

EXCHANGE RATE DETERMINANTS AND FORECASTING FOR USD/INR: HISTORICAL ANALYSIS AND INSIGHTS

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ABSTRACT

Through this research, the intricate world of exchange rate determination and forecasting accuracy, specifically focusing on the USD/INR currency pair, is meticulously explored. The study employs a rigorous methodology involving historical data analysis from 2016 to 2023 and forecasting techniques for 2023-25. Cointegration as a tool for historical analysis, investigates the impact of several key macroeconomic variables including Inflation, Interest Rate, External Debt, Gross Domestic Product (GDP), and Foreign Direct Investment (FDI) on exchange rate fluctuations. Through in-depth analysis of Purchasing Power Parity (PPP) method and with the use of the concept of Real Exchange Rate (RER), the research attempts to forecast the USD/INR exchange rates for the years 2023-2025 taking into account the inflation rates based on Consumer Price Index (CPI) in India and

the USA. The findings reveal that while theoretical models offer reasonable short-term forecasts aligned with market sentiments, the complexities of real-world economic factors make long-term predictions challenging. The study emphasizes the importance of holistic approaches, urging stakeholders to supplement theoretical models with a thorough analysis of multiple macroeconomic indicators and to adapt strategies based on real-time market dynamics. Ultimately, the research provides valuable insights for businesses, investors, and policymakers in navigating the volatile global economic landscape.

Keywords: Exchange rate, USDINR, Purchasing power parity, Forecasting, Inflation, Interest rate

JEL: C53, F31, F37, E43

1. INTRODUCTION

In the ever-evolving global economy, the determination and forecasting of exchange rates stand as critical pillars shaping international trade, investments, and economic policies. The intricate web of factors influencing exchange rates has been a subject of profound fascination and rigorous analysis for economists, policymakers, and financial analysts alike. Understanding these determinants is essential not only for academics aiming to unravel the complexities of financial markets but also for practitioners seeking to make informed decisions in an increasingly interconnected world.

This research paper delves into the multifaceted realm of exchange rate determinants and forecasting methods, shedding light on the myriad factors that influence the value of currencies and the intricate techniques employed to predict their future movements. The exchange rate, representing the price of one currency in terms of another, is influenced by a plethora of economic, political, and psychological factors. Economic fundamentals such as inflation rates, interest rates, trade balances, and economic growth play a pivotal role in shaping exchange rate dynamics. Furthermore, geopolitical events, market

speculation, and central bank interventions add layers of complexity to the intricate web of factors at play.

Given that there has long been the impression that exchange rates are correlated to national price levels, it was not until Cassel introduced the idea of purchasing power parity (PPP) in 1918 that the exchange rates started to be closely linked with the comparable purchasing powers of national currencies. The interest rate parity theory, which describes the link between the interest rate and the exchange rate, was strengthened when forward exchange markets formed. The recognition that exchange rates adjust to international payments established a relationship between the exchange rate and the balance of payments. With the Keynesian revolution and the rapid expansion of international capital transactions related to international trade, however, the behavioral links between the balance of payments and the exchange rate were re-examined and embedded in models that took into account the interplay of external and internal pressures on exchange rates.

The significance of exchange rate determination and forecasting cannot be overstated. For businesses engaged in international trade, accurate predictions of currency movements are indispensable for hedging risks and optimizing profits. Investors, too, rely heavily on exchange rate forecasts to make strategic investment decisions in foreign assets. Moreover, policymakers require a deep understanding of these determinants to formulate effective monetary and fiscal policies that can stabilize economies and foster sustainable growth.

Exchange rate fluctuations are assumed to be realized around a steady-state trend that is consistent with variation in macroeconomic fundamentals over time. However, uncertainty enters the picture in the form of disturbances to both aggregate demand and aggregate supply. Within the context of this notion, currency depreciation affects aggregate demand through exports, imports, and domestic currency demand, whereas aggregate supply is directly impacted by the price of imported intermediate products.

The world economy too has been hit by two major shocks in succession – the Covid-19 pandemic and the Russian invasion of Ukraine – which have contributed to a significant rise in inflation and a global economic slowdown. Large exchange rate movements have been related to these global economic fluctuations and the monetary policy measures used to curb inflation. While exchange rate changes are a fundamental component of an economy's response to shocks and their asymmetric implications, the dollar's role as the world's dominant currency in international trade and finance demonstrates that its movements have major macro-financial ramifications.

This paper aims to provide a comprehensive overview of the major theories and empirical studies surrounding exchange rate determinants. It also delves into the diverse range of forecasting methods, from traditional econometric models to cutting-edge machine learning algorithms, highlighting their strengths, limitations, and applicability in different contexts. It also focuses on showcasing a pre-covid and post-covid impact on the foreign exchange rate fluctuations. By synthesizing existing knowledge and exploring recent advancements, this research endeavors to contribute to the ongoing discourse on exchange rate dynamics, offering valuable insights for researchers, policymakers, and market participants alike.

As we navigate the intricacies of exchange rate determination and forecasting, we embark on a journey that bridges economic theory with practical implications, unraveling the mysteries of currency movements in the global financial landscape. Through this exploration, we aim to not only enhance our theoretical understanding but also provide actionable intelligence for the practical challenges faced by businesses and policymakers in an increasingly interconnected and volatile world economy.

2. LITERATURE REVIEW

Bouraoui & Phisuthtiwatcharavong (2015) state that the exchange rate behavior model is among the unsolved research issues, and it should be addressed because of the crucial significance of exchange rates for the economy. It investigates the macroeconomic fundamentals that may explain the behavior of the exchange rate of the Thai Baht against

the US dollar. It uses monthly data for the period 2004-2013. Their empirical results, based on a multiple regression approach, reveal that the terms of trade and international reserves have a statistically significant impact on the nominal exchange rate THB/USD. However, the interest rates differential, the manufacturing production index, the monetary base and government debt do not exhibit a significant relationship with the exchange rate in Thailand.

Butt et al. (2023), aim to analyze the nominal exchange rate determination with a hybrid approach of macroeconomic and microstructure determinants, i.e., interest rate differential, oil price, order flow, and bid-ask spread over the long- and short-run horizons in the context of Malaysia. The dataset consists of high-frequency daily data from 2010 to 2017, employing a nonlinear ARDL approach. The results indicate that the bid-ask spread, and interest rate differential were found to be key determinants of exchange rate dynamics in the long and short run. The findings show strong evidence of long-run asymmetry in the interest rate differential, while short-run asymmetry effects exist between microstructure determinants and the exchange rate. The empirical results allow for long-run and short-run asymmetric pricing impacts of a hybrid approach on the nominal exchange rate in Malaysia. This study is helpful in providing policy direction and practical implications for monetary authorities and market dealers.

Saeed et al. (2012), undertake an econometric analysis of determinants of exchange rate for US Dollar in terms of Pakistani Rupee within the framework of monetary approach. Monthly data from January 1982 to April 2010 for Pakistan relative to the USA have been used to examine the long run and short run behavior of PKR/USD exchange rate and relationship of exchange rate behavior with relative monetary variables. Stock of money, foreign exchange reserves, and total debt of Pakistan relative to United States along with Political instability in Pakistan as a dummy variable are taken as determinants of PKR/USD exchange rate during the managed floating regime in Pakistan. ARDL approach to co-integration and error correction model are applied. Empirical results confirm that stock of money, debt and foreign exchange reserve balance all in relative

terms are significant determinants of exchange rate between Pakistani Rupee and US Dollar. Moreover, Political instability has a significant negative effect on the value of domestic currency

Mirchandani (2013) talks about substantial changes in the Foreign Exchange Market in India in 2000s. It is imperative by the excessive volatility of Indian Rupee causing its depreciation against major dominating currencies in the international market. This research has been carried out in order to investigate various macroeconomic variables leading to acute variations in the exchange rate of a currency. An attempt has been made to review the probable reasons for the depreciation of the Rupee and analyze different macroeconomic determinants that have impact on the volatility of exchange rate and their extent of correlation with the same. It has been found that Exchange rates are correlated with many variables such as interest rate, inflation rate & GDP Growth rate in either direct or indirect manner. Strong indirect correlation has been found between interest rate & exchange rate. Moreover, mild direct correlation has been found between exchange rate & GDP growth while between Current account balance & Exchange rate there is very weak correlation.

The authors employ a neural network to forecast the weekly USDINR exchange rate. It also compares neural network prediction reliability to linear autoregressive and random walk models. By employing six forecasting evaluation criteria, it is discovered that neural networks outperform linear autoregressive and random walk models in in-sample forecasting. In out-of-sample forecasting, neural networks outperform both linear autoregressive and random walk models. This finding disputes the efficient market hypothesis, implying that there is always a probability of extracting information concealed in the exchange rate and forecasting it in the future. The conclusions drawn from the research could be significant for both policymakers and foreign exchange market capitalists. (Panda & Narasimhan, 2007)

Lam et al. (2008) reiterate that Central banks closely track exchange rate movements on an on-going basis for macroeconomic analysis and market surveillance. Despite Meese and Rogoff's (1983) groundbreaking study demonstrating the superior predictive accuracy of the random-walk model in out-of-sample exchange-rate forecasting, there has been some evidence that suggests exchange-rate movement may be foreseeable over broader time horizons. When multiple specifications are factored in, no single model persistently emerges as the optimal exchange-rate forecasting model. When the root-mean-squared forecast error and the direction of change statistics are incorporated as criteria, the combined forecast tends to perform significantly superior to the forecast computed from a single model. The forecast efficacy of the Purchasing Power Parity model, Uncovered Interest Rate Parity model, Sticky Price Monetary model, model based on the Bayesian Model Averaging technique, and an all-inclusive forecast of all the above models is compared to benchmarks provided by the random-walk model and the historical average return in this study. Empirical evidence suggests that the integrated forecast surpasses the benchmarks and produces better results overall than reliance on a single model.

Fund (1990) unveils new empirical findings that shed light on the dynamics of the currency market. The first half of the paper is an appraised scrutiny of market participants' exchange rate expectations as revealed by survey responses, with the following inferences. First, the forward discount's bias as a metric for the prediction of future spot rates is not due to an exchange risk premium, as is commonly assumed. Second, forecasters tend to superimpose recent trends over short time horizons while forecasting a reversal over long time horizons. Third, based on eight years of data across five currencies, the bias in expectations is fortified in the samples. The paper's second half eliminates the conceptual framework according to which all market participants possess a shared forecast in order to emphasize the relevance of multifaceted expectations. Tests indicate that dispersion of opinion, as expressed in the standard deviation within respondents in the survey, influences market volume and, thus, the degree of volatility

of the exchange rate. The "chartists and fundamentalists" model is an example of how opposing forecasts are able to trigger exchange rate swings. The market weights assigned to the two models alter over time in accordance with recent developments, causing fluctuations in foreign currency demand. The paper concludes with one piece of evidence that reinforces the model: the proportion of foreign exchange forecasting services that use "technical analysis" increased sharply during 1983-85, but then weakened.

Longmore & Robinson (2004) contrasts the performance of linear GARCH models and asymmetric models in projecting the stochastic nature of returns in the foreign exchange market. We investigate the information associated with macroeconomic and market microstructure parameters for 30-day forecasting. Using multivariate GARCH, the paper also investigates the significance of volatility spillovers. The exchange rate was discovered to have a long-lasting recall process, with asymmetric shock effects. In terms of explanatory power, the non-linear GARCH model outperformed the linear models. Out-of-sample forecasts were also well performed by these models, with the model that took into account overbearing kurtosis providing forecasts that were more accurate in some cases. The most significant variables influencing market volatility were expected liquidity conditions, trade volume, and spillover effects from various financial markets. The spread was also discovered to have the capacity for explanation.

Singh & Kanoujiya (2022) discuss a variety of models can be used to forecast a time series. All models can be categorized into two categories based on the number of variables used: univariate forecasting tools and multivariate forecasting tools. VAR is a multivariate time series forecasting method. This model has several advantages and disadvantages. It is a limited model that can only be used in a few common situations. It only employs preordained variables and does not include any contemporary terms in the model requirements. It employs a plurality of variables in the systems of equation format and aids in comprehending the impact on one variable caused by a change or shock in another variable through the application of impulse response function and variable decomposition techniques. It is an excellent tool for multivariate time series forecasting.

Given the abundance of models on the market, including statistical and machine learning tools, predicting which is the most efficient one is difficult. However, VAR holds a special place in the world of multivariate forecasting.

Qureshi et al. (2023) uses the real exchange rate data set (REER), machine learning models such as the multi-layer perceptron model (MLP), Extreme learning machine (ELM) model, as well as classical time series models, Autoregressive integrated moving average (ARIMA), and Exponential Smoothing (ES) model in this work. The data being considered spans from January 2019 to June 2022 and includes 864 observations. This study divided the data set into two phases of training and testing and used all of the models listed. The model chosen for this study adheres to the Key Performance Indicators (KPI) specifications.

(Ali, 2023) The expectation development mechanism is used to examine the exchange rate alienation bewildering in financial markets. This includes how expectations concerning macroeconomic variables, such as interest rates, GDP growth, inflation, and the current account-to-GDP ratio, can influence exchange rate expectations. For the purpose of doing so, this study encompasses real-time quarterly data on G-7 countries' expectations for short-term interest rates, GDP growth, inflation, and current account-to-GDP ratios from Q1: 2012 to Q4: 2021. In this study, we find that increasing the current account-to-GDP ratio in comparison to the US causes domestic currency appreciation while other factors related to macroeconomics stay trivial. This study further indicates that macroeconomic variables may not have the same influence when coupled in a situation such as a mutual cooperative organization of countries that work in tandem rather than individually.

(Nyantakyi & Kudzawu-D'Pherdd, 2023) The tenuous connection between the price of gold and the exchange rate may contain a long shot commodity arbitrage opportunity. While gold has been used for centuries as a store of value and a hedge against economic downturns for citizens and even economies, its historical credibility has kept it as one of the most valuable assets even today. As a result, this study attempted to investigate the

correlation between the volatility of the macroeconomic variable of the exchange rate and the current price of gold. An attempt was made to determine the impact of shocks caused by exchange rate volatility on the value of gold and to develop appropriate models. Apart from interest rates and inflation, the exchange rate is considered to be one of the leading indicators of a country's overall state of economic health, so it is one of the most closely watched, analysed, and subjugated by government economic teams. Furthermore, to other features such as balance of payments deficits, inflation, indebtedness ratios, and political fragility, exchange rates are frequently used in estimating country risk (Bouchet et al, 2018).

Neghab et al. (2023) The multifaceted nature and uncertainty of financial and macroeconomic structures, combined with unpredictable shifts in the economy as a whole, have made accurate estimations anchored in theory-consistent explanations difficult. Understanding the relationships between different factors, increasing trust in the prediction models, and making estimations more attainable are all benefits of comprehending the prediction models used for projecting important macroeconomic indicators. Within an interpretative framework, they cultivate a fundamental-based simulation for the Canadian-US dollar exchange rate in this study. They propose a holistic approach to predicting the exchange rate that employs machine learning and interpretability techniques in order to precisely evaluate the relationships between macroeconomic variables. Furthermore, they carried out a parametric ablation investigation based on the interpretation output so as to enhance the accuracy of predictions of the models. Our empirical findings show that crude oil, Canada's primary commodity export, is the most important factor influencing exchange rate dynamics, with time-varying effects. The variances in the sign and magnitude of crude oil's contributions to the exchange rate are in accordance with key developments in the commodity and energy markets, as well as the evolution of the Canadian crude oil trend. The second and third most important parameters influencing the exchange rate are gold and the TSX stock index. As a result, this analysis provides policymakers and economists with reliable

and practical insights, as well as granular information about the forecasting model's decisions, that are underpinned by empirical evidence.

Gong et al. (2023) The impact of minuscule to major fluctuations in the exchange rate on demand for energy in the Emerging 7 (E7) countries - Brazil, China, India, Indonesia, Mexico, Russia, and Turkey is investigated in this analysis, which has not been completely addressed in the literature. They scrutinize the outcomes of the multiple thresholds nonlinear ARDL (MTNARDL) method to those of traditional ARDL and nonlinear autoregressive distributed lag (NARDL). Furthermore, for tenacity, they employ the hypothesis of Granger causality in the quantile test. The results of this study show that for all E7 nations, the MTNARDL technique with decile series reveals a long-run causal relationship between energy consumption and the exchange rate. The standard ARDL and NARDL methodology, on the flip side of the hand, only finds a long-run conjunction for India. In conclusion, the results derived from the Granger causality in quantile test reveal that the effect alters between quantiles. In accordance with the findings, the report makes worthwhile suggestions for policy makers, underlining the need to take substantial exchange rate fluctuations into careful consideration when developing E7 energy demand regulations.

(Chinn, 2012) provide an overview of various exchange rate models that have emerged in the period following the Bretton Woods agreement. It places particular emphasis on two prominent categories of models: the monetary and portfolio balance approaches. These models are further classified into nominal and real exchange rate models, and the chapter delves into empirical evidence related to these approaches. Additionally, it mentions newer models that don't fit neatly into these categories. Although some of these models may have limitations in terms of their theoretical foundations, they continue to be widely used for empirical exchange rate analysis. The chapter also touches on the concept of purchasing power parity (PPP), which is a simplified version of the real exchange rate model, assuming a constant real exchange rate.

Della Corte & Tsiakas (2012) offer a comprehensive examination of the methods used to assess the predictability of exchange rates, both from statistical and economic perspectives. It evaluates the short-term forecasting performance of several widely recognized empirical exchange rate models, including the random walk (RW) model, uncovered interest parity, purchasing power parity (PPP), monetary fundamentals (MF), Taylor rule (TR), and TRa. Furthermore, the chapter introduces a framework for assessing the economic value of forecasting exchange rates, particularly from the perspective of a risk-averse investor. It considers a dynamic mean-variance portfolio allocation strategy to determine the practical significance of exchange rate forecasting in investment decisions.

Afat et al., (2015) assess three commonly used versions of the monetary model (namely, the flexible price, forward-looking, and real interest differential models) for the OECD member countries. They employ the Johansen co-integration technique to analyze these models. The key findings from their country-specific analyses indicate that the monetary models do not yield the anticipated outcomes. The article highlights several limitations of these models and investigates the foundational aspects of the fundamental version. Contrary to the common belief that deviations from purchasing power parity are solely responsible for the monetary model's failures, the authors' analysis suggests that another significant factor contributing to unfavorable results is the inadequacy of the Keynesian money demand function. In essence, this article challenges the conventional understanding of the monetary model's shortcomings and underscores the importance of reevaluating the underlying assumptions and components of this model.

Woo (1985) propose a reformulation of the monetary approach to exchange rate determination. They base their reformulation on empirical evidence that supports a money demand function with a partial adjustment mechanism over one that assumes instantaneous stock adjustment. The resulting exchange rate equation is estimated using two rational expectations techniques. The study finds that the parameter estimates obtained from these techniques are reasonable and robust. This robustness is observed

across different specifications of the driving processes and changes in the estimation period. Furthermore, the structural model developed in this paper outperforms both the random walk model and its own unconstrained equivalent, which is a pure time series equation, in out-of-sample forecasts. This suggests that the proposed reformulation of the monetary approach provides better predictive power for exchange rates compared to these alternative models.

Bitzenis & Marangos (2007) investigate the flexible-price monetary model in the context of the Greek drachma-US dollar exchange rate. They employ the Johansen multivariate cointegration technique on an unrestricted version of the monetary model. Using quarterly data spanning from 1974 to 1994, the study reveals compelling evidence supporting the existence of cointegration among key variables, including the nominal exchange rate, relative money supply, relative income, and relative interest rates. This finding validates the monetary model as a long-term equilibrium condition for this exchange rate relationship.

(Kaltenbrunner, 2018) This paper presents a comprehensive mixed-method study focused on understanding how exchange rates are determined in the Brazilian foreign exchange market. The study combines semi-structured interviews conducted with foreign exchange market participants in both Brazil and London with advanced time-series econometrics. Aligned with Post Keynesian theory and critical realist ontology, the interviews aim to uncover context-specific expectations and the underlying processes and structures that influence exchange rate dynamics in Brazil and, by extension, in emerging economies more broadly. The study's findings highlight significant structural changes in Brazil's financial integration, particularly in the form of currency internationalization and financialization. Additionally, they reveal that this internationalization has been influenced by a structured and hierarchical international monetary system, which fundamentally distinguishes the drivers of exchange rates in emerging economies from those in developed ones.

3. RESEARCH OBJECTIVES

- a. To identify and analyze key exchange rate determinants of USD/INR.
- b. To utilize forecasting techniques to predict exchange rate movements of USD/INR.

4. METHODOLOGY

This research paper adopts a rigorous methodology that combines empirical analysis from 2016 to 2023 for the USD/INR exchange rates and utilizes various forecasting techniques to predict exchange rate movements for the exchange rate until 2024-25. The study employs secondary research methods with a focus on cointegration analysis and forecasting analysis. The following methods are employed to discern exchange rate determinants and facilitate accurate predictions: Purchasing Power Parity exchange rate (PPPER), Real exchange rate method (RER).

I. Data Collection and Preprocessing (2016-2025):

- Long-Term Data Acquisition: Historical exchange rate data spanning from 2016 to 2025 is collected from reputable financial databases and central banks such as RBI historical data, US government inflation rates ensuring accurate coverage across the USD/INR exchange rates. The mathematical formulation for forecasting analysis has been collected from the literature.
- Macroeconomic Indicators: Relevant macroeconomic indicators, including Inflation, Interest Rate, External Debt, Gross Domestic Product (GDP), and Foreign Direct Investment (FDI) are gathered to supplement exchange rate data.

II. Co-Integration Analysis:

- Statistical Testing: Co-integration analysis is conducted to identify long-term relationships between exchange rates and macroeconomic variables. Johansen tests and Engle-Granger tests are employed to assess the presence of cointegration.

- Identification of Stable Relationships: Stable co-integrating relationships are identified, enabling a deep understanding of the underlying economic factors influencing exchange rate movements.

III. Forecasting Techniques:

- Purchasing Power Parity (PPP): The PPP approach is applied to assess currency valuation based on relative price levels that is determined using historical inflation rates calculated across 2016-2023 using the CPI index for US and India. A mathematical equation that determines the linear relationship between inflation rate and historical exchange rate was utilized for analysis further allowing for predictions on potential exchange rate movements.
- Real exchange rate (RER): Using the nominal exchange rate and inflation, the following equation of RER has been established which is utilized for forecasting the exchange rate movements. A difference between the two methodologies comparing their accuracy has been the prime focus of the findings and analysis.

By employing a comprehensive methodology encompassing co-integration analysis, historical data examination, and forecasting techniques, this research aims to provide valuable insights into exchange rate determinants and facilitate accurate predictions for the years 2024-25. Through rigorous analysis and meticulous modelling, the study endeavors to contribute to the understanding of the intricate relationship between macroeconomic factors and exchange rate movements in a global integrated economy.

5. DATA ANALYSIS

Data Analysis and Findings: Forecasting Accuracy

In our study, we have attempted to forecast the USD/INR Exchange Rates for the years 2016-2022 using the historical data of Exchange Rates from 2015-2022; and the Exchange Rates from 2023-2025 using the historical data of Exchange Rates from 2021-2022 through Purchasing Power Parity approach. The intention to forecast the USD/INR Exchange Rates for the years 2016-2022 is to get a fair idea about the accuracy of this approach.

The Purchasing Power Parity (PPP) forecasting approach is based out of the “law of one price”, which affirms that identical goods, when measured in common currency, freely negotiated goods would have a single and unique price anywhere in the world. This also implies that there should be no arbitrage opportunity for anyone trading the same goods in different countries. The PPP method of forecasting primarily attempts to account for price changes due to inflation prices in different countries and offset them while forecasting future exchange rates.

Purchasing Power Parity exchange rate is thus calculated as:

$$\text{PPPER} = P_{\text{ind}} / P_{\text{usa}} \quad \dots(1)$$

where, P_{ind} = Price of the basket of goods of reference in India

P_{usa} = Price of the same basket of goods in the USA

Now, the change in PPPER can be calculated as,

$$\Delta\text{PPPER} = ((1 + i_{\text{ind}}) / (1 + i_{\text{usa}})) - 1 \quad \dots(2)$$

where, ΔPPPER = change in PPPER

i_{ind} = Domestic (Indian) inflation rate based on Consumer Price Index (CPI)

i_{usa} = Foreign (USA) inflation rate based on Consumer Price Index (CPI)

In order to forecast exchange rates, historical data of – Exchange Rates, Purchasing Power Parity Exchange Rates (PPPER) and Inflation Rates in both the countries have been used.

This data is given below:

Table 1

Year	PPPER	ER	Inflation in India	Inflation in USA
2014	₹18.39	₹61.00		

2015	₹19.24	₹64.80	4.91%	0.12%
2021	₹23.22	₹73.93		
2022	₹24.05	₹78.41	6.70%	8.33%

The forecasted values have been calculated using 2 methods.

In method 1, we have assumed that the Exchange Rate will continue to offset the difference in prices of a standard basket of goods and services in India and USA. Thus, the Exchange Rate can be calculated as follows:

$$\text{Forecasted ER} = \text{Previous Exchange Rate} \times \left[\frac{(1 + i_{\text{ind}})}{(1 + i_{\text{usa}})} \right]^n \quad \dots(3)$$

where, n = number of years.

Further, equation (3) has been used to forecast the Exchange Rates and the results have been presented in the table below.

Table 2

t=2015	2016	2017	2018	2019	2020	2021	2022
Forecasted ER	67.89	71.14	74.55	78.11	81.85	85.77	89.87
Actual ER	67.61	64.49	69.40	70.85	72.37	76.10	78.41

t=2022	2023	2024	2025
Forecasted ER	77.23	76.07	74.92

In method 2, the Real Exchange Rate (RER) is used to modify the above calculations.

It is calculated as the quotient between the exchange market rate (USD/INR) and the PPPER and intends to catch the differential between the market value of the currency and its theoretical value.

$$\text{RER} = \text{ER (market rate)} / \text{PPPER}$$

$$\text{Or, ER} = \text{RER} \times \text{PPPER} \quad \dots(4)$$

where, RER = Real Exchange Rate

In equation (4), the variation of ER can be interpreted as a modified version of the variation of

the PPPER, which is multiplied by a function of the rate of variation of the RER as in Equation.

This can be calculated as follows:

Table 3

t=2015	2016	2017	2018	2019	2020	2021	2022
Forecasted ER	68.94	73.35	78.04	83.04	88.35	94.00	100.01
Actual ER	67.61	64.49	69.40	70.85	72.37	76.10	78.41

t=2022	2023	2024	2025
Forecasted ER	79.06	79.72	80.38

Exchange Rate Determination: Purchasing Power Parity Exchange Rate For Time Period 2015-2022

The methodology of forecasting accuracy using the purchasing power parity exchange rate has been used to conduct the analysis below. To evaluate the efficacy of the forecasting method, an empirical analysis from t=2015 to 2022 has been performed.

The rate of growth in anticipated values using the theoretical values is discovered to be higher than the actual exchange rate values since the forecasting method rises linearly with an increase in years, i.e., t+n. The following graph shows a comparison between actual and predicted values together with time series data. (Figure 1)

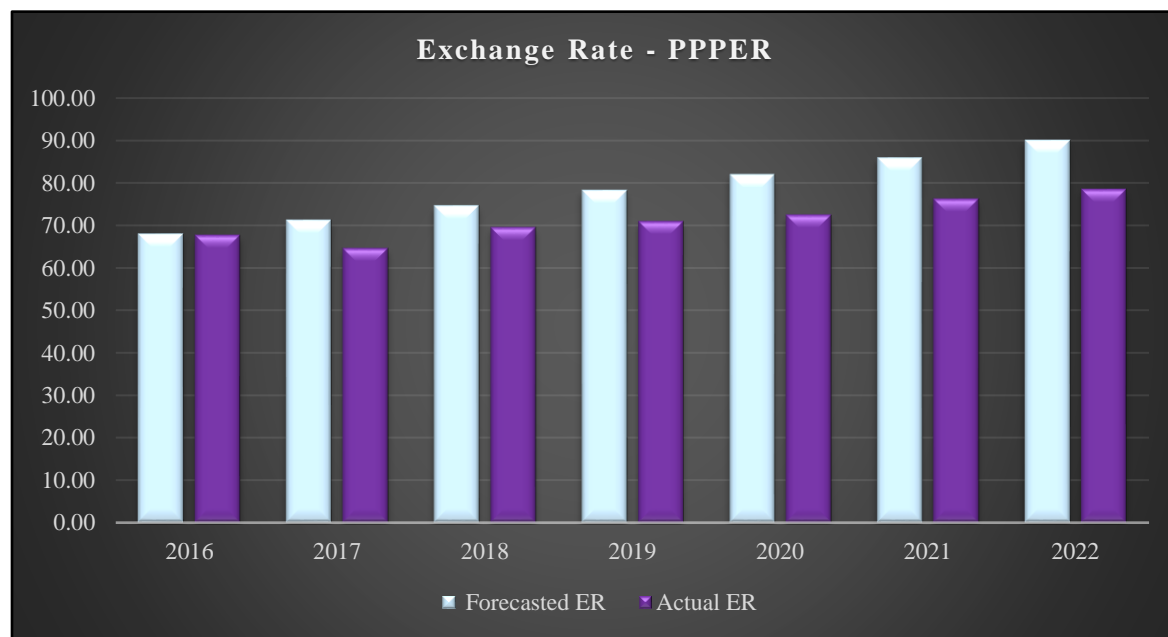


Figure 1

Reasons for variation:

1. Limitations of the purchasing power exchange rate method:

a) PPP assumes constant inflation rates across countries from the base year, which is often unrealistic. Thus, PPPER is a theoretical approach.

b) PPP assumes no transportation costs, trade barriers, and complete market information, which doesn't align with real-world economic conditions.

2. Discrepancy in exchange rate determination in the real-world economy:

The daily forex market sees approximately \$1-2 trillion in currency exchange, considering only one side of currency trades. Daily exchange rate fluctuations are primarily influenced by investor actions rather than importers and exporters, leading to exchange rates that may not accurately reflect real-world trade dynamics.

Exchange Rate Determination: Real Exchange Rate for Time Period 2015-2022

This analysis employs the real exchange rate determination method, which depends on the exchange rate at time "t" (2015) and the Consumer Price Index (CPI) for 2015. The aim is to align actual market exchange rate fluctuations with theoretical ones.

The formula incorporates the impact of the real exchange rate on inflation rate movements. Consequently, it results in a higher year-on-year exchange rate movement across the given timeframe compared to the PPPER method. The following has been illustrated in Figure 2.

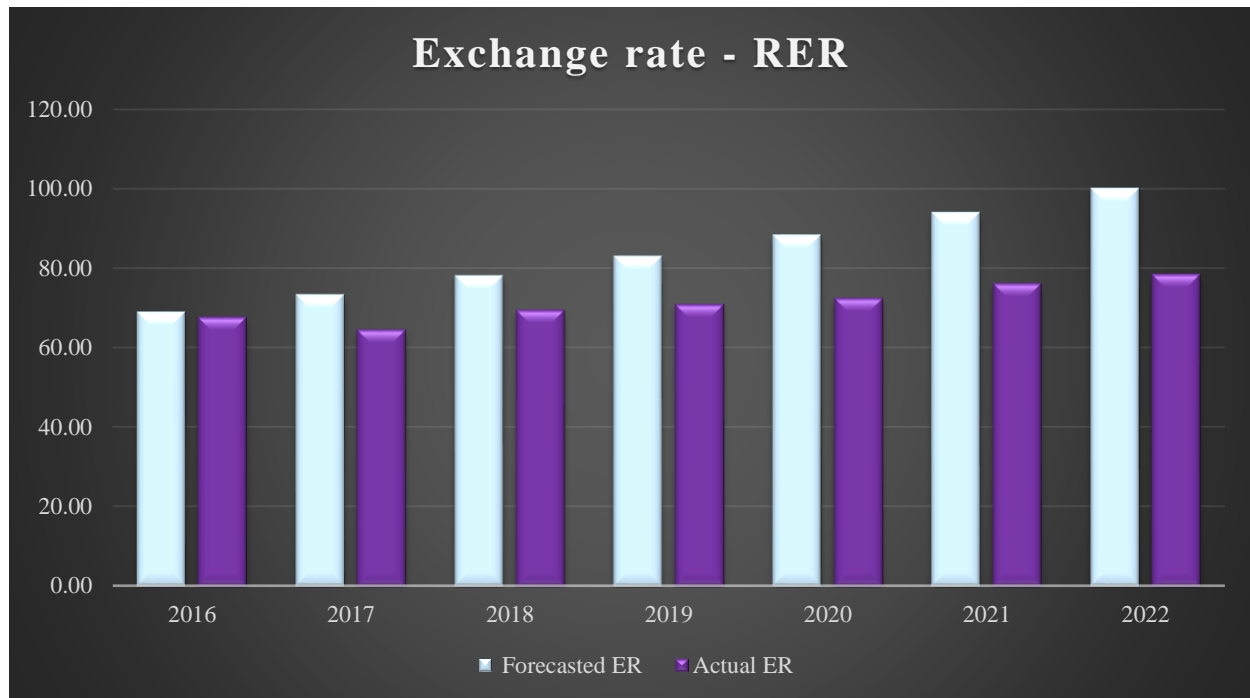


Figure 2

Reason for divergence:

The real exchange rate method assumes an identical change in the period before time 0, implying a lagged approach to forecasting exchange rate values. This methodology also entails a more substantial linear increase, resulting in greater disparities in exchange rate movements.

Upon empirical analysis of exchange rate movements using both the purchasing power parity exchange rate method and the real exchange rate method, it becomes evident that the forecasted values exhibit less disparity in the short term ($t+3$, with t as 2015). However, this disparity progressively increases as the time horizon extends. Consequently, to forecast exchange rate movements, we have chosen a base year of $t=0$ as 2022 and projected values up to the time horizon of 2025 to support our research.

Forecasts:

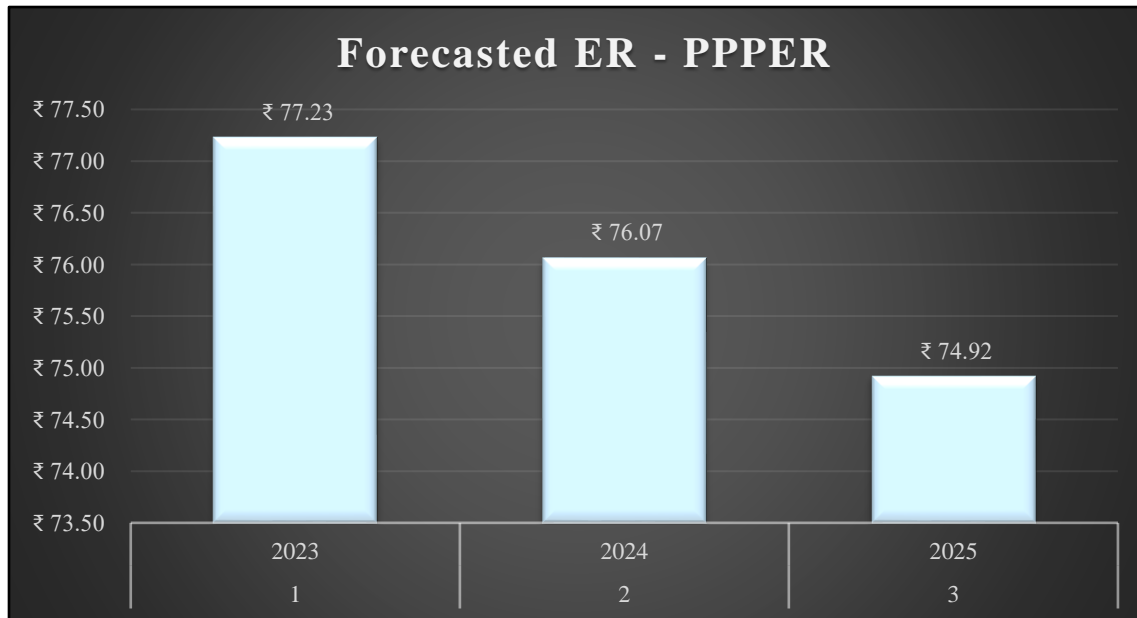


Figure 3

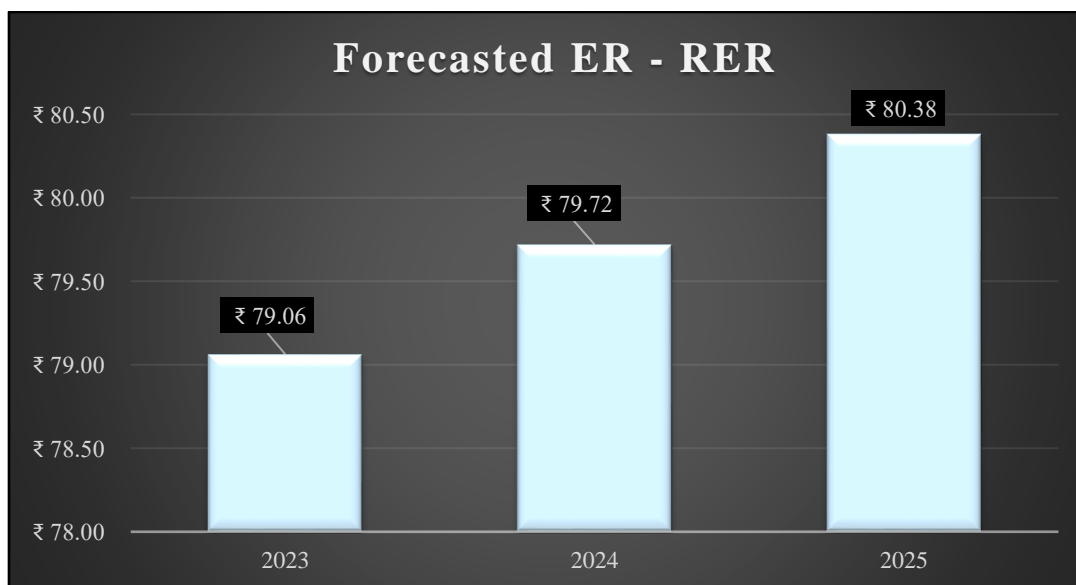


Figure 4

1. The forecasted exchange rate movements for 2023 using the PPPER model and RER model are respectively ₹77.23 and ₹79.06, while the current nominal exchange rate as of October 6, 2022, stands at ₹83.22. This discrepancy between nominal and actual

market rates results from factors such as interest rate differentials and inflation expectations.

2. The USD/INR exchange rate was forecasted differently using the PPPER and RER approaches. PPPER relies on inflation rates for exchange rate forecasts, and with a base year of 2022, where the USA had an 8% inflation rate and India had a 6.7% rate, this led to a decrease in the forecasted values.
3. The RER approach revealed a difference in forecasted values, indicating an increasing trend. However, the higher inflation rate in the US in 2022 led to a less pronounced growth rate increase over the period from 2022 to 2025.

A Comprehensive Conclusion Indicating the Accuracy of The Models:

Theoretical models like PPPER and RER rely solely on inflation rates derived from CPI and real exchange rates, which, in turn, depend on nominal exchange rates and PPP. This research concludes that these theoretical approaches are not highly accurate for long-term exchange rate forecasts.

Over a 1 to 3-year timeframe after t-0, these theoretical approaches exhibit relatively small differences when compared to actual market exchange rates. However, as the timeframe extends into the long term, the disparities between theoretical and market exchange rate movements become more pronounced. This is primarily due to the influence of various macroeconomic factors such as inflation, interest rates, GDP growth, trade, and capital flows, which impact market-determined exchange rates. Consequently, while inflation is a significant indicator of exchange rate movement, it is not precise enough to predict exchange rate changes.

Historical trends suggest that, over time, the rupee tends to weaken against the USD, with rare instances of appreciation. In summary, nominal exchange rates reflect the

expectations of investors, traders, and other parties that influence exchange rate movements. For the short term, theoretical approaches can provide reasonable forecasts of exchange rate movements.

Analyzing The Trend in The Nominal Market Exchange Rate:

In our analysis, the market exchange rate trend (*Figure 5*) is influenced by a range of macroeconomic factors, with the USD playing a pivotal role as a globally accepted currency for commodity trading.

Key factors contributing to exchange rate movements include:

1. In 2018-19, the USD/INR exchange rate saw a significant increase of 7.62%. This was driven by factors such as high commodity prices, especially crude oil, tight monetary policies in the US, an expansion in the Current Account Deficit (CAD), inflationary pressures, and potential fiscal slippage.
2. In 2019-20, exchange rate movements moderated, with a growth rate of 2.09%. Stability continued in 2019-20 at a 2.15% growth rate. India's heavy reliance on crude oil imports, accounting for 80% of its requirements, made it susceptible to CAD fluctuations. However, the US-China trade tensions and a global economic slowdown led to softer crude oil prices, reducing the CAD and contributing to exchange rate stability. Accommodative monetary policies in the latter half of 2019 also aided stabilization efforts.
3. In 2020-21 and 2021-22, the global pandemic had a profound impact, causing significant fluctuations worldwide. The pandemic triggered a massive sell-off in Indian equity markets, resulting in rupee depreciation. This, coupled with a global economic downturn, exacerbated fiscal deficits beyond initial expectations. Challenges further arose from the Federal Reserve's interest rate hikes and US tax increases.
4. In 2021-22, the exchange rate experienced a reduction. Optimism stemming from vaccine availability, the easing of lockdown restrictions, stimulus measures, and

capital inflows into the economy fostered a sense of stability in the forex markets. Additionally, substantial investments in domestic equity markets, driving Sensex and Nifty to all-time highs, provided support for the rupee.

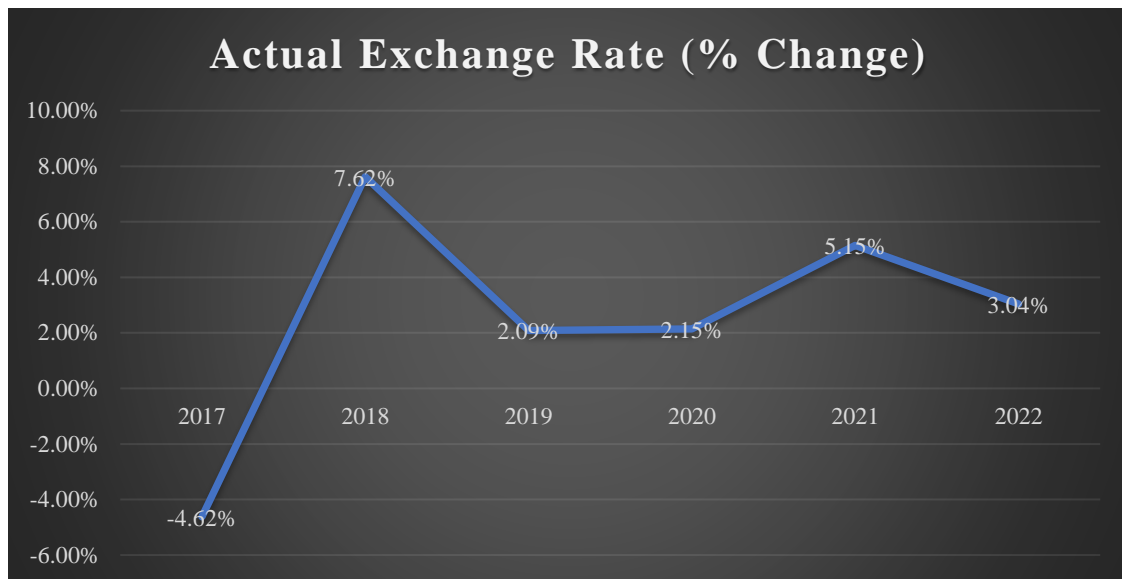


Figure 5

Cointegration

In the pursuit of understanding the intricate dynamics governing exchange rate fluctuations, this study seeks to investigate the impact of several key macroeconomic variables, including Inflation, Interest Rate, External Debt, Gross Domestic Product (GDP), and Foreign Direct Investment (FDI). The primary objective is to discern the extent to which these factors influence exchange rates. In doing so, we have employed the cointegration test methodology, which, as established in prior literature reviews, is regarded as the most robust and reliable approach for yielding accurate outcomes in this context. While alternative tests such as correlation and Anova were considered, it was determined that cointegration best captures the underlying relationships and provides a predictive capability that closely aligns with actual market dynamics. Consequently, our choice of the co-integration test is founded on its superior suitability for investigating

the intricate interactions between exchange rates and the aforementioned macroeconomic indicators.

Prior to conducting the cointegration analysis, a preliminary step involves subjecting our data to the Dickey-Fuller test. This test is employed to evaluate the null hypothesis that a unit root exists within an autoregressive (AR) time series model. Depending on the specific version of the Dickey-Fuller test applied, the alternative hypothesis may entail stationarity or trend-stationarity. The attainment of a stationary model is a prerequisite for proceeding with the cointegration test. Cointegration analysis is a technique designed to explore the long-term correlation among two or more non-stationary time series, either over an extended period or for a specified duration. This sequential approach ensures the robustness and reliability of our investigation into the relationships between the variables under consideration.

Table 4 in our study presents the results of the Johansen cointegration test, which assesses the interrelationships between all the considered macroeconomic variables and the exchange rate. We segmented our analysis into three distinct sections. In the first segment, we operated under the assumption that there exists a trend within the data, implying that the co-integration relationships between the variables do not possess a constant term. The second segment assumed a scenario of no trend, characterized by a constant level without any upward or downward movement. Lastly, the third segment assumed the presence of both a constant and a trend in the cointegration relationships among the variables. These assumptions were contingent upon the outcomes of the Dickey-Fuller test, which established the stationarity of our data at a 5% significance level.

These distinct segments of analysis serve to elucidate the intricate dynamics between the exchange rate and the macroeconomic factors, shedding light on the potential presence of relationships and underlying patterns that may influence the exchange rate.

Table 4: Johansen Cointegration Trace Test

Test	Score	C.V.	Pass?	5.0%
Trace Test (r = 0)	0		r>0	
<i>No Const</i>	579.9	83.9	TRUE	
<i>Const-Only</i>	599.8	95.8	TRUE	
<i>Const + Trend</i>	551.2	107.3	TRUE	

Table 5: Johansen Cointegration Test (Maximum Eigenvalue)

(r = 5)	5		r=6	
<i>No Const</i>	0.1	4.1	FALSE	
<i>Const-Only</i>	1.4	3.8	FALSE	
<i>Const + Trend</i>	12.3	3.8	TRUE	

In Table 5 of our research, we present the results of the null hypothesis (Maximum Eigenvalue) test, which plays a pivotal role in our analysis. This test assesses whether the number of linear combinations is equal to the number of variables in our dataset, which implies that all input data are stationary. In such a case, the cointegration test becomes irrelevant. Notably, a positive indication for this test is observed when we consider the case where 'r = 6,' indicating the presence of both a constant and a trend in the cointegration relationships among the variables. It is important to highlight that this assessment was only feasible when our model exhibited stationarity.

These findings offer valuable insights into the potential existence of deterministic constants and trends in the relationships among the variables under consideration, contributing to a comprehensive understanding of their interplay. Furthermore, the requirement of stationarity underscores the importance of pre-processing and data preparation in our analysis, ensuring the validity and reliability of our results.

Table 6 in our research study focuses on examining the association between Inflation and the exchange rate. Our analysis reveals that Inflation does not exert a significant influence on the exchange rate, as indicated by the test results. Notably, we subjected the model to various scenarios, including those with no constant, a constant only, a constant plus trend, and even a constant plus trend plus trend square. In all these scenarios, the model remained non-stationary at the 5% significance level.

The observed behavior of the Dickey-Fuller model rendered it unfeasible to proceed with the cointegration test, as the initial condition of achieving stationarity could not be met. This underscores the importance of understanding the data's characteristics and acknowledging the limitations posed by non-stationarity when attempting to discern the relationships between variables. Consequently, our findings provide valuable insights into the limited impact of Inflation on exchange rate dynamics and underscore the importance of rigorous testing methodologies in econometric research.

Table 6: Stationarity Test

Test	Score	P-Value	C.V.	Stationary?	5.0%
ADF					
<i>No Const</i>	-0.7	40.1%	-2.0	FALSE	
<i>Const-Only</i>	-1.9	35.1%	-3.0	FALSE	
<i>Const + Trend</i>	-1.9	61.9%	-3.6	FALSE	

<i>Const+Trend+Trend^2</i>	-2.1	71.7%	-4.2	FALSE	
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Table 7 in our research study is dedicated to exploring the relationship between Interest Rate and the exchange rate. Our analysis demonstrates a notable and statistically significant impact of interest rates on the exchange rate. Importantly, the model exhibited stationarity across various scenarios at a 5% significance level, validating the reliability of our findings.

We relied on the Dickey-Fuller test to ascertain stationarity under different conditions, including scenarios with no constant, a constant-only, a constant plus trend, and a constant plus trend plus trend square. The consistently observed t-statistic value of -4.37707 remained lower than that of all three specified models, even at different sample sizes (N=25), and across significance levels of 1%, 2.5%, 5%, and 10%. This consistent pattern underscores the robustness of the relationship between Interest Rate and the exchange rate, further highlighting its statistical significance and stationarity. These findings provide valuable insights into the intricate dynamics governing the relationship between interest rates and exchange rates, with implications for economic policy and financial markets.

Table 7: Stationarity Test

Test	Score	P-Value	C.V.	Stationary?	5.0%
ADF					
<i>No Const</i>	-4.4	1.0%	-2.0	TRUE	
<i>Const-Only</i>	-4.4	1.0%	-3.0	TRUE	
<i>Const + Trend</i>	-4.6	1.0%	-3.6	TRUE	
<i>Const+Trend+Trend²</i>	-4.4	3.4%	-4.2	TRUE	

Table 8 within our research presents an analysis of the relationship between external debt and the exchange rate. Interestingly, our findings reveal a rather unexpected outcome when we consider the scenario in which the model lacks a constant term – it becomes non-stationary and consequently fails to meet the prerequisites for the cointegration test.

However, when we adopt assumptions that include a constant term, such as ‘constant only’, ‘constant plus trend’, and ‘constant plus trend plus trend square’, a strong and discernible influence of external debt on the exchange rate emerges. These results point toward a substantial cointegration between external debt and the exchange rate, and this observation is further substantiated by the calculated t-statistic value of -3.6225. This value consistently remains lower when compared to Model 0, 1, and 2, particularly at the 5% level of significance.

These findings provide crucial insights into the nuanced relationship between external debt and exchange rates, highlighting the importance of certain model assumptions and their impact on statistical significance. The results underscore the relevance of considering both short-term and long-term dynamics when analyzing the influence of external debt on exchange rate movements.

Table 8: Stationarity Test

Test	Score	P-Value	C.V.	Stationary?	5.0%
ADF					
<i>No Const</i>	-0.9	33.4%	-2.0	FALSE	
<i>Const-Only</i>	-3.6	1.4%	-3.0	TRUE	
<i>Const + Trend</i>	-4.5	1.0%	-3.6	TRUE	
<i>Const+Trend+Trend²</i>	-4.4	3.3%	-4.2	TRUE	

Table 9 in our research study presents an examination of the relationship between Gross Domestic Product (GDP) and the exchange rate. Our analysis reveals interesting dynamics in this relationship, which vary depending on the underlying assumptions.

Notably, when we consider scenarios with no constant and the inclusion of a trend square term, the model fails to achieve statistical significance. Consequently, this lack of significance translates to a lack of cointegration between GDP and the exchange rate. This observation is corroborated by the calculated t-statistic value of -0.47395, which consistently exceeds the values observed in Model 0, 1, and 2 at the 5% significance level.

However, a different pattern emerges when we examine scenarios with a constant term and a constant plus trend assumption. In these cases, the model exhibits stationarity, and a cointegration relationship becomes evident. These findings suggest that GDP and the exchange rate are indeed related, but the nature of this relationship hinges on specific modeling assumptions.

These results emphasize the nuanced nature of the link between GDP and exchange rates, underscoring the importance of careful model selection and consideration of different scenarios when analyzing the dynamics between these two economic variables.

Further exploration may be necessary to uncover the underlying mechanisms that drive this relationship under various conditions.

Table 9: Stationarity Test

Test	Score	P-Value	C.V.	Stationary?	5.0%
ADF					
<i>No Const</i>	-0.5	45.9%	-2.0	FALSE	
<i>Const-Only</i>	-3.2	3.6%	-3.0	TRUE	
<i>Const + Trend</i>	-3.8	3.2%	-3.6	TRUE	
<i>Const+Trend+Trend²</i>	-3.9	8.4%	-4.2	FALSE	

Table 10 within our research study delves into the examination of the relationship between FDI and the exchange rate. Our analysis uncovers intriguing insights, revealing that the nature of this relationship is influenced by specific modelling assumptions.

In scenarios where we omit both a trend and an intercept, the t-statistic value of -2.81288 maintains statistical significance at the 5% level of significance in Model 0. This finding implies that there is a statistically meaningful connection between FDI and the exchange rate when we apply this particular model specification. However, it is noteworthy that this significance diminishes when we consider the assumption of 'constant plus trend plus trend square.' In this case, the model does not exhibit cointegration due to its lack of significance.

Conversely, when we focus on the assumptions of 'constant only' and 'constant plus trend,' the model retains its significance, indicating the presence of cointegration between FDI and the exchange rate under these specific conditions. This underscores the

notable impact of FDI on the exchange rate, which becomes apparent when we adopt certain modeling frameworks.

These findings shed light on the multifaceted nature of the relationship between FDI and exchange rates and underscore the importance of considering various model specifications when investigating their interactions. Further exploration may be warranted to gain a deeper understanding of the mechanisms at play in this complex relationship.

Table 10: Stationarity Test

Test	Score	P-Value	C.V.	Stationary?	5.0%
ADF					
<i>No Const</i>	-2.8	1.0%	-2.0	TRUE	
<i>Const-Only</i>	-3.4	2.3%	-3.0	TRUE	
<i>Const + Trend</i>	-4.0	2.3%	-3.6	TRUE	
<i>Const+Trend+Trend²</i>	-4.0	6.9%	-4.2	FALSE	

6. CONCLUSION

In conclusion, this research paper has undertaken a comprehensive analysis of exchange rate determination using two key methodologies: Purchasing Power Parity Exchange Rate and Real Exchange Rate, focusing on the time period from 2015 to 2025. The study also incorporated cointegration tests to examine the relationships between exchange rates and various macroeconomic variables, including Inflation, Interest Rate, External Debt, GDP, and FDI.

The findings from the analysis of exchange rate determination methodologies indicate that while PPPER and RER can provide reasonable short-term forecasts of exchange rate

movements, their accuracy diminishes over longer time horizons. These theoretical models, which rely on factors such as inflation rates, real exchange rates, and nominal exchange rates, are not highly accurate for long-term exchange rate predictions. This is primarily because real-world exchange rates are influenced by a multitude of complex macroeconomic factors beyond the scope of these models, including interest rates, fiscal policies, trade dynamics, and investor sentiment.

The study also sheds light on the complex relationships between exchange rates and macroeconomic variables. Notably, Interest Rate and External Debt have demonstrated statistically significant impacts on exchange rate movements when the appropriate modeling assumptions are employed. However, Inflation, GDP, and FDI exhibit varying degrees of influence on exchange rates depending on the specific modeling scenarios considered. These nuanced findings highlight the importance of careful model selection and consideration of various factors when analyzing exchange rate dynamics.

Furthermore, the research underscores the necessity of addressing stationarity in time series data, as demonstrated by the Dickey-Fuller test. Achieving stationarity is a fundamental prerequisite for conducting cointegration tests, which offer valuable insights into the long-term relationships between exchange rates and macroeconomic indicators.

In the context of exchange rate movements over the study period, several key factors have emerged as drivers of change. These include fluctuations in global commodity prices, particularly crude oil, as well as monetary policies in the United States and India, trade dynamics, and fiscal deficits. The COVID-19 pandemic also had a significant impact on exchange rates, causing fluctuations in equity markets and affecting investor sentiment.

In summary, exchange rate determination is a complex and multifaceted process influenced by a myriad of macroeconomic factors. The accuracy of exchange rate forecasts depends on the time horizon and the specific methodologies employed. While theoretical models like PPPER and RER can provide short-term insights, they are limited

in their ability to predict long-term exchange rate movements accurately. Therefore, policymakers, businesses, and investors should consider a holistic approach that takes into account a wide range of economic variables and their dynamic interactions when making decisions related to exchange rates. This research contributes to our understanding of these complexities and offers valuable insights for future research and practical applications in the field of international finance.

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