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DETERMINANTS OF THE FOREIGN EXCHANGE RATE OF INDIA: AN ECONOMETRIC ANALYSIS

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ABSTRACT

The foreign exchange rate is considered to be an excellent indicator of an economy's competitiveness for global trade. Exchange rate volatility is one important component escalating the risks related to the financial markets. When currency rates fluctuate excessively, it has a negative impact on foreign trade and investments. The current study has made an effort to identify the various macroeconomic variables that influenced India's nominal exchange rate from 1991 to 2021 with the help of time series analysis. Augmented – Dickey Fuller test is used to test the stationarity of the variables. Johansen's Cointegration test and Vector Error Correction model are used to study the long and short-run relationship between the variables. The results suggested that in the short run all the variables except inflation rate have a significant impact on the nominal exchange rate of India. In the long run, the coefficient of GDP and Trade openness are negative which implies that a 1 per cent increase in GDP and trade openness will lead to appreciation of the Indian Rupees. The coefficient of INF and TR are positive which implies that a 1 per cent increase in INF and TR will lead to depreciation of the Indian Rupees. Variance Decomposition analysis results indicated total foreign exchange reserves and GDP have strong influence on the exchange rate of India as compared to inflation and trade openness.

Keywords: *Nominal Exchange Rate, VECM, Johansen Cointegration Test, Variance Decomposition.*

Introduction

The foreign exchange rate is a significant financial factor that influences the decisions made by investors, exporters, importers, lenders, financial institutions, and policymakers. Changes in exchange rates have an effect on a number of variables, including investment portfolios, exports and imports, the value of foreign exchange reserves, the cost of international travel, and the value of debt payments in various currencies (Dua & Ranjan, 2010). Thus, changes in exchange rates have a significant impact on the business cycle, trade, and capital flows of the economy, making them crucial to comprehend financial trends and changes in economic policy. The role of exchange rates has changed in importance from the perspective of policymakers and market participants due to the growing integration of international financial markets, necessitating a reliable evaluation of exchange rate movements, hence it is important to study the macroeconomic factors that cause movement in the foreign exchange rate.

There are several macroeconomic factors that create pressure on the foreign exchange rate. Many macroeconomic variables affect a nation's exchange rate, and examining these variables will help stabilize the country's exchange rate. Stančík & Stančík (2006) studied the sources of exchange rate fluctuations and found economic factors such as money supply, inflation, level of output, interest rate,

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trade openness, and central bank independence as determinants of the foreign exchange rate. Similarly, Hassan et al.(2017) explained the sources of exchange rate volatility of Nigeria using the cointegration and error correction model and found that variables like fiscal balance, interest rate, nominal gross domestic product, economic openness, and net foreign assets have a substantial impact on the exchange rate volatility.

The objective of this study is to examine the macroeconomic indicators that impact the nominal exchange rate of India using econometric methods. The macroeconomic variables chosen in the study are selected on the basis of theoretical and empirical analysis of the previous research works.

Remaining research paper consists of: Section 2 summarizes the review of literature. Data description and Methodology are explained in Section 3. Section 4 presents the Data analysis and results; the last section concludes the paper.

Review of Literature

Various empirical studies have been conducted on determinants of foreign exchange rate in different nations using time series analysis in different time periods. Different studies have used different independent variables to analyse the factors affecting the foreign exchange rate.

Hassan, Abubakar, and Dantama (2017) analysed the sources of exchange rate volatility in Nigeria for the period of 1989 to 2015. Variables used in the study were net foreign asset, fiscal balance, economic openness, oil price, nominal gross domestic product, interest rate... Augmented Dickey Fuller test(ADF) and Phillips and Perron (PP) tests were used to check the stationarity of the variables. Cointegration results showed that there is a positive and significant impact of Net foreign asset and Interest rate on Exchange rate volatility whereas Nominal GDP had negative impact on the exchange rate volatility. Error correction model showed that there is a high speed of adjustment from short run equilibrium towards long run equilibrium.

Saibu & Adeoye (2014) examined the sources of fluctuations in exchange rate from monetary policy shocks in Nigeria. The explanatory variables in the study are interest rate, money supply, inflation rate, reserve money, real output. Exchange rate used in the study is Naira/USD. Engle-Granger(EG) Cointegration and Error Correction Model (ECM) concluded that there existed a long and short-run relationship between the monetary policy shocks and exchange rate volatility.

Saradhi& Goel (2014)studied the relation between capital inflows and real exchange rate in India using Auto regressive distributed lag model. The independent variables were net capital flows, government consumption expenditure, terms of trade, trade openness, GDP growth rate, current account balance and forex reserves. Net capital flows in India are positively related with the real exchange rate appreciation.

Ajao et al. (2013) studied the influence of public expenditure, money supply, openness of the economy, productivity index, and real interest rate on the exchange rate volatility for the period of 1981 to 2008 in Nigeria. GARCH model was used to generate real exchange rate from nominal exchange rate. To study the short term and long-term relationship between the variables, ECM and cointegration test revealed that government spending and real exchange rate had a positive impact whereas openness of the economy and real interest rate had a negative impact on exchange rate volatility. Money supply and productivity index were not significant in their impact.

Mirchandani (2013) analysed the determinants of exchange rate of India using correlation analysis. The macroeconomic variables used in the study were Interest rate, inflation rate, current account deficit, GDP Growth, Foreign capital and investment flow. The study concluded that there is a significant correlation between the independent variables and exchange rate.

Kishor (2012) studied the determinants of the Indian foreign exchange market that determine the movement in USD/INR using multiple regression. The study concluded that there is significant impact of the lagged value of USD/INR, current account balance, relative money supply have a significant impact on USD/INR. There was a minimal effect of forward premia, capital account balance, RBI intervention on USD/INR.

Dash(2012) studied the factors affecting exchange rate of India using Johansen cointegration and error correction model. The explanatory variables used in the study were interest rate, intervention by the central bank, and inflation rate differential. Study concluded that Interest rate and intervention by the central bank have a negative influence on the exchange rate whereas inflation rate is not significant in its impact.

Kumar(2010)examined the determinants of real exchange rate using the quarterly data for the period of Q2 of 1997 to Q2 of 2009 for India using ARDL approach. Variables included in the study are growth differential, government final consumption expenditure, terms of trade, external openness, and foreign exchange assets. The study concluded that growth differential, terms of trade and foreign exchange assets had a negative and a significant impact on the exchange rate volatility whereas external openness had a positive and a significant impact.

Inoue(2009)studied the sources of exchange rate fluctuations in India. The explanatory variables included in the study are nominal exchange rate, real exchange rate, relative output of India with the US and Euro area. Monthly data was taken for the period of 1999 to 2009. Exchange rate used in the study are USD/INDIAN RUPEES and EURO/INDIAN RUPEES. Vector Autoregressive Model(VAR) was used to study the causation of variables. Study found out that in India and USA, real demand shocks explain 97% of variation in real exchange rate whereas real supply shocks explain 2% of variation in real exchange rate whereas in India and Euro area, real demand shocks explain 96 % and real supply shocks explain 2% variation in exchange rate volatility.

Suthar(2008) studied the determinants of exchange rate of India using interest rate differential, money supply, foreign exchange reserves as explanatory variables using regression analysis. The study concluded that short term and long term interest rate differential and foreign exchange reserves had a significant impact on the exchange rate of India.

From the above studies, it can be concluded that there are various determinants that affect the foreign exchange rate of India. It can be examined from the various studies that inflation rate, foreign exchange reserves, trade openness, interest rate, GDP, central bank intervention have a significant impact on the exchange rate. The present study is an attempt to examine the determinants of foreign exchange rate of India using econometric methods in order to provide robust results using the recent data. The determinants are selected on the basis of the above review of literature.

Data and Methodology

Data

The independent and dependent variables are chosen for the study on the basis of review of literature. The annual data is obtained for the period from 1991 to 2021. The dependent variable is the nominal exchange rate of India in the Indian Rupees/US Dollar. It means an increase in the exchange rate will lead to depreciation of Indian Rupees and decrease will lead to appreciation of the Indian Rupees. The independent variables are real gross domestic product (Real GDP), inflation rate, trade openness, and total foreign exchange reserves. For estimating purposes, the log value of all the variables are obtained. The data source of all the variables is World Development Indicators of the World bank. A detailed description of the variables is listed in Table 1.

Table 1: Description of the Variables Used

Variable Name	Form of the Variable
Nominal exchange rate	US Dollar/ Indian Rupee (Period Average)
Gross Domestic Product (Real in US Dollars) Base = 2015	Measured in US Dollars Base = 2015
Inflation Rate	Measured by Consumer Price Index
Trade openness	(Total Trade / GDP)*100
Total foreign exchange reserves	foreign exchange reserves including gold in US Dollar

Source- Authors' Compilation

Methodology

For examining the relation between nominal exchange rate of India and macro-economic variables, regression technique is used and following model is prepared.

$$lnXR_t = \alpha 0 + \alpha 1 lnRGDP_t + \alpha 2 lnIF_t + \alpha 3 lnOPEN_t + \alpha 4 lnTR_t + u_t \quad (1)$$

Where XR, dependent variable, is nominal exchange rate of India and independent variables are: RGDP is real gross domestic product; IF is inflation rate; OPEN is trade openness and TR is total foreign exchange reserves, u_t is the error term.

The study in the first instance, analyses correlation and descriptive analysis of the variables. Then optimal lag selection is determined according to the Akaike Information Criterion.

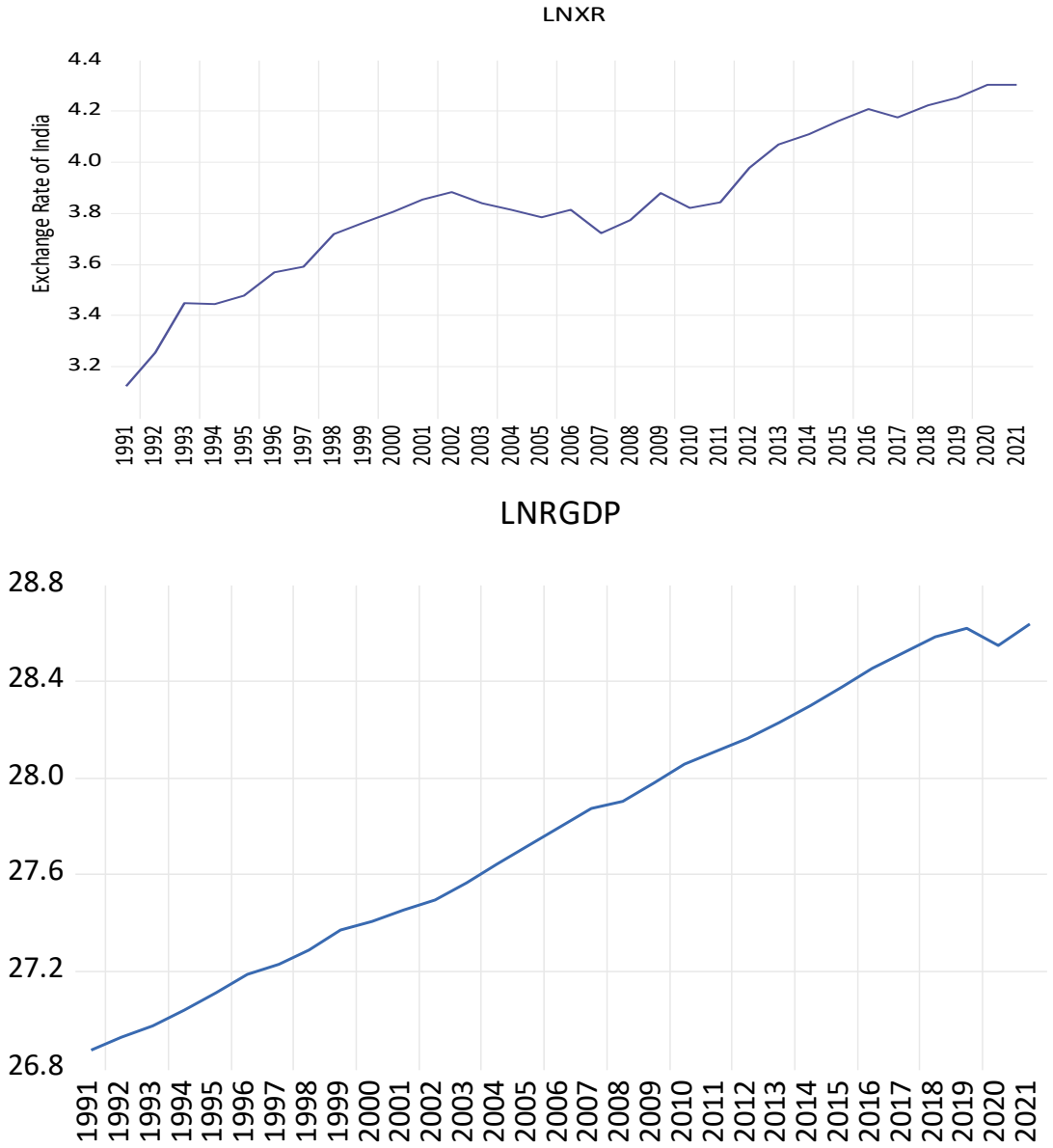
The stationarity of the variables is examined using the Augmented Dickey-Fuller (ADF) unit root test. Afterwards, Johansen Cointegration test is conducted to study the long-run relationship in the model. After cointegration is established, VECM (Vector Error Correction Model) estimates the long-run and short run relation. VECM is a cointegrated VAR, consisting of p-1 lags on the differences of the variable and an error correction term derived from the estimated cointegration relationship which shows the speed of adjustment towards the long run equilibrium. Further, Variance Decomposition analysis is estimated to study the unexpected variation in each variable that is produced by shocks from other variables.

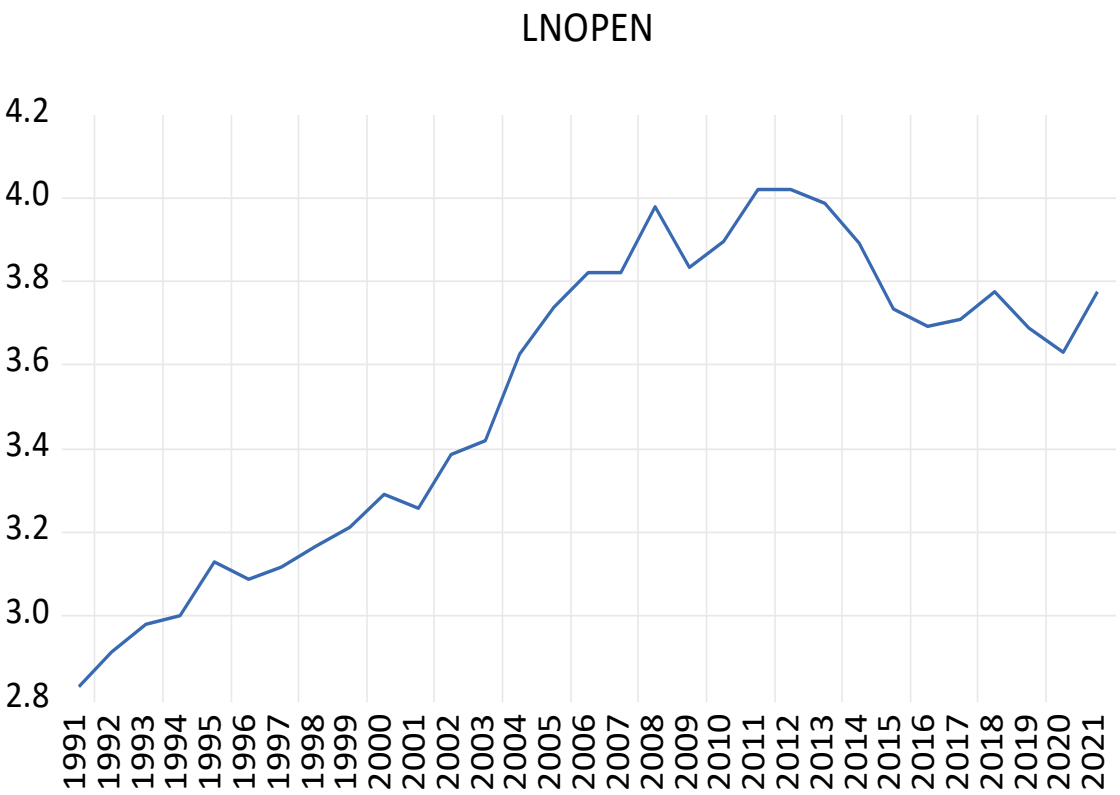
Data Analysis and Results

- **Trends of Selected Variables**

Trends of log of nominal exchange rate(XR), real gross domestic product (RGDP), inflation rate(IF), trade openness(OPEN), and total foreign exchange reserves (TR) are depicted in Figure1.

Figure 1: Graphical Representation of the Dependent and Independent Variables




LNOPEN
4.2
4.0
3.8
3.6
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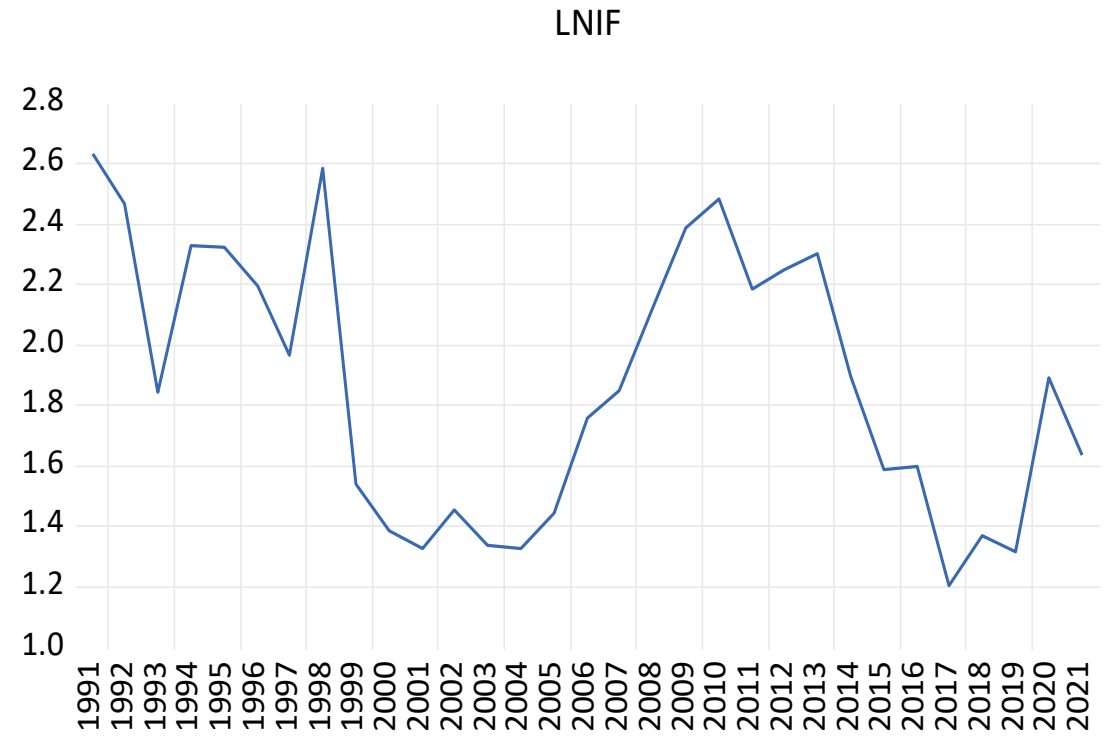
LNIF
2.8
2.6
2.4
2.2
2.0
1.8
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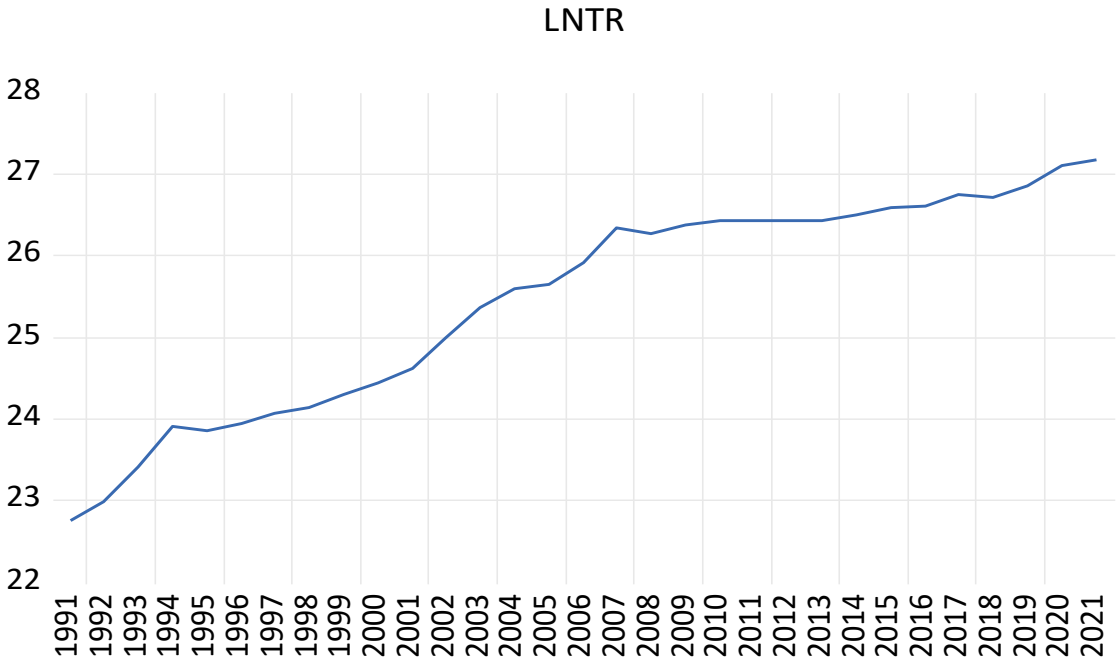
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021



Graphical analysis of all the variables except log of inflation rate and trade openness shows an upward trend. Log of inflation rate and trade openness shows fluctuations during the time period of the study. Graph of exchange rate also demonstrates fluctuations over the years.

- **Descriptive Statistics and Correlation Analysis**

The correlation and descriptive statistics of the independent and dependent variables are listed in Table 2 and Table 3 respectively. It gives a basic idea of the variables used in the study.

Table 2: Correlation Analysis

Variables	lnXR	lnRGDP	lnIF	lnOPEN	lnTR
LnXR	1				
Ln	0.93434308	1			
Lnif	-0.5359469	-0.3639389	1		
Lnopen	0.72315065	0.83929849	-0.1801336	1	
Lntr	0.89327205	0.96396733	03409302	0.92625370	1

Source- Authors' Computation

Table 2 shows that GDP, trade openness and total forex reserves have positive and significant correlation with nominal exchange rate of India whereas inflation has negative and significant correlation with the exchange rate. Table 3 presents the results of the descriptive statistics of the variables.

Table 3: Descriptive Statistics

Variable	ln XR	ln RGDP	ln IF	ln OPEN	ln TR
Mean	3.839493	27.78861	1.871347	3.530059	25.45000
Median	3.822671	27.79868	1.852052	3.687942	25.90533
Maximum	4.305410	28.63644	2.629764	4.021661	27.18236
Minimum	3.121880	26.87634	1.202424	2.832491	22.75352
Std. Dev.	0.301629	0.563724	0.443391	0.369655	1.326481
Skewness	-0.358307	-0.007633	0.138799	-0.384040	-0.516553
Kurtosis	2.711285	1.715755	1.646337	1.75302	1.899944
Jarque- Bera	0.770985	2.130627	2.466393	2.756733	2.941684
Probability (J-B)	0.680116	0.344620	0.291360	0.251990	0.229732
Observations	31	31	31	31	31

Source- Authors' Computation

In Table 3, Descriptive statistics shows the nature of the variables. All the variables are negatively skewed except the inflation rate. Kurtosis measures whether the data set is highly tailed or lightly tailed as compared to the normal distribution. In case of all the variables, kurtosis value is greater than zero, indicating leptokurtic nature of the variables. Jarque Bera's test of normality shows that all the variables are normally distributed.

- **Unit Root Test Results**

In time series analysis, it is required to check the stationarity of the variables. To check for the stationarity, Augmented– Dickey Fuller (ADF) test is applied. Table 4 presents the results of the ADF test which checks for the presence of unit rootin the variables.

Table 4: Unit Root test (Augmented Dickey-Fuller Test)

Variables	Level		First Difference	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
lnXR	-2.301947	-2.890193	-4.661654***	-4.679920***
lnRGDP	-0.820813	-2.832042	-5.060961***	-5.084635***
lnIF	-2.609255	-2.545571	-6.663502***	-6.597967***
lnOPEN	-1.964836	-0.905929	-4.693736***	-5.007237***
lnTR	-2.579019	-1.552072	-3.948086***	-4.381130***
*** represents the coefficients are significant at 1per cent level				

Source- Authors' Computation

Results from the stationarity test (Table 4) indicate that all the variables are integrated of order one, I(1) . That means, variables are non-stationary at their level forms andbecome stationary after their first difference, making Johansen Cointegration test justified.

- **Lag Length Criteria**

Before estimating Johansen cointegration, the appropriate lag length is to be determined. In this study, lag length is determined using Akaike Information Criterion as it provides better results as compared to other criteria. The results of different lag selections are given in Table5.

Table 5: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	17.61744	NA	2.88e-07	-0.870168	-0.634427	-0.796337
1	185.1634	265.7626*	1.60e-11	-10.70093	-9.286482	-10.25794
2	213.8060	35.55635	1.47e-11*	-10.9521*	-8.358994	-10.14000

Note- * indicates lag order selection by the criterion

From Table 5, Akaike Information Criterion (AIC) shows the lag length of 2 is appropriate for further analysis.

- **Cointegration Results**

To test for the presence of long run relationship between the exchange rate and its determinants, Johansen Cointegration Test is applied. The results of the test are presented in Table 6.

Table 6: Johansen Cointegration Test (Maximum Eigenvalue)

Hypothesized no. of Cointegration Equation(s)	Eigenvalue	Trace statistic	0.05Critical value	Probability value
None*	0.865688	56.21251	33.87687	0.0000
At most 1 *	0.761903	40.18216	27.58434	0.0007
At most 2*	0.599860	25.64634	21.13162	0.0108
At most 3	0.371600	13.00820	14.26460	0.0782
At most 4	0.261479	8.486963	3.841465	0.0036
Maximum – eigenvalue test indicates 3 cointegrating equations at the 5 percent level *Denotes rejection of the hypothesis at the 5 % level				

Source- Authors' Computation

Johansen cointegration test (Maximum eigenvalue statistic) indicates a long run relationship in the model. Null hypothesis of no cointegration is rejected at 5 per cent level. Maximum Eigenvalue statistics show that there are at most three cointegrating equation in the model. Overall, there exists long run relationship between the nominal exchange rate and macroeconomic variables in the model.

- **Vector Error Correction Model (VECM) Results**

After cointegration is established among the variables, Vector error correction model is estimated to examine the long and short run model. VECM results are listed below in Table 7.

Table 7: VECM Results (Long Run)

Variable	lnXR	lnGDP	lnINF	lnOPEN	lnTR	C
	1.000	-0.982 (0.164) [-5.971]	0.198 (0.042) [4.674]	-0.778 (0.198) [-3.918]	0.530 (0.117) [4.516]	12.332

Source- Author's Computation

Note: Standard errors in () and t-statistic in []

The long run VECM model is represented as:

$$ECT_t^{-1} = 1.00\ \ln XR_{t-1} - 0.982510 \ln RGDP_{t-1} + 0.198353\ \ln IF_{t-1} - 0.778607\ \ln OPEN_{t-1} + 0.530414 \ln TR_{t-1} + 12.33288$$

In the long run, the coefficient of GDP and Trade openness are negative which implies that a 1 per cent increase in GDP and trade openness will lead to appreciation of the Indian Rupees relative to US Dollar by 0.98 and 0.778 per cent respectively. It implies that as GDP rises, demand for goods and services of the domestic economy in the international market also rises, which increases the demand of the domestic currency and this makes Indian Rupees to appreciate. Theoretically, the coefficient of OPEN can be negative (Obstfeld and Rogoff, 2002). They argued that because of the price rigidity in the non-traded goods, a larger real exchange rate changes would be required for a relatively closed economy to ensure equilibrium in the domestic economy.

The coefficient of INF and TR are positive which implies that a 1 per cent increase in INF and TR will lead to depreciation of the Indian Rupees by 0.19 and 0.53 per cent respectively. This is in contrast to the theoretical argument that as inflation rises in the economy, prices of goods and services increases which reduces exports and increases imports. This cause value of domestic currency to depreciate and foreign currency to appreciate. This is in contrast with the theory, which states that as the foreign exchange reserves increase, this leads to appreciation of the domestic currency.

The VECM short run results are presented in Table 8.

Table 8: Vector Error Correction Model Results (Short Run)

Variable	Coefficient	Std. Error	t-statistic	Probability Value
ECT_{t-1}	-0.381010	0.077469	-4.918231	0.0001
$\Delta\ \ln XR_{t-1}$	-0.371167	0.156507	-2.371568	0.0269
$\Delta\ \ln RGDP_{t-1}$	-1.276151	0.327790	-3.893195	0.0008
$\Delta \ln IF_{t-1}$	0.006121	0.026690	0.229337	0.8207
$\Delta \ln OPEN_{t-1}$	-0.280003	0.121894	-2.297100	0.0315
$\Delta \ln TR_{t-1}$	-0.152539	0.050737	-3.006457	0.0065
Constant	0.155728	0.027598	5.642700	0.0000
R- Square – 0.647105 Adj. R-Squared – 0.550860 Durbin- Watson Stat- 1.766660				

Source- Authors' Computation

The short run model in equation form can be represented as:

$$\Delta \ln XR_t = -0.3810\ ECT_{t-1} - 0.371167\ \Delta \ln XR_{t-1} - 1.276151\ \Delta \ln RGDP_{t-1} + 0.0061\ \Delta \ln IF_{t-1} - 0.280003\ \Delta \ln OPEN_{t-1} - 0.152539\ \Delta \ln TR_{t-1} + 0.155728 \quad (3)$$

As can be seen from the VECM results in Table 7, the coefficient of error correction term is negative and significant, which shows the speed of adjustment towards the long equilibrium. It can be said that disequilibrium of the nominal exchange rate of India is able to correct in the range of 38 per cent within a year.

In the short run, a 1 per cent increase in GDP, trade openness and total foreign exchange reserves will lead to appreciation of the Indian currency by 1.27 per cent, 0.28 per cent and 0.15 per cent respectively. Inflation rate is insignificant in this study in the short run.

- **Diagnostic Test Results**

The model is tested by various diagnostic tests. Table 9 illustrates the results for the Serial Correlation Lagrange - Multiplier test and Heteroskedasticity test.

Table 9: Residual Diagnostic Tests

Test	Test statistic	P- value	Conclusion
VEC Residual Serial Correlation LM test	LRE Stat = 23.11848	0.5706	No Serial correlation in residuals
VEC Residual Heteroskedasticity Tests	Chi- Square = 192.4909	0.2487	No Heteroskedasticity in residuals

Source- Authors' Computation

Results from Table 9, show that the residuals are homoscedastic in nature and model is free from autocorrelation problem. This means that the estimated model's long-term relationship is stable, and any short-term disequilibrium will gradually be fixed over time.

- **Variance Decomposition Results**

Variance Decomposition analysis depicts how much information each independent variable adds to the exchange rate. It is used to evaluate the relative contributions of various factors or sources of variation to the overall variation seen in a dataset. The results are presented in Table 10.

Table 10- Variance Decomposition Analysis of Lnxr

Period	Std. error	Lnxr	Lngdp	Lnif	Lnopen	Lntr
1	0.040489	100.0000	0.00000	0.0000	0.000000	0.00000
2	0.073490	71.43459	3.191370	3.011114	0.010811	22.35211
3	0.100438	61.25243	6.257750	3.406660	0.151012	28.93214
4	0.122494	58.64247	11.55106	2.548573	1.248573	26.00932
5	0.135116	59.07834.	11.43734	2.343289	1.929999	25.21103

Source- Authors' Computation

Variance decomposition results (Table 10) indicates relative impact of a variable on the other. Variance decomposition results indicate that in long run, 59.07 per cent of exchange rate is explained by exchange rate itself, 11.43 per cent of exchange rate is explained by GDP, 2.34 per cent by inflation rate, 1.92 per cent by trade openness and 25.21 per cent by foreign exchange reserves. Total foreign exchange reserves and GDP have strong influence on the exchange rate of India as compared to inflation and trade openness. The major portion in explaining exchange rate is GDP and Total foreign exchange reserves.

Summary and Conclusion

Emerging economies frequently experience instability and shocks in the exchange rate. In a country like India, where international trade is an important pillar of the economy, it becomes relevant to study the determinants of the foreign exchange rate of India. In this research work, time series analysis has been done to study the determinants of India's nominal exchange rate from 1991 to 2021 using Real GDP, Inflation Rate, Trade Openness and Total Foreign Exchange reserves as its determinants.

The empirical findings of the cointegration analysis demonstrated that the independent variables have a long-term relationship with the nominal exchange rate of India. The coefficients of the VECM indicated a fair rate of adjustment toward long-term equilibrium. Analyzing the coefficients of the independent variables in the long-run model, an increase in GDP and trade openness leads to the appreciation of the Indian currency and whereas increase in foreign exchange reserves and inflation will lead to depreciation in the Indian context. In short run, all the variables except the inflation rate have a significant impact on the exchange rate. Variance decomposition analysis indicated that a major portion of the nominal exchange rate of India is explained by forex reserves and GDP. From these results, it can be concluded that growth in GDP of India, appreciates the Indian Rupee. Inflation needs to be kept under control in order to prevent the Indian Rupee's depreciation.

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