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The Interaction Between Exchange Rate, Interest Rate and Inflation Rate: The Case of India.

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Abstract
The purpose of this article is to empirically analyze the long and short runs association of exchange rate, interest rate and inflation rate in Indian context. In order to establish this relationship monthly data from January 2021 to March 2025 were used. Unit Root Test (Augmented Dickey Fuller test) revealed that all the variables are stationery at second difference and hence was used for further long run investigation. Johansen and Juselius co-integration test suggest the existence of actual long-run relationship between exchange rate, inflation rate and interest rate in India. The coefficient of the second error correction term in the exchange rate equation is positive which shows a strong evidence of a stable long-run relationship between the exchange rate and the explanatory variables (interest rate and inflation). In the short run, none of the lagged values of interest rates and inflation rate are statistically significant in influencing the Exchange Rate. Results of Granger Causality indicated the presence of unidirectional causal association between Inflation rate and Exchange rate which indicates causality is running from the inflation rate to the exchange rate. Further the results also suggest that Interest rates and Exchange rates do not have any causality relationship among them.

Key Words- Exchange rate, Interest Rate, Inflation Rate, VECM, Granger Causality, ADF Test.

1. Introduction

Post economic liberalisation in India, exchange rates played a vibrant role in the country's role of trade and economic growth. It has been observed that India has benefited from the flexible exchange rate system but at the same time faced threat from constant devaluation of currency especially post Covid 19. US dollar becoming stronger than the rupee and higher level of volatility in the foreign exchange market generates a negative impact on the investment inflow as it is susceptible to exchange rate risk. To maintain the excessive volatility in foreign exchange market, the policy of high-interest rate is adopted which brings the exchange rate stability. As Emerging Market Economies (EMEs) remain susceptible to external shocks, a strong foreign exchange reserves becomes imperative for these countries, Das (2024).

India has majorly played in the interest rate as one of the parameter towards controlling the volatility in the exchange rate. Moreover in developing countries like India Interest rate is one of the important factor which boosts capital inflow as investors get better return in comparison to their home country which lead to rupee appreciation. Nevertheless an increase in the interest rate owing to control inflation increases additional burden on the government which can further lead to inflation. Like any other developing economy, India's external debt to gross domestic product (GDP) ratio is quite high. There are different views in regard to the relationship between the interest rate and exchange rate, some stating that higher domestic rate of interest would attract capital inflows and simultaneously appreciation in the exchange rate appreciation. On the other hand economists are of the view that increase in interest rate reduces the demand for money and lead to capital outflows; rise in inflation

which tends to depreciation in currency. Higher interest rate increases the risk premium and causing exchange rate depreciation Furman et al. (1998).
The intent of this study is to probe into the course of relationship existing among three significant economic variables namely Exchange rate, Interest rate and Inflation rate in Indian context. Specifically our intention is to determine the relationship that exists between exchange rates, the interest rates and the level of inflation.

The paper has been organised as per the following: Section I introduces the topic, Section II of the paper assesses the literature in the concerned area of the study, Section III of the manuscript explains the methodology or the tactics of the study, Section IV includes the analytical work and discussion and thereby the study has been concluded in Section V.

2. Literature Review

Asari et al. (2011) examined the connections between Malaysia's inflation rate, interest rates, and exchange rates over the period from 1999 to 2009. Their findings suggested that raising interest rates would effectively reduce exchange rate volatility. They also identified a unidirectional causal relationship running from interest rates to inflation and from inflation to exchange rates. However, their study concluded that no causal relationship existed between inflation and exchange rates.
Gul and Ekinci (2006) identified a unidirectional causal relationship running from exchange rates to inflation in Turkey between 1984 and 2003. Additionally, they highlighted that the relationship between exchange rates and inflation differs depending on the economic structure of each country. In contrast, Rana and Dowling (1985) concluded in their study of 9 Asian countries that exchange rate policy had no significant impact on inflation.
In a study on the Turkish economy (1993), Rittenberg identified a unidirectional relationship from inflation to the exchange rate. He discovered that the devaluations occurred after 1980 were not the principal driver of domestic price changes, and inflation played a key role in determining exchange rate movements.
Similarly, Kholdy and Sohrabian (1990) in their econometric study discovered a bidirectional causal relationship between the general price level and exchange rates in selected countries based on a Granger causality analysis.
Nordin et al. (2018) in their study examined the Long Run Dynamic Relationships between Oil Prices, Exchange Rates, Stock Market and Interest Rate in Malaysia using Weekly data from 1 January 2006 until 22 April 2018. ARDL test and Johansen and Juselius cointegration test suggest the existence of actual long-run relationship between oil price, stock price index, exchange rate and interest. The study identified unidirectional causality between oil prices and Malaysian stock market. They also identified bidirectional causality between interest rate and oil prices and existence of uni-directional causality running from the exchange rate to the oil prices.
Khan (2014) has examined factors which influence the exchange rate variability in Pakistan. The study was conducted during May 2006 to April 2013. It analysed the effects of inflation, interest rate, oil prices, and trade balance on exchange rate variability. It concluded that inflation significantly impacts exchange rate variability.
Özen et.al.(2020) in their study to measure the impact of changes in exchange rates and interest rates or inflation and also to determine whether the exchange rates or interest rates has a greater impact on inflation rate, found that there is a long-term relationship between the inflation rates and both the exchange rate and interest rates. Moreover it specified that the effect of the exchange rate on the inflation is greater than that of the interest rates.
Mehmood et al. (2023) conducted research on the influence of macroeconomic variables on the foreign exchange rates in SAARC nations. Analysing data from 1981 to 2019, the research applied

the Fully Modified Ordinary Least Square method, finding that GDP, trade openness, inflation and tariff rates inversely impact the exchange rate.
On the basis of the empirical literature on the relationship between interest rate, inflation rate and exchange, we postulate exchange rate as a function of interest rate and inflation rate.

3. Methodology

The Theoretical Framework

The identified model is a three variable model which hypothesize that Exchange Rate as a function of interest rate and inflation rate.

3.1 Relationship between Exchange Rate and Inflation

As per the purchasing power parity; the value of one country's national currency versus another country's currency depends on the prices of similar products and services in those countries. The arbitrage mechanism leads to the elimination of the difference between the prices of a product in different markets. Purchasing power parity attempts to compare the different purchasing powers of each country according to the general price level (and not the exchange rate). This makes it possible to determine the country with the most expensive cost of living. Changes in purchasing power parity affect the exchange rate. If inflation is the same in both countries, the exchange rate does not change. If it is higher in one country than in the other, this is when inflation affects the exchange rate. The currency with the higher inflation rate then loses value and depreciates, while the currency with the lower inflation rate appreciates on the Forex market due to increase in the domestic demand for foreign commodities and lowers the foreign demand for domestic commodities, which, in turn, would lead depreciation of domestic currency

3.2 Relationship between Exchange Rate and Interest Rate

Interest rates are measured as the cost of borrowing. Central banks utilise interest rates to stabilize the exchange rate and control inflation. Covered interest parity theory implies that, the interest rate differential between domestic and world interest rate is equal to the expected change in the domestic exchange rate. Therefore, a higher interest differential would attract foreign capital, leading to exchange rate appreciation vice versa; lower interest rates can cause capital outflows, resulting in depreciation.

3.3 Data Description and Analytical tools used

This study intends to analyse the relationship between exchange rate (ER), inflation rate and the interest rate (IR). The data on Indian exchange rate monthly exchange rate in INR/USD, CPI as Inflation rate and Bond rate as Interest rate. The sample employs monthly data from 1st January 2021 until 31st March 2025 consisting of 51 monthly data gathered from Investing.com, tradingeconomics.com and RBI website.

Table 1. Highlights the descriptive statistics of the variables.

	N	Minimum	Maximum	Mean	Std. Deviation
Interest Rate	51	5.71	7.46	6.8618	0.47382
Inflation Rate	51	3.10	7.80	5.4980	1.10100
Exchange Rate	51	72.51	87.47	80.1377	4.38459
Valid N (listwise)	51				

A set of tools and techniques have been adopted to arrive at descriptive statistic such as central tendency, standard deviation minimum and maximum value which provide a useful summary and

inferential statistics such as Unit Root Test (Augmented Dickey Fuller test), Johnson's Co integration test, Vector error correction model and Granger Causality test has been employed to establish relationship variables using statistical package SPSS and R.

3.3.1 Unit root test (Augmented Dickey –Fuller test)

Time series data is stationary if the data characteristics such as mean and variance, do not change over time. The Augmented Dickey Fuller unit root test developed by Dickey, D. and W. Fuller (1979) is on the basis of the null hypothesis that H0: Yt is not I (0), thus H (0) specifies the data of the specified variable is not stationary or got unit root. However, if the value of the calculated ADF test statistic is less than the critical value, then the null hypothesis stands discarded. However, if the variable does not attain stationarity that is when the null hypothesis is accepted than the ADF test will be carried out at the first difference. The entire model with trend and intercepts is shown in equation (1):

$$\Delta Y_t = \alpha + \beta T + \rho Y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta Y_{t-i} + e_t \ \dots\dots\dots\dots\dots (1)$$

$\boldsymbol{Y_t}$ is the variable selected for the period t, Δ is the difference operator, T denotes a time trend, e_t is an error term disturbance with mean 0 and variance as σ^2 , and k corresponds to the number of lags of the differences in the ADF equation. The unit root test is conducted on the basis of the coefficient of y_{t-1} in the regression. Thus, if the coefficient is significantly less than zero then the hypothesis that variable data series contains a unit root is rejected.

3.3.2 Johansen co integration Test

The Johansen's co-integration test is being considered as a compact maximum likelihood test that assists for examining co-integration in a whole system of equations. Johansen, S. and K. Juselius, (1990) co-integration test through Co-integration Rank Test has been used to determine if there subsist long run association between the variables in the study. Thus, if the error term arising from the linear combination of two variables is stationary, then co-integration relationship exist between the two variables which further clearly specify that long run affiliation exist between these variables. The trace statistics test is being specified in the following equation (4):

$$Trace\ (r,k) = -T \sum_{i=r+1}^{k} \ln (1 - \lambda_i) \dots\dots\dots\dots . (4)$$

Where λi is the i the largest eigen value, and T is the number of observations in the variable selected. In this Trace test the null hypothesis states that there exists no co-integration between the variables whereas alternate hypothesis states there is co-integration between the selected variables.

3.3.3 Vector Error Correction Model (VECM)

In case co-integration has been noticed within the set of variables than it can be stated that long term relationship exists between them. If the variables having one or more co-integrating vector then a suitable estimation technique is a Vector Error Correction Model which adjusts to both short run changes in variables and deviations from equilibrium. General form of VECM model used is:

$$\Delta Y\ t = a_1 + a_2\ ec\ t\ 1 + a_3\ \Delta Y\ t\ 1 + a_4\ \Delta X\ t\ 1 + \epsilon\ t\ .$$

A crucial parameter in the estimation of the VECM dynamic model is the coefficient of the error correction term, (ECT1), which measures the adjustment of exchange rate (dependent variable) to its

equilibrium level. With VECM all the variables are taken as endogenous (ΔY) and exogenous (ΔX), in order to establish the long and short run association between them.

3.3.4 Granger Causality Test

Granger Causality method developed by Engle and Granger (1987) has been used to locate the path of causality among the variables. It is a tool for discovering if one time series data is substantial in estimating another set of selected variables or not.

The null hypothesis (H_0) framed is that the variable X does not Granger cause variable Y and variable Y does not Granger cause variable X. To test for granger the following regression equation (2) and (3) can be applied. Therefore, Granger Causality test is used to determine whether there is a cause-effect relationship between variables and to determine the direction of causality relationship if any. The Granger causality test equations are as follows (Gujarati, 2001).

$$Y_t = \beta_0 + \sum_{k=1}^{M} \beta_k Y_{t-k+} \sum_{l=1}^{N} \propto_l X_{t-l} + u_t \dots\dots\dots\dots\dots\dots (2)$$

$$X_t = \gamma_0 + \sum_{k=1}^{M} \gamma_k X_{t-k+} \sum_{l=1}^{N} \delta_l Y_{t-l} + v_t \dots\dots\dots\dots\dots (3)$$

Where X_t and Y_t are the time series data variables to be tested, and u_t and v_t are mutually uncorrelated errors, t refers to the time period and 'k' and 'l' are the number of lags.

4. Data Analysis and Interpretation

Table 2: Augmented Dickey-Fuller Unit Root Test

Variables Test	Statistic Z(t)	P-value	Null Hypothesis	Result
Interest Rate	-0.5679	0.9755	Accept	Variable is not stationary
Inflation Rate	-1.8426	0.6376	Accept	Variable is not stationary
Exchange Rate	-1.569	0.7476	Accept	Variable is not stationary

Source: R Package, critical values at 5% level of significance

The ADF test statistics given in Table 2 reveals that the variables do not attain stationarity in the time series data set. Since the Sig Value or P value of the three variables namely is greater in comparison with the critical P-value at 95% level of confidence interval. Therefore, the null hypothesis was accepted which connotes variables are not stationary and ADF test was carried out for the variables not attaining stationarity by taking the second difference to the time series of Interest Rate, Inflation rate and Exchange Rate in Table 3.

Table 3: Result of ADF second difference

Variables Test	Statistic Z(t)	P-value	Null Hypothesis	Result
Interest Rate	-5.8178	0.01	Reject	Variable is stationary
Inflation Rate	-6.6714	0.01	Reject	Variable is stationary
Exchange Rate	-7.0963	0.01	Reject	Variable is stationary

Source: R Package, critical values at 5% level of significance

Table 3 illustrates the result of the ADF test after taking the second difference. The resultant value of the ADF test statistics are compared with critical values for the variables Interest Rate, Inflation rate

and Exchange Rate which specifies that the variables attain stationary and can be taken for further analysis.

Table 4: Johansen and Juselius Co-integration Test

Maximum Rank	Trace Statistics	P Value	Result of Null Hypothesis
r <= 2	41.99	9.24	Reject There is cointegration
r <= 1	94.49	19.96	Reject There is cointegration
r = 0	159.34	34.91	Reject There is cointegration

Source: R ; Note: Table 4 shows the result of Johansen co-integration test with constant trend and lag 2 using Trace Statistics

Following to determination of unit roots and integration at second order, Johansen co-integration tests was applied to divulge whether co-integration exists among these variables. Johansen and Juselius Cointegration Test uses two tests namely Maximum Eigenvalue test and Trace test. Trace test has been done to determine the r cointegrating relations against the alternative of r+1 cointegrating relations for r = 0, 1, 2…n-1.

The above table 4 enclose a separate row for each likely value of r that is the number of co-integrating vectors. The value of trace statistic at r = 0 is 159.34 go beyond the critical value of 34.91 and thereby rejecting the null hypothesis of no co-integrating equations. Thus, from the above table it is apparent that r from 0 to 2, the value of trace statistics is higher than the 5 % critical value. Consequently, we accept the alternate hypothesis for each of the co-integrating vectors which specifies the presence of more than one co-integrating vectors. We consider that the variables are co integrated each other, which means they have long term association or they move collectively in long run. The outcome depicts that presence of long run association among inflation rate, interest rate and exchange rate in India.

Table 5: Vector Error Correction Model Estimates

Regressor	**Coefficient**	**Standard Error**	**Significance**
ECT1	-0.0845	(0.0537)	–
ECT2	0.9190	(0.4229)	* (p < 0.10)
Intercept	2.9649	(2.6527)	–
Exchange rate (-1)	-0.4309	(0.1648)	* (p < 0.10)
Interest Rate (-1)	0.0826	(1.1121)	–
Inflation Rate (-1)	0.1942	(0.1812)	–
Exchange rate (-2)	-0.1278	(0.1548)	–
Interest Rate (-2)	-1.4980	(1.0816)	–
Inflation Rate (-2)	0.2829	(0.1747)	–

Note: Standard errors in parentheses indicate significance at the 10% level.

The presence of cointegration between variables suggests a long term relationship among the variables under consideration. The Vector Error Correction Model (VECM) was estimated to examine both the short-run dynamics and long-run adjustment of the exchange rate in response to changes in the interest rate and inflation. Table 5 presents the estimated VECM results with EXCHN3 (exchange rate) as the

dependent variable. The error correction terms (ECTs) capture the speed at which the exchange rate adjusts to deviations from the long-run equilibrium. The coefficient of the second error correction term (ECT2) in the exchange rate equation is positive and statistically significant (0.9190, $p < 0.10$), indicating that approximately 92% of the disequilibrium from the previous period is corrected in the current period. This provides strong evidence of a stable long-run relationship between the exchange rate and the explanatory variables (interest rate and inflation).

In contrast, ECT1 is negative but statistically insignificant, suggesting that the first co-integrating vector does not meaningfully influence the long-run adjustment of the exchange rate. Overall, the significance of ECT2 confirms that monetary fundamentals (interest rate and inflation) jointly exert long-term influence on the exchange rate.

In the short run, the exchange rate is significantly influenced by its own first lag (Exchange Rate (-1)), with a coefficient of -0.4309 ($p < 0.10$), indicating short-run persistence.

However, none of the lagged values of interest rates (Interest Rate (-1), Interest Rate (-2)) and inflation (Inflation Rate (-1), Inflation Rate (-2)) are not statistically significant in influencing the exchange rate (Exchange Rate) in the short run. This implies that in the short term, changes in interest rates and inflation do not significantly affect the exchange rate, suggesting that other factors might be driving the short-term movements of the exchange rate.

Table 6: Granger Causality Test

Null Hypothesis	F statistic	P Value	Result
Interest Rate does not Granger Cause Exchange Rate	1.365	0.2662	Accept Null Hypothesis
Exchange Rate does not Granger Cause Interest Rate	1.0048	0.3747	Accept Null Hypothesis
Inflation Rate does not Granger Cause Exchange Rate	3.5022	0.0392	Reject Null Hypothesis
Exchange Rate does not Granger Cause Inflation Rate	0494	0.9519	Accept Null Hypothesis

Table 6 highlights the outcomes of Granger causality. Interest rates do not have predictive power over future exchange rates in this model. This means past values of interest rates do not help predict future movements in the exchange rate. Consequently, Exchange rates do not have predictive power over future interest rates in this model. This means past values of exchange rates do not help predict future interest rates. The results explain that there is a unidirectional causal association between Inflation rate and Exchange rate which indicates causality is running from the inflation rate to the exchange rate at 5 % level of significance by acceptance of the alternate hypothesis due to the smaller P value in comparison with the confidence interval. Thus, the past values of inflation can help predict future exchange rate movements. Furthermore, the outcome revealed that that Inflation rate granger cause Exchange rate, whereas exchange rate does not grangers cause inflation. This means past exchange rate values do not help predict future inflation rate movements.

5. Conclusion

The relationship between the Exchange rate, interest rate and exchange rate has always been a source of severe concern for economic and financial researchers. Exchange market plays an important role in achieving economic growth and development of a country through mobilization and efficient direction of funds. The current study was able to examine the existence of relationship between the exchange rate, inflation rate and the interest rate. Augmented Dicky Fuller test was done to check the nature of stationarity of the time series data. After stationarity of the data at second difference Johansen and Juselius co-integration test was done which revealed that long term co-integrating

relationship exists among the selected variables. The coefficient of the second error correction term from the Vector error correction model revealed a strong long run relationship among the exchange rate and the explanatory variables. Results of Granger Causality indicated the presence of unidirectional causal association between Inflation rate and Exchange rate which indicates causality is running from the inflation rate to the exchange rate. It is clear indication that inflation is an important factor in creating an impact on the exchange rate and therefore measures should be taken to control the inflation because of its probable impact on the exchange rate.

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