

Factors Influencing Rupee-Dollar Exchange Rate in the Post-Reform Period: An ARDL Approach

Tarif Hussain^{†*} and Amiya Sarma[‡]

Abstract

In the era of growing global economic integration, international transactions such as trade, investment, and financial activities have become inevitable for every country, and central to these activities is the exchange rate. Nowadays, the Indian economy is more open, and hence, the stability of the rupee-dollar exchange rate (₹/\$ ER) has become a crucial issue for the economy. Despite the historic 1993 reform in the Indian exchange rate management system, the rupee remained highly volatile, especially against the dollar, raising questions about the factors driving its fluctuations. The present study aims to identify these factors. The study employs the ARDL model, using annual data from reliable sources such as the Reserve Bank of India (RBI) and the World Bank for the post-reform period (1993-2023). The analysis reveals a long-run cointegrating relationship among the variables in the reference period. The estimated long-run ARDL model suggests that, among the selected macroeconomic factors, inflation and the interest rate are significant determinants of the ₹/\$ ER in the post-reform period, and that, among the selected external factors, foreign portfolio investment (FPI), the current account balance, and oil prices are significant determinants of the ₹/\$ ER in the post-reform period. However, the short-run dynamics highlight the role of interest rates and FPI alone, while the error-correction term confirms a moderate adjustment toward equilibrium. Identification of the significant factors affecting the ₹/\$ ER would help in implementing policies to control these factors, at least to some extent, which may help to keep the ₹/\$ ER more or less stable. The findings underscore the interconnectedness of monetary policy, trade dynamics, and global financial flows in shaping exchange rate behaviour.

Keywords: Macroeconomic Factors; Foreign Portfolio Investment; Crude Oil Prices; ARDL Model; Cointegration; Monetary Policy

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Introduction

In the era of growing global economic integration, international economic activities such as trade, investment, and financial transactions play a vital role in shaping nations' economic trajectories. Central to these activities is the exchange rate, that is, the price of one currency in terms of another. The exchange rate is a unique economic variable that reflects the interaction of various socio-economic and policy factors and influences a nation's economic stability, trade competitiveness, and capital flows.

India's economic landscape underwent a significant transformation in the early 1990s, with structural reforms reshaping multiple sectors. Before 1993, India operated under a pegged exchange rate regime, in which the rupee-dollar exchange rate (₹/\$ ER) was controlled by the Reserve Bank of India (RBI) through predetermined interventions. This regime limited the role of market forces in determining exchange rates. In 1993, India adopted a market-determined exchange rate regime, marking a paradigm shift that brought endogenous factors to the forefront of the determination of the Indian rupee's exchange rate. However, severe instability has been observed in the ₹/\$ ER since the 1993 reform.

This historical transition of India's exchange rate mechanism underscored the growing importance of understanding the factors driving exchange rate behaviour, especially in an economy transitioning towards liberalisation and globalisation. Despite its critical role in economic policymaking, the determinants of the ₹/\$ ER were not adequately explored. While studies on the determination of exchange rate are abundant for advanced economies, research specific to India is relatively sparse and fragmented. Existing studies often focus on isolated factors or limited time spans, failing to capture the comprehensive, dynamic interplay among macroeconomic and external variables. Furthermore, India's reliance on foreign capital inflows, exposure to global crude oil price fluctuations, and prolonged current account

shortfalls create unique challenges for its exchange rate stability. These factors necessitate a thorough examination of the determinants of the ₹/\$ ER, particularly in the post-reform period, when market forces began to play a dominant role.

The findings of this research are expected to inform policymakers about the drivers of exchange rate fluctuations and their broader economic implications. This knowledge can help in designing strategies to manage exchange rate volatility, improve trade competitiveness, and enhance India's resilience to global economic shocks. Additionally, this study contributes to the academic discourse by providing empirical evidence on the interconnectedness of domestic and external factors in shaping exchange rate behaviour.

The rest of the paper is organised into five sections. The next section presents a brief review of extant literature. The section following this highlights the research question and study-centric objectives. Section four details the data sources and the methods used. The subsequent section outlines the findings, while the concluding section wraps up the study and highlights the study's significant economic implications.

Review of Literature

In economic literature, the exchange rate occupies a fundamental stance since the start of international transactions. There are many debates and conflicts among researchers, economists, and policymakers regarding various issues related to exchange rates. Determining a currency's exchange rate is not a straightforward task. A substantial body of literature seeks to identify the significant factors that determine currency value. In this section, some key factors affecting currency exchange rates have been highlighted, as acknowledged by the extant literature.

Inflation Rate: It is said that the currency of a country with a higher inflation rate depreciates against the currency of another country with a lower inflation rate. This is because there is an

inverse relationship between the inflation rate and purchasing power. The studies by Arora et al. (2014) for the period 1991-2013 and Kaur (n.d.) for the period 1991-2017 found that the inflation rate proportionally affects the ₹/\$ ER. Furthermore, studies by Goyal (2004), Narang (2014), Singh (2013), and Younus (2014), found that higher inflation rates were among the tributaries of rupee depreciation.

Interest Rate: The interest rate, along with the inflation rate, affects the forex rate by influencing capital flows. A relative change in the home interest rate influences capital flows, which in turn affect the demand and supply for foreign exchange and thereby the forex rate. Empirical studies such as Arora et al. (2014), Hossain and Ahmed (2009), Singh (2007), Singh (2013), Srikanth and Kishor (2012), and Younus (2014) conclude that interest rate is one of the crucial determinants of the ₹/\$ ER.

GDP: An increase in GDP indicates more productions, which reflect the greater demand for the products of a nation concerned. A greater demand for the products of a nation raises its home currency's demand, which will raise the currency's external value. In this way, a higher GDP growth rate appreciates currency (Beers, 2022). The empirical study by Younus (2014) suggested that lower growth in India led to depreciation of the rupee.

Money Supply: The monetary approach asserts that a relative increase in the supply of home currency leads to a proportional decline in its value, and vice versa. Thus, a higher money supply is associated with a decline in currency value (Arora et al., 2014; Dua & Sen, 2013; Krugman & Obstfeld, 2003; Srikanth & Kishor, 2012).

Fiscal Health of the Government: High fiscal deficits and public debt raise inflation in a country, discouraging capital inflows. As a result, demand for the home currency will decline, leading to its depreciation. The large government deficit, along with high public debt, is widely cited as the factor behind the rupee depreciation (Hossain & Ahmed, 2009; Narang, 2014; Singh, 2013; Younus, 2014).

Current Account Balance (CAB): The CAB of a country reflects a country's spending and earnings in foreign exchange. A country's current account shortfall signals increased foreign-exchange demand in the country, contributing to a weakening of its home currency. Cerra and Saxena (2002), Narang (2014), Singh (2013), and Srikanth and Kishor (2012) found that a huge shortfall in the current account adversely affects the rupee value.

Capital Flow: A larger inflow of foreign capital into a country raises demand for the country's currency, which tends to appreciate the currency (Goyal, 2004; Singh, 2007). On the contrary, a greater outflow of capital from a country tends to depreciate the home currency. Goyal (2004), Narang (2014), Singh (2013), and Younus (2014) conclude that greater outflows and lower inflows of foreign capital contributed to rupee depreciation.

Oil Price: Oil exports, imports, or both are inevitable for every country. In an oil-importing country like India, a rise in oil prices increases foreign exchange demand (especially for USD), which tends to weaken the home currency (Alam et al., 2020; Beckmann et al., 2020; Dawson, 2007; Nandelenga & Simpasa, 2020; Singh, 2013).

Terms of Trade (TOT): A favourable TOT (an increase in export prices relative to import prices) of a country implies the attractiveness of its products to foreign countries, signifying the higher demand for the country's currency, which will strengthen the external value of the home currency. Thus, an improvement in the TOT appreciates the home currency (Cerra & Saxena, 2002; Twin, 2022).

Reserves: The central bank of a country often uses reserves as an effective tool to regulate fluctuations in its currency's value, especially under a fixed or pegged exchange rate system. Dash and Narayanan (2011) found a long-run relationship among reserves, imports, and the rupee's exchange rate (nominal) during the timeframe of 1974 to 2008.

Political Condition: A country experiencing political instability is unable to build investor

confidence, which adversely affects many economic activities. The domestic currency will be under pressure to decline as a result. Goyal (2004) and Singh (2013) argued that political instability in India is another factor contributing to rupee depreciation.

From the above analysis, it is apparent that the rate at which a country's currency is exchanged in the foreign exchange market is influenced by numerous factors. Besides the determinants mentioned above, there may have been many other factors influencing a currency's exchange rate. Various studies have sought to explain the determination of the ₹/\$ ER by including different factors. Although there seem to be enough research studies in this area, the extant literature leaves gaps for further research for several reasons. Firstly, the available literature is inconclusive primarily. Secondly, much of the above-cited literature focused solely on the causes of rupee appreciation or depreciation, without applying appropriate statistical and econometric methods to the empirical data. Thirdly, relatively few works have so far incorporated both macroeconomic and external factors within a single framework.

Research Question and Objectives

Keeping the research gaps in mind, the present research is being undertaken to answer the following research question:

$$NER = f(INF, ROI, M3, GDP, CAD, FPI, OILP, D1, D2)$$

In linear form:

$$NER_t = \alpha + \beta_1 INF_t + \beta_2 ROI_t + \beta_3 M3_t + \beta_4 GDP_t + \beta_5 CAD_t + \beta_6 FPI_t + \beta_7 OILP_t + \delta_1 D_1 + \delta_2 D_2 + \varepsilon_t \quad (1)$$

In equation (1), α is the intercept term, $\beta_1, \dots, \beta_7$, are the slope coefficients, δ_1 and δ_2 are the shift coefficients, ε_t is the disturbance term, and 't' is the time period. The detailed description of the variables under consideration is given in Table 1.

Do the selected macroeconomic and external variables affect the ₹/\$ ER in the post-reform period?

The formulated research question is being answered by fulfilling the following objectives:

- To identify the significant determinants of the ₹/\$ ER in the post-reform period
- To analyse the short-run and long-run relationships between the ₹/\$ ER and selected determinants in the post-reform period

Research Methodology: Materials, Models and Methods

The present study uses secondary data across 31 years from 1993 to 2023 in the post-reform period, which are collected from reliable sources like the World Development Indicators (World Bank), the RBI's Data Warehouse (Database on Indian Economy), and the World Bank Commodity Price Data (The Pink Sheet).

The present study considers inflation rate, interest rate, money supply, GDP, current account deficit, foreign investment, and crude oil price as the explanatory variables for the dependent variable (₹/\$ ER). The study also incorporated two dummies to capture the structural breaks in the ₹/\$ ER series (identified in Figure 1, Table 7, and Table 8). Therefore, the proposed model of the study can be written in functional form as follows:

Table 1: Variable Description				
Sl. no.	Variable name	Description	Symbol	Expected sign
1.	Exchange rate	Rupees per dollar (nominal)	NER	Not applicable
2.	Inflation rate	Annual rate of change in CPI (consumer price index)	INF	(+)
3.	Rate of interest	Lending interest rate	ROI	(-)
4.	Money supply	Annual broad money growth rate.	M3	(+)
5.	GDP	Annual percentage growth rate of GDP at market prices based on constant local currency	GDP	(-)
6.	Current account deficit	Current account deficit as a percentage of GDP	CAD	(+)
7.	Foreign portfolio investment	Portfolio investment expressed as a proportion of the total foreign investment (net FPI plus net FDI)	FPI	(-)
8.	Oil price	Annual rate of change in the prices of crude oil (average spot price of Brent, Dubai, and West Texas Intermediate) per barrel	OILP	(+)
9.	1 st Dummy (2003)	0 for 1993 to 2002 and 1 for 2003 to 2023	D1	(-)
10.	2 nd Dummy (2012)	0 for 1993 to 2011 and 1 for 2012 to 2023	D2	(+)
Source: Authors' Own Compilation				

The study begins with preliminary analyses, including a line graph, a correlation analysis, and a stationarity analysis. After these preliminary analyses, the study proceeds to the ARDL model to estimate the long- and short-run relationships between the ₹/\$ ER and the selected

explanatory variables. Equation (1) can be written in the general form of the ARDL model as follows (Abonazel & Elnabawy, 2020; Bahmani-Oskooee & Chi Wing Ng, 2002; Murthy & Okunade, 2016; Pesaran et al., 2001):

$$\begin{aligned}
 NER_t = & \alpha + \sum_{i=1}^p \beta_i NER_{t-i} + \sum_{j=0}^q \delta_{1j} INF_{t-j} + \sum_{j=0}^q \delta_{2j} ROI_{t-j} + \sum_{j=0}^q \delta_{3j} M3_{t-j} \\
 & + \sum_{j=0}^q \delta_{4j} GDP_{t-j} + \sum_{j=0}^q \delta_{5j} CAD_{t-j} + \sum_{j=0}^q \delta_{6j} FPI_{t-j} + \sum_{j=0}^q \delta_{7j} OILP_{t-j} \\
 & + \gamma_1 D1 + \gamma_2 D2 + \varepsilon_t
 \end{aligned}
 \tag{2}$$

In equation (2), NER is the dependent variable and INF, ROI, M3, GDP, CAD, FPI, and OILP are independent variables. α is the intercept term, while p and q stand for the number of lags for the dependent variable and independent variables, respectively. $\beta_i, \delta_{1j}, \dots, \delta_{7j}, \gamma_1$ and γ_2 are coefficients and ε represents the error term.

The bounds testing (cointegration) approach of the ARDL model is applied to confirm the presence of a long-run relationship. The formulated hypotheses for the test are:

Null hypothesis: There is no long-run relationship/ no cointegration exists

$$H_0: \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = \lambda_7 = \lambda_8 = 0$$

Alternative hypothesis: There is a long-run relationship/ cointegration exists

$$H_1: \text{At least one } \lambda_i \neq 0; i = 2, 3, \dots, 8$$

The corresponding unrestricted error correction form for bounds testing can be written as equation (3):

$$\begin{aligned} \Delta NER_t = & \alpha + \sum_{i=1}^{p-1} \beta_i \Delta NER_{t-i} + \sum_{j=0}^{q-1} \delta_{1j} \Delta INF_{t-j} + \sum_{j=0}^{q-1} \delta_{2j} \Delta ROI_{t-j} + \sum_{j=0}^{q-1} \delta_{3j} \Delta M3_{t-j} \\ & + \sum_{j=0}^{q-1} \delta_{4j} \Delta GDP_{t-j} + \sum_{j=0}^{q-1} \delta_{5j} \Delta CAD_{t-j} + \sum_{j=0}^{q-1} \delta_{6j} \Delta FPI_{t-j} + \sum_{j=0}^{q-1} \delta_{7j} \Delta OILP_{t-j} \\ & + \lambda_1 NER_{t-1} + \lambda_2 INF_{t-1} + \lambda_3 ROI_{t-1} + \lambda_4 M3_{t-1} + \lambda_5 GDP_{t-1} + \lambda_6 CAD_{t-1} \\ & + \lambda_7 FPI_{t-1} + \lambda_8 OILP_{t-1} + \gamma_1 D1 + \gamma_2 D2 + \varepsilon_t \end{aligned} \quad (3)$$

In equation (3), Δ denotes the first difference operator of the respective variables. Now, the derived long-run model from equation (3) can be written as equation (4):

$$NER_t = \phi_0 + \phi_1 INF_t + \phi_2 ROI_t + \phi_3 M3_t + \phi_4 GDP_t + \phi_5 CAD_t + \phi_6 FPI_t + \phi_7 OILP_t + \varepsilon_t \quad (4)$$

In equation (4), ϕ_0 is the intercept term and $\phi_i = -\frac{\lambda_i}{\lambda_1}$; ($i=2, 3, \dots, 8$) are the long-run coefficients.

Finally, the ECM (error correction model), which captures the short-run dynamics and speed of adjustment towards the long-run equilibrium, can be written as equation (5):

$$\begin{aligned} \Delta NER_t = & \alpha + \sum_{i=1}^{p-1} \beta_i \Delta NER_{t-i} + \sum_{j=0}^{q-1} \delta_{1j} \Delta INF_{t-j} + \sum_{j=0}^{q-1} \delta_{2j} \Delta ROI_{t-j} + \sum_{j=0}^{q-1} \delta_{3j} \Delta M3_{t-j} \\ & + \sum_{j=0}^{q-1} \delta_{4j} \Delta GDP_{t-j} + \sum_{j=0}^{q-1} \delta_{5j} \Delta CAD_{t-j} + \sum_{j=0}^{q-1} \delta_{6j} \Delta FPI_{t-j} + \sum_{j=0}^{q-1} \delta_{7j} \Delta OILP_{t-j} \\ & + \gamma_1 D1 + \gamma_2 D2 + \pi ECM_{t-1} + \varepsilon_t \end{aligned} \quad (5)$$

where,

$$ECM_{t-1} = NER_{t-1} - (\phi_0 + \phi_1 INF_t + \phi_2 ROI_t + \phi_3 M3_t + \phi_4 GDP_t + \phi_5 CAD_t + \phi_6 FPI_t + \phi_7 OILP_t + \varepsilon_t)$$

In equation (5), π is the adjustment coefficient that determines how quickly the system returns to equilibrium. Once the model specification is complete, we can proceed to the empirical findings of the present study.

Results and Discussion

The empirical findings of the present study began with the line graph of the ₹/\$ ER, depicted in Figure 1. A line graph provides a brief picture of the trend and whether there is a sudden change (structural break) in the underlying data

series. Checking structural breaks in time series data is crucial because they can significantly affect model accuracy, reliability, and validity. Identifying structural breaks not only helps us understand the significant economic or political events behind the breaks but also helps us avoid under- or overestimation.

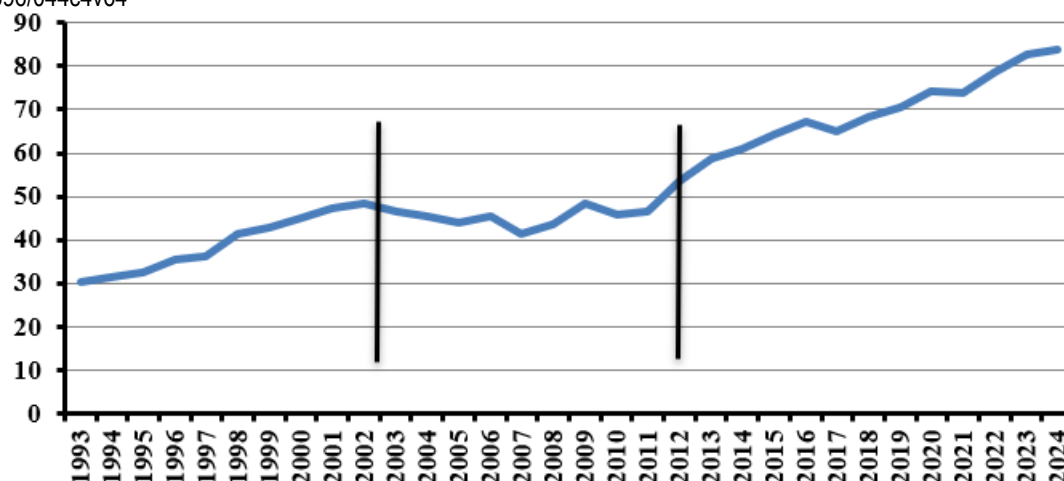


Figure 1: Rupee-Dollar Exchange Rate during 1993 to 2024

Source: Authors' Estimation Based on Data from WDI, World Bank

In Figure 1, although there are several ups and downs in the ₹/\$ ER line, drastic changes are observed in 2003 and 2012. In the initial phase of the reform period, the rupee depreciated, but after 2003 it began to appreciate. However, this appreciation phase did not last long, and since 2012, the rupee has again started depreciating. Accordingly, the presence of two structural breaks in the years 2003 and 2012 was suspected in the ₹/\$ EX rate. This is further confirmed by the Bai-Perron and Chow tests (see Tables 7 and 8 in the Appendix). Therefore, two break dummies, D1 and D2, were incorporated into our analysis to represent the structural breaks, as shown in Table 1. Overall, the first break (2003) mirrors the rupee's appreciation

phase, while the second break (2012) mirrors its depreciation phase.

In order to avoid multicollinearity, the study estimated the correlation matrix (Table 9 in the Appendix). Table 9 shows that proceeding with the selected variables would not create multicollinearity, as none of the cross-correlation coefficients exceed 0.550.

To check the stationarity of the variables under study, ADF (Augmented Dickey-Fuller) and PP (Phillips-Perron) unit root tests are performed under the null hypothesis: "the underlying series has a unit root, that is, non-stationary" against the alternative hypothesis: "the underlying series is stationary". The estimated ADF and PP test results are given in Table 2.

Table 2: ADF and PP Test Results

Variable	ADF t-statistic		PP t-statistic		Integration order
	Level	1 st difference	Level	1 st difference	
NER	0.760	-4.693***	0.653	-4.718***	I(1)
INF	-2.650*	-7.402***	-2.655*	-7.516***	I(0)
ROI	-2.211	-4.432***	-2.521	-8.475***	I(1)
M3	-2.459	-9.587***	-2.343	-9.366***	I(1)
GDP	-5.349***	-8.340***	-5.878***	-24.599***	I(0)
CAD	-2.599	-5.539***	-2.663*	-7.370***	I(1)
FPI	-6.112***	-6.867***	-6.125***	-22.715***	I(0)
OILP	-5.622***	-7.867***	-5.091***	-12.955***	I(0)

Note: *** Significant at 1%, ** significant at 5%, * significant at 10%

Source: Authors' Estimation

In Table 2, it is observed that the variables under consideration are stationary either at the level or after first difference, that is, $I(0)$ and $I(1)$. Under such circumstances, the ARDL model, which works well even in small samples, would be the best model.

Finally, the ARDL model has been estimated, beginning with the bounds test to determine the cointegrating relationship between the ₹/\$ exchange rate and the selected determinants. The estimated results are presented in Table 3.

The computed F-statistic (= 6.45) is greater than the critical upper bound level at 5% as well as 1% level of significance. Therefore, the null hypothesis of no cointegration is rejected, suggesting a long-run equilibrium relationship between the ₹/\$ ER and selected determinants in the reference period.

Now, the question arises, which among the selected determinants are significant in the long run? The long-run significant determinants of the ₹/\$ ER are given in Table 4.

Table 3: ARDL Bounds Test Result					
Computed F-statistics = 6.45					
Significant	Critical Bounds				Decision
	Asymptotic, Pesaran et al. (2001)		Finite sample, Narayan (2005)		
	Lower	Upper	Lower	Upper	
10%	1.92	2.89	2.27	3.49	Cointegration
5%	2.17	3.21	2.73	4.16	Cointegration
1%	2.73	3.9	3.86	5.69	Cointegration
Note: *** Significant at 1%, ** significant at 5%, * significant at 10%					
Source: Authors' Estimation					

Table 4: Long-run Determinants of the ₹/\$ ER				
Regressor	Coefficient	Std. Error	t-Statistic	p-value#
INF	1.063**	0.467	2.274	0.038
ROI	-3.399***	0.610	-5.564	0.000
M3	-0.276	0.492	-0.561	0.582
GDP	0.010	0.303	0.034	0.972
CAD	2.339**	1.069	2.186	0.045
FPI	-0.139***	0.023	-5.997	0.000
OILP	0.089**	0.038	2.296	0.036
C	94.446***	6.919	13.648	0.000
#: p-values are based on HAC (Newey–West) robust standard errors				
Note: *** Significant at 1%, ** significant at 5%, * significant at 10%				
Source: Authors' Estimation				

In Table 4, it is observed that the rupee-dollar exchange rate is influenced substantially by all selected regressors, except money supply and GDP, in the long run. Let us analyse the effect of significant determinants one by one. The coefficient for inflation demonstrates a positive relationship with the ₹/\$ ER, which is consistent with PPP theory and the empirical study of Arora et al. (2014). The coefficient of interest rate is

also consistent as per conventional theory, as it is negative (-3.399) and significant at 1% level, suggesting an inverse relationship between ₹/\$ ER and ROI, that is, when the interest rate in India rises, ₹/\$ ER falls (rupee appreciates). The positive coefficient of CAD (2.339) is also consistent, reflecting a direct relationship between ₹/\$ ER and CAD (Cerra & Saxena, 2002; Narang, 2014; Singh, 2013; Srikanth & Kishor,

2012). The coefficient of FPI (= -0.139) indicates an inverse relationship with ₹/\$ ER; that is., FPI inflows cause rupee appreciation (Goyal, 2004; Singh, 2007), while FPI outflows cause rupee depreciation (Narang, 2014; Singh, 2013; Younus, 2014). The coefficient of oil prices is positive, consistent with the perspective of oil-importing countries like India (Alam et al., 2020; Beckmann et al., 2020; Dawson, 2007; Singh, 2013). Thus, our estimated long-run model guarantees the combined influence of both macroeconomic and external factors in shaping the ₹/\$ ER behaviour.

As we know, exchange rates are often influenced by various short-term factors, such as shocks and policy changes; therefore, the short-run analysis is as important as the long-run analysis. ECM is the built-in mechanism in the ARDL framework for identifying these short-run adjustments. It also measures the speed at which the deviations from the long-run equilibrium are corrected in the subsequent periods. The estimated ECM, showing the short-run dynamic relationship between the ₹/\$ ER and its determinants, is depicted in Table 5.

Table 5: Estimated ARDL Error Correction Model				
Variable	Coefficient	Std. Error	t-Statistic	p-value#
ΔROI	-0.578***	0.189	-3.044	0.008
ΔM3	0.034	0.056	0.609	0.551
ΔFPI	-0.024***	0.003	-8.024	0.000
ΔOILP	0.009	0.006	0.150	0.882
D1	-2.403***	0.421	-5.701	0.000
D2	7.260***	0.644	11.272	0.000
ECT(-1)	-0.359***	0.038	-9.439	0.000
#: p-values are based on HAC (Newey–West) robust standard errors				
Note: *** Significant at 1%, ** significant at 5%, * significant at 10%				
Source: Authors' Estimation				

The estimated ECM in Table 5 reveals that the interest rate and FPI exert a short-run influence on ₹/\$ ER in our research period. The negative coefficients of both determinants reinforce the consistency of our estimated long-run model with conventional theories. Coefficients of the first dummy (= -2.40) as well as the second dummy (= 7.20) are also significant at the 99% confidence level, which is consistent with their expected sign as cited earlier in Table 1. Most importantly, the coefficient of the error correction term (ECT) is significant and consistent with the negative sign. The estimated coefficient of ECT is -0.359, which not only confirms the cointegrating relationship but also indicates that about 35.90% of the disequilibrium in the ₹/\$ ER arising from previous shocks is being eliminated in the current period. In other words, the ₹/\$ ER adjusts toward its long-run equilibrium at the speed of 35.90% per year.

It is worth noting that although most of the factors included in our proposed model have been found significant in the long run, only a few are significant in the short run. However, in the short run, many socio-economic and geopolitical factors also influence the exchange rate. Some empirical studies also found various significant factors affecting the exchange rate in the short run. For instance, Evans (2020) found that oil prices, inflation, interest rates, the current account, investment, growth, and budget balance were significant short-run determinants of the naira-dollar exchange rate for the period 1970 to 2015.

Some diagnostic tests have been performed in the subsequent section to assess the robustness and stability of our estimated ARDL model. We began with CUSUM (cumulative sum of residuals) and CUSUM of squares (cumulative sum of squared residuals) tests, which are used to assess the stability of a model. The CUSUM

and CUSUM of squares tests for our estimated model are shown in Figures 2 and 3.

Figures 2 and 3 prove the stability of our estimated model because the blue lines representing CUSUM in Figure 2 and the CUSUM of squares in Figure 3 remain within the confidence bands represented by dashed lines.

Finally, we proceeded with additional diagnostic tests, including the Breusch-Godfrey serial correlation LM test, the Breusch-Pagan-Godfrey

heteroskedasticity test, and the Jarque-Bera normality test. The results of these three tests are presented in Table 6.

From Table 6, the calculated test statistics confirm the absence of serial correlation and heteroskedasticity and indicate that the residuals are normally distributed for our estimated model. All the analysed diagnostic tests indicate the stability and robustness of our estimated ARDL model.

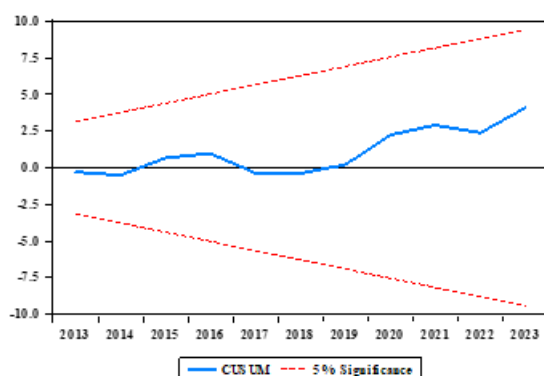


Figure 2: CUSUM Test

Source: Authors' Estimation

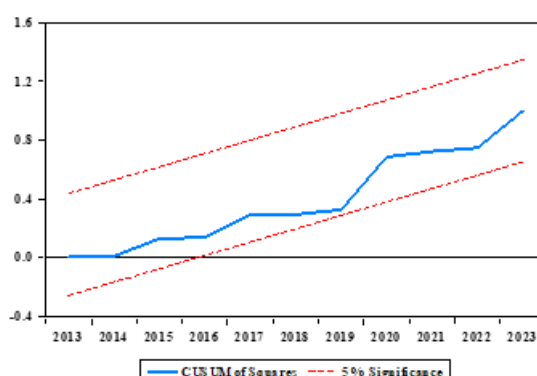


Figure 3: CUSUM of Squares Test

Table 6: Serial Correlation, Heteroskedasticity and Normality Tests Results		
Tests	Test-statistic	p-value
Autocorrelation: Breusch-Godfrey serial correlation LM Null: No serial correlation up to lag 2	1.679	0.224
Heteroskedasticity: Breusch-Pagan-Godfrey Null: No heteroskedasticity	0.843	0.622
Normality: Jarque-Bera Null: Residuals are normally distributed	2.331	0.311
Source: Authors' Estimation		

Conclusion

The ₹/\$ ER plays a pivotal role in India's economic stability, influencing trade competitiveness, inflation, and capital flows. This study identifies the significant determinants of the ₹/\$ ER during the post-reform period (1993–2023) by using the ARDL model. The bounds test results confirm cointegration among the variables under consideration. The estimated long-run ARDL model suggests that interest rates and inflation rates are significant

macroeconomic determinants, thereby validating prominent theories such as the PPP (purchasing power parity) and IRP (interest rate parity) theories, as well as the monetary model. Our estimated results further suggest that foreign portfolio investment, the current account deficit, and oil prices are significant external factors affecting the ₹/\$ ER, providing empirical support for the Mundell-Fleming model and balance-of-payments theory in the Indian context. However, the short-run analysis emphasises only the roles of interest rates and

FPI. Moreover, the coefficient of the ECT is -0.359, which not only confirms the cointegrating relationship but also indicates that about 35.90% of the disequilibrium in the ₹/\$ ER arising from previous events is being corrected in the current period. It implies that the system returns to its long-run equilibrium at a moderate speed. The analysed diagnostic tests demonstrate the robustness of our estimated model, thus enhancing the reliability of the findings. To summarise, the outcomes of this study are highly congruent with theoretical underpinnings and a selection of extant empirical investigations. Thus, the empirical results emphasise the sensitivity of the rupee-dollar exchange rate to monetary policy and global financial markets.

Apart from the macroeconomic fundamentals and external factors included in our study, various geopolitical factors also play a crucial role in determining the ₹/\$ ER. Events such as political instability, changes in trade policies, border conflicts, diplomatic relations, and global sanctions can affect investors' decisions and, in turn, capital flows into the Indian economy. For instance, an increase in geopolitical tensions may cause capital outflows, thereby increasing demand for the dollar and leading to depreciation of the rupee. Similarly, during periods of uncertainty (arising from global sanctions, wars, pandemics, border conflicts, strained diplomatic relations, etc.), investors prefer to invest in safe-haven assets like gold and the dollar, leading to a greater outflow of capital that will adversely affect the rupee's value. This way, various geopolitical factors can affect the ₹/\$ ER in the short run as well as in the long run. Incorporating these geopolitical aspects would further strengthen the analysis, giving a better understanding of the factors influencing the ₹/\$ ER.

The findings hold some crucial policy implications. A coordinated approach, integrating monetary policy, trade strategies, and measures to attract foreign investments is essential for exchange rate stability. Moreover, addressing structural challenges, such as current account deficits and reliance on crude oil imports, can mitigate exchange rate

vulnerabilities. This work emphasises the importance of forward-looking strategies to navigate exchange rate challenges in an increasingly globalised economy.

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Ethical Approval

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. As the research does not involve human participants, surveys, or confidential data linked to individuals, ethical approval was not required; therefore, no institutional review committee approval was necessary. However, we declare that the manuscript has not been submitted simultaneously to any other journal for consideration, nor has it been published elsewhere. We also confirm that the manuscript has been prepared in accordance with the ethical standards of academic research publication.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. No financial, professional, or personal relationships have influenced the research, analysis, or conclusions presented in this paper.

Author Contribution Statement

Tarif Hussain (Corresponding Author): Conceptualisation, collecting resources, review of literature, data analysis, writing the first draft, and collecting references.

Dr Amiya Sarma (Co-Author): Methodology, final reviewing of the draft, cross-checking for references, and final editing.

Informed Consent

Not applicable since this article does not contain any studies with human participants or animals performed by the author.

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Data Availability Statement

The data supporting the findings of this study are publicly available and were accessed on **04 January 2025** from the following official sources:

- **World Bank – World Development Indicators (WDI):**
<https://databank.worldbank.org/source/world-development-indicators>
- **World Bank – World Bank Commodity Price Data (The Pink Sheet):**
<https://www.worldbank.org/en/research/commodity-markets>
- **Reserve Bank of India – Database on Indian Economy (DBIE):**
<https://data.rbi.org.in/DBIE/>

All data are available without restriction and were used in their original or transformed form as described in the methodology section.

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Appendices

Table 7: Bai-Perron Multiple Breakpoints Test Result

Bai-Perron test:	L+1 vs. L sequentially determined breaks	
Breaking variables:	Constant and trend, Sample: 1993-2023	
Break Test	F-statistic	Critical Value
0 vs. 1 *	34.50	11.47
1 vs. 2 *	15.86	12.95
2 vs. 3	6.92	14.03
Estimated break dates: 2003 and 2012		
Source: Authors' Estimation		

From Table 7, it is clear that there are two structural breaks in our dependent variable, with estimated break dates of 2003 and 2012. In Table 8, since the calculated statistics exceed critical values, the null hypothesis of no breaks at 2003 and 2012 is rejected, implying the presence of two structural breaks in 2003 and 2012.

Table 8: Chow Breakpoint Test Result

Null: No breaks at 2003 and 2012		
Sample: 1993-2023		
	Statistic	p-value
F-statistic	55.13	0.000
Log likelihood ratio	70.81	0.000
Wald Statistic	220.52	0.000
Source: Authors' Estimation		

Table 9: Correlation Matrix

	NER	INF	ROI	M3	GDP	CAD	FPI	OILP
NER	1							
INF	-0.357	1						
ROI	-0.846	0.293	1					
M3	-0.725	0.350	0.547	1				
GDP	-0.165	0.033	0.012	0.022	1			
CAD	-0.051	-0.529	0.167	0.051	-0.243	1		
FPI	-0.376	-0.072	0.184	0.164	0.211	0.251	1	
OILP	0.005	-0.268	-0.166	0.080	0.284	-0.193	-0.132	1

Source: Authors' Estimation