a unit root			
Lag Length: 0			
		t-stat	probability
ADF test statistic		-3.57993	0.0005
Critical values	1%	-2.57188	
	5%	-1.94177	
	10%	-1.61607	

Source: Author’s calculation of RESID01 using Eviews’s student version.