Hindco Research Journal ISSN: APPLIED
(A Multidisciplinary Research Journal) 2018, Volume – 1; Issue – 1;
http://mdthinducollege.org/hindco_journal.html Page 91

Casual Relationship Between Foreign Exchange Rate and Foreign Exchange Reserves: An Empirical Study

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Introduction

As Bretton Wood system has collapsed several low income and developing countries have made remarkable increase in their accumulation of external reserves. Afraid among the foreign exchange policy markets have prevailed about the uncertainties of the flexible exchange rate system introduced after the collapse of Bretton Woods System. So as to intervene in the foreign exchange markets and shrink foreign exchange volatility along with achieve price stability accumulation of external reserves continued unabated. These accumulations are made regardless of whatever effects they have on the exchange rates itself price stability and volatility of both. Despite the accumulations, policies and measures to manage external reserves, volatility and inflationary pressures persist. This paper, therefore, made an attempt to investigate the causal relationship between foreign exchange rate and foreign exchange reserves in India using the annual data.

In this study, the variables Foreign Exchange Rate (EXR) and Foreign Exchange Reserves (FOREX) have been converted into their natural logarithms to avoid the problems of heteroscedasticity. The entire estimation procedure consists of four steps: unit root test; co-integration test; the vector auto regression test and Wald test estimation.

Methodology

The time series data of the foreign exchange reserves (only foreign exchange currency reserves considered here) and the exchange rate (Indian

Rupee versus U.S. Dollar) during 1970-71 to 2014-15 has been taken for analysis. EXR (Exchange rate) is the dependent variable and FOREX (Foreign Exchange Reserves) is the independent variable The data is being statistically processed using Unit Root Test to check the stationary of the variables under consideration, Johansan Co-integration test to analyze the long run relationship between exchange rate and foreign exchange reserves and VAR (Vector Auto Regression) model was used to find the long and short run relationship between the variables.

Unit Root Test

The econometric methodology of the unit root test first examines the stationarity properties of each time series of consideration. The present study uses Augmented Dickey-Fuller (ADF) unit root test to examine the stationarity of the data series. It consists of running a regression of the first difference of the series lagged once, lagged difference terms and optionally, a constant and a time trend. This can be expressed as follows:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \alpha_2 Y_{t-1} + \sum_{j=1}^{P} \alpha_j \Delta Y_{t-j} + \varepsilon_t$$

The additional lagged terms are included to ensure that are uncorrelated. In this ADF procedure, the test for a unit root is conducted on the coefficient of Y_{t-1} in the regression. If the coefficient is significantly different from zero, then the hypothesis that Y_t contains a unit root is rejected. Rejection of the null hypothesis implies statioarity. Precisely, the null hypothesis is that the variable Y_t is non-statioarity series (Ho : $\alpha_2 = 0$) and is rejected when α_2 is significantly negative ($Ha : \alpha_2 < 0$). If the calculated value of ADF statistic is higher than McKinnan's critical values, then the null hypothesis (H_0) is not rejected and the series is non-stationarity or not integrated of order zero, I(0). Alternatively, rejection of the null hypothesis implies stationarity. Failure to reject the null hypothesis leads to conducting the test on the difference of the series, so further differencing is (variables) are non-stationarity in their levels, they can be integrated with I(1), when their first differences are stationary.

Co-integration Test

Once the unit roots are confirmed for data series, the next step is to examine whether there exists a long-run equilibrium relationship among the variables. This calls for co-integration analysis which is significant so as to avoid the risk of spurious regression. Co-integration analysis is vital because if two no-stationary variables are co-integrated, a Vector Auto-Regression (VAR) model in the first difference is mis-specified due to the effect of a common trend. If co-integration relationship is identified, the model should include residuals from the vectors (lagged one period) in the dynamic VECM system. In this stage, Johansen's co-integration test is used to identify co-integration relationship among the variables. The Johansen method applies the maximum likelihood procedure to determine the presence of co-integrated vector's in non-stationary time series. The testing hypothesis is the null of non-co-integration against the alternative of existence of co-integration using the Johansen maximum likelihood procedure.

In the Johansen framework, the first step is the estimation of an unrestricted, closed p^{th} order VAR in k variables. The VAR model as considered in this study is:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots.. + A_p Y_{t-p} + BX_t + \varepsilon_t$$

Where Y_t is a k –vector of non-stationry I(1) endogenous variables, X_t is a d-vector of exogenous deterministic variables, $A_1, \ldots\ldots, A_p$ and B are matrics of coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

Since most economic time series are non-stationary, the above stated VAR model is generally estimated in its first-difference form as:

$$\Delta Y_t = \prod Y_{t-1} + \sum_{i-1}^{p-1} \Gamma \Delta Y_{t-i} + BX_t + \varepsilon_t$$

Where

$$\prod = \sum_{i=1}^{p} A_i - I, \quad \text{and} \quad \Gamma_i = \sum_{j=i+1}^{p} A_j$$

Granger's representation theorem asserts that if the coefficient matrix $\prod$ has reduced rank r < k, then there exist k × r matrices E and B each with rank r such that $\prod = \alpha \beta'$ and β' Y_t is I(0). r is the number of co-integration relations (the *co-integrating rank*) and each column of β is the co-integrating vector. α is the matrix of error correlation parameters that measures the speed of adjustments in ΔY_t.

The Johansen approach to co-integration test is based on two test

statistics, viz., the trace test statistic, and the maximum Eigen value test statistic.

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Trace Test Statistic

The trace test statistic can be specified as: $\tau_{trace} = -T \sum_{i=r+1}^{k} \log(1-\lambda_i)$, where λ_i is the largest Eigen value of matrix $\prod$ and T is the number of observations. In the trace test, the null hypothesis is that the number of distinct co-integrating vector(S) is less than or equal to the number of co-integration relations (*r*).

Maximum Eigen Value Test

The maximum Eigen value test examines the null hypothesis of exactly r co-integrating relations against the alternative of *r* + 1 co-integrating relations with the test statistic: $\tau_{\max} = -T \log(1-\lambda_{r+1})$, where λ_{r+1} is the $(r+1)^{th}$ largest squared Eigen value. In the trace test, the null hypothesis of *r*=0 is tested against the alternative *r* +1 co-integrating vectors.

It is well known that Johansen's co-integration test is very sensitive to the choice of log length. So, at first a VAR model is fitted to the time series data in order to find an appropriate lag structure. The Akaie Information Criterion (AIC), Schwarz Criterion (SC) and the Likelihood Radio (LR) test are used to select the number of lags required in the co-integration test.

Hence we proceed to the vector auto regression model without alluding to the adjustment parameters that ought to be sought through VECM method in case of a cointegrated trend.

VAR Model

A typical autoregressive model of order p is used when the variables concerned are depending on 'p' lag. In below we write the equation that models such n autoregressive process.

$$Y_t = c+a_1Y_{t-1}+\ldots\ldots\ldots a_pY_{t-p}+\varepsilon_1$$

We note that are stochastic terms incorporating the fluctuations or noises attributed to certain unexpected events happening. A vector auto regression model is considered when n number of variables together follows a correlation with influences from past (lagged) values of themselves. We also note that in our specific case the value of n and the value of p. The AI criteria is the one through which we have fixed two lags for our VAR model, since taking lag we get the required stationary of the time series ensemble. The equation is a typical autoregressive model for a single variable. Let represent the variable in the AR model corresponding to, represent the variable in the AR model corresponding to and so on. Thus we have the vector incorporating all the variables that we have considered which we denote for simplicity as indicating its value for the current time series. Similarly its lags are denoted by etc. Thus the autoregressive model considering all the macroeconomic variables reads as in equation.

Results of Unit Root Tests

It was felt that prior to causality testing, it is essential to examine the time series properties of the given variables in differences. Now, it is required to determine the order of integration for each of the two variables used in the analysis along with their stationarity tests. Stationarity of the LnEXR and LnFOREX series has been examined using Augmented Dicky Fuller tests and the results are presented in Table 1, 2, 3 and 4.

Table 1

Unit Root Test at Levels

Variable (SIC)	**Intercept**	**P - Value**	**Trend & Intercept**	**P – Value**	**None**	**P - Value**
LnEXR	-0.210	0.929	-1.141	0.910	2.313	0.994
LnFOREX	-0.601	0.859	-1.848	0.664	3.992	1.000
	1 % C V -3.588		1 % C V -4.180		1 % C V -2.619	
	5% C V -2.929		5% C V -3.515		5% C V -1.948	
	10% C V -2.603		10% C V -3.188		10% C V -1.612	

Source: Researcher's own calculation.

Table 2

Unit Root Test at Levels

Variable (AIC)	**Intercept**	**P - Value**	**Trend & Intercept**	**P – Value**	**None**	**P - Value**
LnEXR	-0.549	0.871	-2.254	0.352	2.313	0.994
LnFOREX	-0.601	0.859	-2.999	0.144	3.992	1.000
	1 % C V -3.592		1 % C V -4.234		1 % C V -2.619	
	5% C V -2.931		5% C V -3.540		5% C V -1.948	
	10% C V -2.603		10% C V -3.202		10% C V -1.612	

Source: Researcher's own calculation.

The ADF statistics were calculated for the variables in levels and first differences (defined as natural logarithms – log). The order of the ADF test was chosen on the basis residual whiteness. Table 1 and 2 clearly show that the series of each variable at level were non-stationary at 10 per cent, 5 per cent and 1 per cent level of significance. Hence we move on to first difference.

Table 3

Unit Root Test at First Differences

Variable (SIC)	Intercept	P - Value	Trend & Intercept	P – Value	None	P - Value
LnEXR	-4.468	0.000	-4.410	0.005	-3.394	0.001
LnFOREX	-5.148	0.000	-5.099	0.000	-3.940	0.000
	1 % C V -3.592 5% C V -2.931 10% C V -2.603		1 % C V -4.186 5% C V -3.518 10% C V -3.189		1 % C V -2.619 5% C V -1.948 10% C V -1.612	

Source: Researcher's own calculation.

Table 4

Unit Root Test at First Differences

Variable (AIC)	Intercept	P - Value	Trend & Intercept	P – Value	None	P - Value
LnEXR	-4.468	0.000	-4.410	0.005	-2.140	0.032
LnFOREX	-5.148	0.000	-5.099	0.000	-2.501	0.013
	1 % C V -3.592 5% C V -2.931 10% C V -2.603		1 % C V -4.186 5% C V -3.518 10% C V -3.189		1 % C V -2.619 5% C V -1.948 10% C V -1.612	

Source: Researcher's own calculation.

Table 3 and 4 presents the calculated t-values from ADF tests on each variable in first differences. Although we have included trend in levels, we exclude it in first differences. Since the calculated values were greater than the critical value at 5 per cent level for LnEXR and LnFOREX, none of them have unit root, when their first differences have taken. The results of the ADF tests indicate that the variables were integrated of order one, that is I(1).

Results of Co-integration Tests

In the next step, the co-integration between the stationary variables has been tested by the Johansen's Trace and Maximum Eigen value tests. The results of these tests are show in Table 5 and 6.

Table 5

Unrestricted Co-integration Rank Test (Trace)

Co-integration Equation	Eigen value	Trace statistics	5% critical value	Probability **
None	0.162	7.894	15.494	0.476
At Most 1	0.006	0.273	3.841	0.601

Source: Researcher's own calculation.
**Mackinnon – Haug – Michelis (1999) p – values.

Table 6

Unrestricted Co-integration Rank Test (Maximum Eigen)

Co-integration Equation	Eigen value	Max-Eigen statistics	5% critical value	Probability **
None	0.162	7.621	14.264	0.418
At Most 1	0.006	0.273	3.841	0.601

Source: Researcher's own calculation.
**Mackinnon – Haug – Michelis (1999) p – values.

The p value at None (no variables being co-integrated), At most 1 (1 variable co-integrated) in Trace Statistics as well as the p value at None (no variables being co-

ISSN: APPLIED
2018, Volume – 1; Issue – 1;

integrated), At most 1 (1 variable co-integrated) in Maximum Eigen Statistics indicating that LnEXR and LnFOREX were not co-integrated and do not exhibit long run relationship among themselves. As the variables under consideration do not exhibit co-integration we undertake unrestricted VAR (Vector Auto Regression) model.

Vector Auto Regression Tests

The results of Vector Auto Regression test have been presented in Table 7.

Table 7

Vector Auto Regression Test for Long Run Correlation

	Coefficient	Standard Error	t - Statistics	Probability
C (1)	0.0425	0.0458	0.9278	0.3597
C (2)	0.2615	0.1761	1.4847	0.1463
C (3)	0.2180	0.1738	1.2542	0.2178
C (4)	-0.0730	0.0366	-1.9944	0.0637
C (5)	-0.0285	0.0380	-0.7508	0.4576
C (6)	0.0464	0.0156	2.9787	0.0052

R squared	0.2767	Mean dependent variance	0.0497
Adjusted R squared	0.1763	S.D. dependent variance	0.0701
S.E. of regression	0.0636	Akaike info criterion	-2.5383
Sum squared residuals	0.1459	Schwarz info criterion	-2.2901
Log likelihood	59.305	Hannan-Quinn criterion	-2.4473
F statistic	2.7551	Durbin-Watson statistic	2.1907

Source: Researcher’s own calculation.

The VAR output indicates that coefficients of Foreign Exchange Reserves at different lags C4 and C5 in the equation show p values of 0.0637 and 0.4576 respectively which are insignificant indicating that the Foreign Exchange Reserves variable does not exhibit a long run correlation with the exchange rate, neither the Exchange Rate coefficients as independent variables exhibit any long run correlation with Foreign Exchange Reserves.

Wald Tests for Short Run Correlation

The results of Wald test have been presented in Table 8.

Table 8

Wald Test for Short Run Association

<table>
<tr><th>Test Statistic</th><th>Value</th><th>df</th><th>Probability</th></tr>
<tr><td>Chi-square</td><td>5.5890</td><td>2</td><td>0.0611</td></tr>
<tr><td colspan="4">Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:</td></tr>
<tr><th colspan="2">Normalized Restriction (=0)</th><th>Value</th><th>Standard Error</th></tr>
<tr><td colspan="2">C(4)
C(5)</td><td>-0.0730
-0.0285</td><td>0.0366
0.0380</td></tr>
</table>

Source: Researcher's own calculation.

The short run correlation between foreign exchange rate and foreign exchange reserves can be quantified by Wald test for C4 and C5 the chi square statistic p value being 0.0611 which is greater than 1 per cent indicating that C4=C5=0 and jointly do not influence the exchange rate. Thus the statistical analysis clearly rules out both long run as well as short run relationship among the variables Exchange Rate and Foreign Exchange Reserves.

Conclusion

The quantum of foreign exchange reserves essentially does not exhibit a long run or short run correlation with the exchange rate in case of Indian economy. Although the accumulation of foreign exchange reserves are unprecedentedly high thereby exhibiting a marked departure from the thumb rule ratios suggested by several researchers, it does not have a direct bearing on the exchange rate as suggested by some authors and there could be many other parameters that contribute to excessive fluctuating in the currency exchange rate between a U.S. Dollar and Indian Rupee. The foreign exchange reserve accumulation in the Indian context could have been largely in anticipation of overcoming financial crisis than a tool for regulating the exchange rate. It could also be looked upon as a face lift to the Indian economy through enhanced credit ratings which in turn would attract investors to India in the form of foreign direct investment and portfolio investments thereby supplying the much needed capital for stimulating economic growth.

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