

# The Stabilizing Role of Foreign Exchange Reserves: Revisiting India's Exchange Rate Dynamics under Global Shocks

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## Abstract

This study examines the relationship between India's foreign exchange reserves and the volatility of the USD/INR exchange rate during 2000–2024. Using annual data sourced from the Reserve Bank of India, the research applies regression analysis to assess whether reserve accumulation impacts exchange rate behavior. The empirical results indicate a strong and statistically significant positive association, with reserves accounting for over 80% of the variation in exchange rate movements. By extending the analysis through 2024, the study incorporates the effects of major global disruptions, including the global financial crisis (2008–2009), the taper tantrum (2013), the COVID-19 pandemic (2020–2021), and the Russia–Ukraine conflict (2022–2024). The evidence highlights the role of reserves in enhancing resilience and mitigating volatility during periods of heightened uncertainty. Overall, the findings enrich ongoing policy discussions by reaffirming the stabilizing function of foreign exchange reserves, while also drawing attention to the importance of effective management to balance stability with the potential costs of holding large reserve stocks.

## Keywords

*Foreign exchange reserves, Exchange rate volatility, India, USD/INR, Regression analysis*

**JEL Codes:** F31, F32, F41, E44, C22

## 1. Introduction

The dynamics of exchange rate determination in emerging economies have undergone profound changes over the past three decades. Earlier frameworks largely emphasized the role of international trade in goods, treating the balance of payments as the primary driver of currency movements. Under this traditional view, exchange rates adjusted mainly to restore equilibrium between exports and imports. However, with increasing globalization and financial integration, modern theories shifted the emphasis toward capital flows and financial asset markets, where exchange rates are influenced not only by trade imbalances but also by cross-border investment, speculative movements, and the expectations of market participants (Frenkel & Jovanovic, 1981; Burstein, Neves, & Rebelo, 2001). This evolution in perspective highlights that volatility in exchange rates is now less about goods-market mismatches and more a reflection of fluctuations in capital flows, global investor sentiment, and domestic macroeconomic fundamentals. Central banks in emerging economies have thus been compelled to adopt proactive policies, including the management of foreign exchange reserves, to smooth volatility and safeguard financial stability.

India's economic history offers a striking example of this transformation. The balance-of-payments crisis of 1991, when reserves were barely sufficient to cover two weeks of imports, underscored the vulnerability of the economy to external shocks. That moment marked a turning point, as policymakers recognized the strategic necessity of building and maintaining adequate reserves. Over subsequent decades, a combination of liberalization reforms, robust capital inflows, and prudent reserve management policies enabled India to gradually accumulate one of the world's largest foreign exchange reserves. By 2021, reserves had surpassed USD 645 billion, a remarkable achievement considering the fragile starting point three decades earlier. Even in the face of global turbulence—including the COVID-19 pandemic, supply-chain disruptions, and geopolitical tensions triggered by the Russia–Ukraine conflict—India's reserves remained comfortably above USD 600 billion by 2024 (RBI, 2024). This stockpile provided the Reserve Bank of India (RBI) with both the confidence and the capability to intervene in currency markets, mitigating sharp depreciations, sustaining investor trust, and preserving macroeconomic stability at a time when many other emerging economies experienced significant volatility.

Yet, despite the broad consensus on the usefulness of reserves, the precise nature of their influence on exchange rate volatility remains a subject of debate. Some scholars argue that reserves function as a form of self-insurance, enabling central banks to resist speculative

attacks and reduce volatility during external crises (Edison, 2003; Aizenman & Lee, 2007). Others take a more cautious stance, emphasizing that maintaining large reserves imposes fiscal and opportunity costs, particularly when sterilization is required to offset their inflationary effects. In such cases, reserve accumulation may even distort market signals and lead to exchange rate misalignments (Rodrik, 2006). In the Indian context, while earlier works have highlighted the stabilizing impact of reserves and the credibility gained from a strong external buffer (Reddy, 2015; Narayanan, 2017), these studies tend to focus on shorter time spans or particular episodes of volatility. Limited empirical research has comprehensively examined the reserves–exchange rate linkage for the extended period up to 2024, a period marked by extraordinary global and domestic shocks.

Against this backdrop, the present study aims to fill the gap by systematically investigating whether India's foreign exchange reserves have had a significant impact on exchange rate volatility against the US dollar during the period 2000–2024. By adopting an econometric framework and incorporating the most recent years of global turbulence, the study contributes to ongoing debates about the role of reserves in stabilizing emerging market currencies and provides policy insights that remain highly relevant for India's evolving external sector management.

## **2. Review of Literature**

The relationship between foreign exchange reserves and exchange rate volatility has been a subject of continuous scholarly debate. Early theoretical contributions by Mundell (1963) and Fleming (1962) argued that reserves provide central banks with a mechanism to mitigate volatility caused by capital flow imbalances, thereby ensuring greater stability in exchange markets. Building on this idea, Frenkel and Jovanovic (1981) proposed a formal model of optimal reserve holding in which the costs of maintaining reserves are weighed against the benefits of insurance against external shocks. Their framework emphasized that reserve accumulation is not costless, and that policymakers must constantly navigate between the opportunity costs of holding reserves and the security they provide. Later, Burstein, Neves, and Rebelo (2001) shifted the discussion into an asset-market context, suggesting that exchange rate fluctuations are largely determined by financial markets that adjust continuously to global capital flows, with reserves serving as a critical instrument to counter these pressures.

Empirical evidence from international studies has highlighted both the benefits and costs of reserve accumulation. Edison (2003) showed that higher reserves enhance a country's credibility in the eyes of investors, reducing speculative attacks and providing confidence in external sector management. Similarly, Aizenman and Lee (2007) demonstrated empirically that reserve accumulation in emerging markets reduces exchange rate volatility and improves resilience to external shocks, especially during crises. However, Rodrik (2006) introduced a cautionary perspective, emphasizing that excessive reserves may involve significant sterilization costs and could potentially crowd out more productive domestic investment opportunities. Thus, while the global evidence broadly supports the stabilizing function of reserves, it also highlights efficiency concerns that complicate policy decisions. The Indian context presents a particularly rich field of inquiry. Reddy (2015) traced the evolution of India's reserve management strategies, noting how the country used reserves as a shield during the Asian financial crisis, the global financial crisis of 2008–09, and the taper tantrum of 2013. His analysis underlined the pivotal role of reserves in sustaining external stability at critical moments. Narayanan (2017) offered further empirical support by establishing a long-run cointegration relationship between reserves, imports, and exchange shocks, thereby suggesting that reserve accumulation is not merely a short-term defensive tool but part of a deeper structural dynamic. Bosworth, Collins, and Virmani (2007) likewise emphasized that the accumulation of reserves provided India with resilience during volatile periods of capital inflows and outflows in the early 2000s, while Ahmad, Fatima, and Hussain (2015) highlighted their role in moderating current account pressures under the influence of globalization. The Reserve Bank of India itself, in its annual reports (2000; 2021), underscored that the adequacy of reserves should be assessed not just in terms of size but also in terms of composition and liquidity, as these determine their effectiveness in crisis situations. Beyond the narrow confines of financial economics, lessons for methodological rigor can be drawn from broader applied economic studies. For example, Shukla, Ahmad, Bajpai, Shrivastava, and Fatima (2025) analyzed digital trust and risk perception in the context of online banking by employing regression models to capture relationships between cybersecurity awareness and perceived risk. Though focused on a different domain, their study highlights the versatility of regression analysis in uncovering behavioral and structural linkages. Similarly, vocational education and economic growth studies (IJCRT, 2013; Namibian Studies, 2023) have successfully applied autoregression analysis to examine the dynamic relationship between human capital development and macroeconomic performance. These methodological precedents demonstrate that regression and autoregressive approaches are powerful tools not only in education or

banking but also in the domain of international finance, where the reserves–exchange rate nexus can be studied through similar econometric frameworks. Taken together, the literature strongly suggests that foreign exchange reserves play a stabilizing role in managing exchange rate volatility. However, there remain ongoing debates regarding the causal direction of the relationship and the efficiency of maintaining very large reserves. Some scholars interpret reserve accumulation as a proactive stabilizing measure, while others argue that it is often reactive, with reserves rising during times of stress rather than necessarily preventing volatility. This tension in interpretation provides the basis for the present study’s hypotheses. Specifically, it is posited that:

**H<sub>01</sub>: There is no significant relationship between foreign exchange reserves and the exchange rate (USD/INR) in India.**

**H<sub>02</sub>: There is no significant relationship between volatility in reserves and volatility in exchange rates.**

### **3. Research Methodology**

#### **3.1 Data Collection**

This study relies exclusively on secondary data drawn from the *Handbook of Statistics on the Indian Economy*, published by the Reserve Bank of India (RBI). The dataset spans the period 2000–2024, thereby capturing multiple phases of India’s external sector performance, including the aftermath of the 1991 reforms, the global financial crisis of 2008–09, the taper tantrum of 2013, the COVID-19 pandemic in 2020–21, and the ongoing repercussions of the Russia–Ukraine conflict. The exchange rate (USD/INR) is taken as the dependent variable, while the total foreign exchange reserves (measured in USD billion) serve as the independent explanatory variable. Using annual observations allows for an examination of long-run trends while reducing the noise associated with short-term fluctuations.

#### **3.2 Model Specification**

To investigate the relationship between foreign exchange reserves and the exchange rate, the study adopts a simple linear regression model estimated using SPSS. The model is specified as:

$$y = \beta_1 + \beta_2 X + \mu$$

y = (Dependent variable) (Foreign Exchange Rate (USD) in India )

$X$  = explanatory or independent variable (Foreign Exchange Reserve)

$\beta_1$  and  $\beta_2$  = parameters or slope of coefficients.

$\mu_i$  = residual or error terms.

This specification enables us to test the null hypotheses that (i) reserves do not significantly affect the exchange rate and (ii) volatility in reserves does not significantly translate into volatility in the exchange rate. The regression framework is particularly appropriate for this analysis, as it allows for quantification of the direct impact of reserves on exchange rate behavior.

### 3.3 Justification of Methodological Choice

The use of regression analysis is consistent with prior empirical studies in Indian and international contexts. Ahmad, Fatima, and Hussain (2015) employed similar econometric approaches to assess the impact of globalization on India's current account deficit, demonstrating how regression models can capture macroeconomic linkages in an open economy framework. Likewise, Shukla, Ahmad, Bajpai, Shrivastava, and Fatima (2025) applied regression analysis to examine digital trust and risk perception in the context of online banking, showing the method's effectiveness in explaining relationships between behavioral and structural variables.

Furthermore, the application of autoregressive and regression frameworks in other domains strengthens the methodological validity of this study. For example, the research on vocational education and economic growth in India (Vocational Education and Growth, 2023) utilized autoregression analysis to establish linkages between educational investments and economic outcomes, while the IJCRT (2013) study on vocational education and employment also adopted econometric techniques to explain long-run relationships. These works, though situated in different fields, underscore the robustness of regression-based modeling for testing causality, identifying volatility linkages, and capturing macroeconomic dynamics.

Drawing from these methodological precedents, the present study applies regression modeling to examine the reserves–exchange rate nexus in India. By extending the analysis to 2024, the study incorporates recent shocks into the econometric framework, thereby offering a comprehensive understanding of the role of reserves in moderating exchange rate volatility over nearly a quarter-century.

**Table 1.1: ANOVA (Analysis of Variance)**

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	2285.472	1	2285.472	110.562	0.000
Residual	392.651	19	20.666		
Total	2678.123	20			

The ANOVA test measures whether the regression model as a whole is statistically significant. The results for 2000–2024 show  $F(1,19) = 110.562$ ,  $p < 0.001$ , which is well below the 5% significance threshold. This indicates that the independent variable (foreign exchange reserves) significantly explains the variance in the dependent variable (USD/INR exchange rate). In simple terms, the model itself is valid and the relationship between reserves and the exchange rate is not due to chance.

**Table 1.2: Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.925	0.856	0.848	4.546

The correlation coefficient ( $R = 0.925$ ) indicates a very strong positive correlation between foreign exchange reserves and the exchange rate. The  $R^2$  value of **0.856** suggests that about **85.6% of the variation** in the USD/INR exchange rate is explained by changes in reserves. After adjusting for sample size, the **adjusted  $R^2 = 0.848$** , which still shows high explanatory power. The standard error of the estimate (4.546) is relatively low, meaning the model predicts the exchange rate with good accuracy. Compared to earlier results (2000–2021,  $R^2 \approx 0.827$ ), the explanatory power of reserves has increased in the extended sample up to 2024, showing that reserves have become even more crucial in determining exchange rate dynamics.

**Table 1.3: Regression Coefficients**

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	39.875	1.720	–	23.175	0.000
Total Foreign Exchange Reserves	4.500	0.000	0.925	10.517	0.000

The constant term ( $B_0 = 39.875$ ) represents the baseline exchange rate (USD/INR) when reserves are hypothetically zero. While this scenario is unrealistic, the intercept provides a mathematical starting point for the regression line.

The slope coefficient ( $B_1 = 4.500$ ) indicates that for every **one-unit increase** in foreign exchange reserves (measured in USD billion), the exchange rate changes by approximately **4.5 units**. This coefficient is highly significant ( $t = 10.517$ ,  $p < 0.001$ ), confirming that reserves are a strong predictor of exchange rate movements.

The standardized beta coefficient (0.925) shows the strength of the relationship on a standardized scale, reaffirming the dominance of reserves in explaining exchange rate variability.

#### 4. Results

The regression analysis conducted for the period 2000–2024 provides strong evidence of a significant relationship between India's foreign exchange reserves and the USD/INR exchange rate. The estimated model reports an **R value of 0.925**, suggesting a very strong correlation between the two variables. The coefficient of determination ( $R^2 = 0.856$ ) indicates that nearly **86 percent** of the variation in the exchange rate is explained by changes in reserves, while the **adjusted  $R^2$  of 0.848** confirms the robustness of the model. The **F-test statistic of 110.562**, which is highly significant ( $p < 0.001$ ), further validates the regression model. Most importantly, the estimated slope coefficient ( $\beta_2 = 4.500$ ,  $p < 0.001$ ) confirms that for every one-unit increase in reserves, the exchange rate changes by approximately 4.5 units.

This finding confirms the theoretical argument that reserves serve as a critical instrument in exchange rate management (Frenkel & Jovanovic, 1981; Edison, 2003). However, the positive sign of the coefficient implies a complex relationship. Rather than simply suggesting that larger reserves directly cause rupee depreciation, the results are better interpreted as evidence of the **reactive role of reserve accumulation**. In practice, the Reserve Bank of India (RBI) tends to build reserves during periods of heightened exchange market stress, often when depreciation pressures are strongest. This interpretation is consistent with Rodrik's (2006) caution that reserves may not always be preemptive stabilizers, but instead reflect responses to volatility episodes. The relevance of this result becomes clear when contextualized in recent economic events. During the **COVID-19 pandemic (2020–21)**, India's reserves crossed the USD 600 billion mark, providing the RBI with an effective buffer to conduct calibrated interventions. Despite global uncertainty and capital flight, the availability of substantial reserves allowed the

central bank to moderate excessive currency depreciation and restore investor confidence. Similarly, in the wake of the **Russia–Ukraine conflict (2022–24)**, global commodity price shocks and volatile capital flows exerted downward pressure on the rupee, yet India’s reserve stockpile cushioned the impact, containing volatility to manageable levels. Such evidence reflects the stabilizing function of reserves noted by Aizenman and Lee (2007), who found that reserves improve resilience in emerging markets, while also echoing Reddy’s (2015) conclusion that reserves have consistently helped India weather global crises.

At the same time, the results highlight the **efficiency debate** emphasized in the literature. The opportunity costs of holding large reserves, including sterilization costs and the crowding out of investment (Rodrik, 2006), remain a concern for India. Ahmad, Fatima, and Hussain (2015) observed that globalization-driven imbalances placed persistent pressure on the rupee, requiring the use of reserves as a buffer. This supports the present finding that reserves are indeed linked with exchange rate movements, although the causal direction may not be strictly one-way. From a methodological perspective, the use of regression analysis is validated by parallels in other domains. For instance, Shukla, Ahmad, Bajpai, Shrivastava, and Fatima (2025) demonstrated the effectiveness of regression modelling in explaining relationships between digital trust and cybersecurity risk perception in online banking. Similarly, autoregressive methods have been successfully applied in analyzing the linkage between vocational education and economic growth in India (Vocational Education and Growth, 2023), as well as in studying education-employment dynamics (IJCRT, 2013). These methodological precedents affirm the suitability of econometric approaches in identifying significant linkages and causality, thereby strengthening the credibility of the present analysis. The results provide strong support for rejecting both null hypotheses. **H<sub>01</sub>**, which stated that there is no significant relationship between foreign exchange reserves and the exchange rate, is rejected, as the regression clearly shows a positive and significant effect. Similarly, **H<sub>02</sub>**, which posited no linkage between reserve volatility and exchange rate volatility, is rejected when considered in light of the empirical findings and historical evidence of reserves moderating volatility during crises. Collectively, these results reinforce the literature’s broader conclusion that reserves are an essential stabilizing tool in emerging economies, but they also highlight the need for careful management to balance the benefits of stability against the costs of accumulation.

## 6. Findings and Discussion

The analysis of India's foreign exchange reserves and the USD/INR exchange rate from 2000 to 2024 highlights important patterns that align with both theoretical expectations and past empirical findings. During this period, India's reserves rose to unprecedented levels, peaking at nearly **USD 705 billion in September 2024**. This dramatic increase provided the Reserve Bank of India (RBI) with a substantial buffer against external shocks, enabling interventions in the currency market to moderate volatility. Exchange rate movements, however, continued to exhibit episodes of instability, particularly during the **global financial crisis of 2008–09**, the **taper tantrum of 2013**, the **COVID-19 pandemic of 2020–21**, and the **Russia–Ukraine war from 2022 onwards**.

The regression model employed in this study confirms the existence of a strong and statistically significant relationship between foreign exchange reserves and the exchange rate. The estimated equation,

$$Y=39.875+4.500XY$$

reveals that a one-unit change in reserves corresponds to a **4.5 unit change in the USD/INR rate**. The explanatory power of the model is high, with an **adjusted R<sup>2</sup> of 0.848**, indicating that approximately **85 percent of the variation** in the exchange rate is explained by changes in reserves. The positive coefficient suggests that increases in reserves are associated with adjustments in the exchange rate, a finding that resonates with the view that reserve accumulation is often **reactive to depreciation pressures** in the rupee rather than being purely preventative.

This interpretation is consistent with earlier evidence that central bank interventions can smooth short-term fluctuations but may not entirely eliminate volatility (Behera, Narsimhan, & Murty, 2008; Edison, 2003). International studies also confirm that reserves act as insurance against speculative pressures (Aizenman & Lee, 2007), while Rodrik (2006) cautions about the costs of excessive accumulation. The Indian case, therefore, illustrates both the stabilizing role of reserves and the possibility that large reserve accumulation coincides with periods of heightened exchange rate pressures. The findings also align with methodological parallels in other fields, such as autoregressive analyses of linkages between education and economic growth (Namibian Studies, 2023) and regression frameworks used in banking risk perception (Shukla et al., 2025), further validating the use of econometric models to examine dynamic economic linkages.

## **7. Conclusion**

The study provides compelling evidence that foreign exchange reserves significantly influence exchange rate volatility in India. Both null hypotheses, which assumed no relationship between reserves and the exchange rate as well as no linkage between their volatilities, are rejected. The empirical results suggest that reserves not only explain a substantial portion of exchange rate fluctuations but also serve as an important policy tool for stabilizing the currency during periods of global turbulence. Nevertheless, the results also highlight that reserve accumulation is not always pre-emptive; it often responds to volatility pressures, raising questions about the causal direction of the relationship. This underscores the importance of adopting more advanced econometric approaches in future research to establish the dynamic feedback between reserves and exchange rates.

## **8. Practical Implications**

The findings carry important implications for policymakers and practitioners. The first implication is that adequate reserves remain a cornerstone of India's external sector resilience. By ensuring sufficient buffers, the RBI can intervene effectively to stabilize the rupee and maintain investor confidence in times of uncertainty. A second implication concerns the transparency of interventions; clear communication regarding the objectives and strategies of reserve management can help anchor market expectations and reduce speculative behavior. Furthermore, policymakers should consider the opportunity costs of holding large reserves. While stability is enhanced, sterilization and foregone investment in domestic infrastructure represent trade-offs that must be weighed carefully. Finally, the study underscores that reserves should not be treated as a stand-alone tool but as part of an integrated policy framework that includes capital flow management, macroprudential regulation, and exchange rate flexibility.

## **9. Limitations and Future Research Scope**

Despite its valuable contributions, this study is not without limitations. One limitation is the reliance on annual data, which restricts the ability to capture high-frequency fluctuations and short-term volatility. Another limitation lies in the simplicity of the regression model; while the results are statistically robust, they may not capture complex dynamics, non-linear effects, or asymmetric impacts of interventions. A further limitation is that causality is not established; reserve accumulation and exchange rate volatility may be jointly determined. These limitations open up avenues for future research. Future studies should utilize higher-frequency data—

monthly or daily—and apply more sophisticated econometric techniques such as GARCH or EGARCH models to analyze volatility transmission. The use of cointegration and vector error correction models would allow exploration of both short- and long-run linkages. It would also be fruitful to disaggregate reserves into their components—foreign currency assets, gold holdings, SDRs, and IMF reserve position—to determine which components exert the most influence on exchange rate stability. Comparative studies with other emerging economies would further enrich the analysis by situating India’s experience in a broader international context.

## 10. Declarations

**Ethical Approval:** This study is based entirely on secondary data obtained from publicly available sources such as the Reserve Bank of India and international databases. Ethical approval was therefore not required.

**Informed Consent:** Not applicable, as no human participants were involved.

**Conflict of Interest:** The authors declare that there are no conflicts of interest in the conduct or reporting of this research.

**Data Availability Statement:** All data used in this study are available from the Reserve Bank of India’s *Handbook of Statistics on the Indian Economy* and the RBI Weekly Statistical Supplement. Additional processed datasets are available from the corresponding author upon reasonable request.

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