



2024 - EC6011:Business Forecasting

Continuous Assessment Team Project: Team 17

SUBMITTED BY

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We hereby declare that this work is entirely our own and has not been submitted as part of any other examination or assignment. Any use of the work of others in this assignment is duly acknowledged

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Introduction

Importance of currency in Global Trade

Currency stands as one of the major determining factors of livelihood in all parts of the globe. All activities carried out in order for sustaining day to day necessities is facilitated by the exchange of currency. Just like the river symbolizes the flow of water, all the way up from the source to its tributaries and riverbanks, the total amount or the flow of currency (money) can also be juxtaposed with the flowing nature of the river to the tributaries in the form of profits by a business, salaries or wages and investments/ returns and the riverbanks which inherently are characterized by economic institutions, regulations and other financial instruments . Here we try to think of currency as the amount of money circulating within the ecosystem, and the riverbanks (financial institutions) as sturdy economic systems that mediate and facilitate the proper flow of the currency, preventing droughts (economic depression) or floods (inflation).

Continuing the same train of thought, the global economy can be juxtaposed to the main river signifying the flow of currency all over the world. The tributaries can be contrasted to national economies flowing into the main river. Where these tributaries meet the main river, there are varying heights of the riverbanks, which signify exchange rates or the difference in the values of these currencies. The purchase power parity suggests that the heights of the river banks or the exchange rates of the tributaries (national economies) flowing into the main river (global economy) should be adjusted for consumers to be able to buy the same amount of goods and services in each country. The Consumer Price Index (CPI) in each country signifies how much the goods and services cost in each country.

In other words, the flow of currency in the global economy is arbitrated through tools such as purchasing power parity and consumer price index. Each country has its own economic landscape with factors such as import/export costs, interest rates, inflation rates and others that influence the overall currency. The nominal exchange rate is the predictor for the striking price for the exchange rate or how much of one currency one can obtain in exchange for the other. Whereas the real exchange rates take into consideration the purchasing power and the consumer price index of both countries.

Purchase Power Parity (PPP) Theory and Role of CPI

Our reports have specified the home country as India with its currency as Indian Rupees (INR) and the foreign country to be the United States of America with its currency being US Dollars (USD). Our report shed light on procuring the nominal exchange rate data for the home country, India, against the foreign country, United States of America. The Consumer Price Index data was also gathered for both the countries which is a metric to determine the change of the price of goods and services overtime in a particular country. The CPI data for both India and the United States were gathered and preprocessed in an excel sheet to match the data frequency and cohesively clean the data. The Real Exchange rates were calculated in the further steps and subsequently added to the data sheet.

Furthermore, the log of nominal exchange rate , real exchange rate and consumer prices were calculated for both the home country , India and the foreign country, the United States. In further steps, analyzed the properties of the variable created to test the relative and absolute values of purchasing power parity. Finally, a modeling and forecasting of the real exchange rates were carried out using Box Jenkins modeling produces.

Objectives: Data Procurement, Analysis, and Insights

In this report, we aim to create a clear elucidation of the requisite steps that were involved in each of that collectively contributed to the report as a whole including data procurement, data preprocessing, extracting the data into the code and subsequently carrying out the required analysis and obtaining insights in the form of line graphs, scatter plots, pair plots and bar charts advanced and finally modeling the data using the Box Jenkins Model. We aim to delve deep into the essential steps that contributed in terms of extracting valuable insights from the data procured and also corroborate the insights and results obtained from the analysis.

Trade relation history – India / United States of America

The United States has surpassed China as India's main commercial partner from 2021 to 2022 (Iqbal, Nosheen and Wohar, 2023). This developing trade relationship, marked by a high volume of traded products and services and a positive trade surplus for India.

The "third-country effect" adds another amount of depth. Exchange rate fluctuations between the rupee and the yen and the dollar might have an indirect impact on India-US commerce. For example, the yen's dynamics may have an influence on Indian firms manufacturing agricultural machinery or telecommunications equipment (Iqbal, Nosheen and Wohar, 2023). A weakening yen compared to the rupee might make Japanese goods more costly in India, perhaps opening up opportunities for Indian companies to fill the vacuum in the US market.

Import volumes of specific goods, such as chemical elements from the US, might also be dampened by volatile exchange rates. However, the lagged effects, where past exchange rate fluctuations continue to influence present trade patterns, add another dimension to consider.

Our paper, which examines the India-US trade relationship through the prism of exchange rate volatility, can provide significant insights. It can show how currency changes disturb established trade patterns, possibly altering the content of exported and imported commodities.

Data Acquisition and Preprocessing

For the primary steps, we selected India and the United States of America, with India as the home country and USA as the foreign country. We obtained the data for the nominal exchange rate between Indian Rupees(INR) and US Dollars(USD) from Yahoo Finance. The data was downloaded from Yahoo Finance website by importing a python library module named *yfinance*. Here the daily exchange rates of INR against USD were gathered starting from January 2012 all the way up to January of 2022, marking 10 years of gathered data considering the guidelines of the report. The next steps involved combining the data for the individual nominal exchange rates generated in daily format to create a monthly average for the gathered data. This was done in order to match the data frequency of the Consumer Price Index Data which was to be gathered and processed in the succeeding steps.

Following the aggregation of the exchange rate data into monthly averages, we moved on to the analysis phase of the project. This involved juxtaposing the monthly average exchange rates against corresponding Consumer Price Index (CPI) data for both India and the USA. By aligning these datasets, we aimed to uncover trends and patterns in currency exchange rates in relation to changes in the cost of goods and services over time.

On conducting analysis, several key findings made themselves pronounced. We observed fluctuations in the monthly average exchange rates between the INR and USD, reflecting high shifts in currency valuation over the ten-year period. These fluctuations were further examined in correlation to changes in CPI data, shedding light on the impact of inflation and purchasing power disparities between the two economies. By identifying these correlations, we gained insights into the factors influencing currency exchange rates and their implications for economic stability and international trade relations.

The data for the Consumer Price Index (CPI) for both the home country, India and the foreign Country, USA was gathered from the World Bank Database. The World Bank data contained consumer price index data for all countries around the world. Our data processing steps involved filtering out the data pertaining to the selected counties and then subsequently creating a CSV file and converting the data into the desired format for us to carry out the next steps which were to analyze the data and derive insights from them.

A CSV file was created using these data sets which included metrics such as the dates in a monthly format from the year 2012 to 2022, nominal exchanges pertaining to each of these dates and the CPI index for both the home country and the foreign country.

The next step involved calculating the Real Exchange rates from the procured data which were concatenated into the CSV file. This was done through the real exchange rate formula using the CPI index. The formula used: $RER = (e * (P^*/P))$, where e is the nominal exchange rate, P^* is the average price in the foreign country and P is the nominal exchange rate in the home country.

After calculating the real exchange rates for our selected home country against its foreign counterpart, we primarily spotted fluctuations between the real and nominal exchange rates of the home country over the past 10 years with periods of comparatively high RER and lower RER. A few factors that affect the real exchange rates are:

1. Nominal Exchange Rates (e)- The predictor for the striking price for the exchange rate or how much of one currency you can get in exchange for the other.
2. Relative Price Levels: (P^*/P)- The ratio of average prices in foreign and home countries represented by their respective CPI indices.

Several factors affect the nominal currency fluctuation which are inflation, interest rates and demand for currency. If the home currency weakens, it makes goods cheaper in a foreign country. This is because the real exchange rate goes up, meaning the same amount of your currency can buy more goods abroad. However, if prices in the home country rise faster than in the foreign country or there is higher inflation, goods in the home country become relatively more expensive, even though your currency might be weaker.

In our report, the nominal and real exchanges rates have highly fluctuated for the home country over the period of ten years. Periods signifying a higher real exchange rate usually imply the inflation in the foreign country to be higher whereas the periods spotting a lower exchange rate imply the inflation in the home country to be higher than the foreign country.

All inclusive, the data gathered on the home and foreign countries indicate a highly fluctuating trend with multiple factors such as inflation, CPI index, import/export costs, interest rates and other factors that contribute to the same.

Moreover, in next steps we create a detailed analysis of how the real and nominal values of the currency have fluctuated by creating logarithmic equivalents of the same and calculating the validity of relative and absolute purchase power parity.

Testing Purchasing Power Parity (PPP)

Purchasing Power Parity (PPP) is an economic theory that suggests a link between exchange rates and inflation. It implies that, in a condition of equilibrium, the exchange rate between two currencies should adjust such that a basket of equivalent goods and services costs the same amount in both nations (Mankiw, 2016). In simpler terms, PPP implies that currencies should have the same purchasing power across different countries.

Absolute PPP

According to this precise concept of PPP, the exchange rate between two currencies should exactly equal the ratio of the price levels of an identical basket of goods and services in each nation (Lafrance and Schembri, 2002). Imagine buying a basket of identical groceries in both India and the USA. Absolute PPP suggests that, in a perfect world, the exchange rate should be exactly what you need to spend the same amount of money (in rupees or dollars) on that basket, regardless of the country.

We looked for a long-term equilibrium relationship between the exchange rate and the difference in inflation rates. While we found some connection, it might not be as strong as absolute PPP predicts. While the test findings indicate cointegration, the coefficient is not equal 1, which is a rigorous criterion for absolute PPP (Corbae and Ouliaris, 1988).

Relative PPP

This dynamic type of PPP takes into account that achieving absolute PPP may be challenging owing to considerations such as transportation costs and non-tradable items. However, it suggests that exchange rate adjustments should be proportional to the relative changes in price levels between the two nations (Rogoff, 2024).

An Augmented Dickey-Fuller (ADF) test revealed that the differenced series of the log nominal exchange rate is stationary. We checked if the changes in the exchange rate itself exhibited a stable pattern over time (stationarity). This is a necessary step for further analysis. The test result (p-value of $3.78e-11$, highly significant) suggests we can proceed (De Carvalho and Júlio, 2012).

We looked for a long-term tendency for changes in the exchange rate to move in relation to the difference in inflation rates. The test result (p-value of 0.043) suggests a weak cointegration, meaning there might be some connection, but it's not very strong.

Insights and Implications for Trading:

Our findings show that there may be a small connection between exchange rate movements and inflation variations. In other words, if inflation in India rises quicker than in the United States, the rupee may weaken (exchange rate rises) little relative to the dollar. However, the data is not convincing, and other variables are likely to influence the exchange rate.

Currency Depreciation and Exports: If inflation in India grows faster than in the US, the rupee may depreciate (become weaker relative to the dollar). This, in principle, may make Indian commodities cheaper for American customers, thereby increasing Indian exports to the United States.

Currency Appreciation and Imports: If inflation is higher in the United States than in India, the rupee may appreciate (become stronger). This might increase the cost of American imports for Indian customers, thereby affecting the flow of goods from the United States to India.

Factors of consideration

The following must be considered before assumptions:

Not the only factor: Our study indicates that inflation is not the only factor impacting currency rates and trade flows. Other important issues include trade restrictions, productivity gaps, and global economic situations (Lafrance and Schembri, 2002).

Time Lags: Inflationary movements may not immediately affect currency rates or trade flows. There may be temporal gaps before these impacts are completely realised.

Analysis of Exchange Rates and Inflation

Using python, we calculated the log of nominal exchange rate, real exchange rate along with the logs of the Consumer Price Index (CPI) for both the home and foreign countries respectively.

Taking the logarithm for both nominal and real exchange rate is beneficial for linearizing the relationship as both the aforementioned metrics exhibit non-linear behavior.

This makes it easier to analyze and is useful in the context of an ARIMA model. Using logarithms also dampens the impact of large fluctuations on the data and focuses on percentage changes allowing for ease of comparison.

In the context of Consumer Price Index (CPI), using logarithms as mentioned before, linearizes the relationship and reduces the impact of large fluctuations, in addition to this, raw CPI values do not clearly show percentage changes and using logarithms sheds light on the percentage changes of CPI, therefore enabling us to easily compare rates of inflation across different countries and also analyze economic trends.

We therefore analyze the historical behavior of the log of nominal and real exchange rates, in an effort to identify trends and patterns relating to our home and foreign currencies.

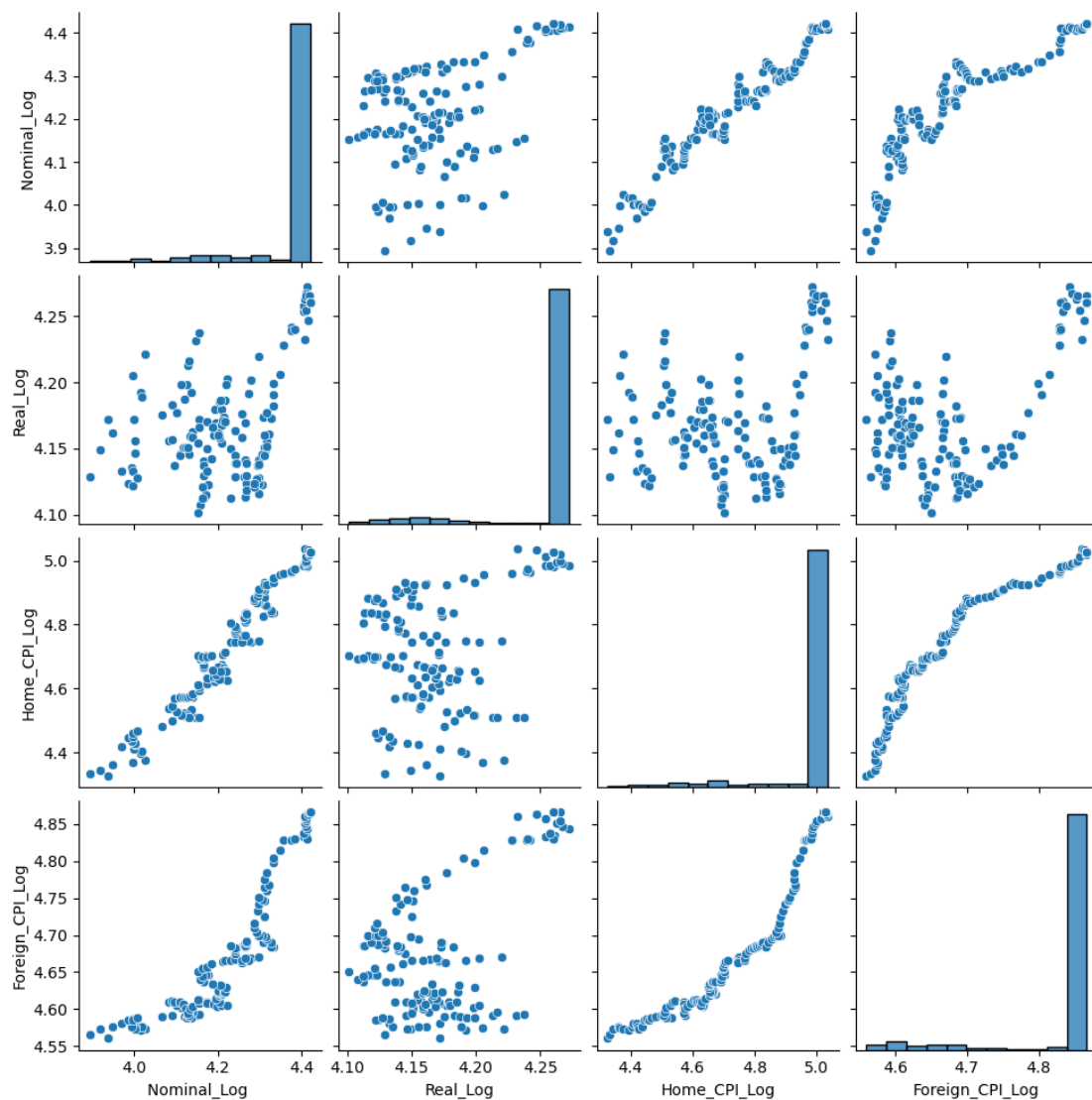


Figure 1: Pair plot

The following figure displays a Pair plot representing the logs of Nominal exchange rate, real exchange rate and the log of Consumer Price Index of both home and foreign countries.

The graph gives us a visual representation of the correlation between each of these metrics.

Correlation Matrix:				
	Nominal_Log	Real_Log	Home_CPI_Log	Foreign_CPI_Log
Nominal_Log	1.000000	0.860961	0.991258	0.967946
Real_Log	0.860961	1.000000	0.824884	0.906315
Home_CPI_Log	0.991258	0.824884	1.000000	0.976053
Foreign_CPI_Log	0.967946	0.906315	0.976053	1.000000

Figure 2: Correlation Matrix

The table above represents a correlation matrix, which shows us the strength and direction of linear relationships between the logs of Nominal Exchange rate, Real Exchange Rate, CPI of the home country (India), CPI of the foreign country(USA).

According to the matrix, the log of nominal exchange rate and log of CPI of the home country (India) have a strong positive correlation (0.991258) implying that as the log of nominal exchange rate increases, the log of CPI of the home country also tends to increase. An increase in CPI also indicates inflation in the country.

There is also a strong positive correlation between the log of the real exchange rate and the log of the CPI of the foreign country (0.906315). This implies that appreciation in the real exchange rate is associated with an increase in the CPI of the country, which therefore indicates inflation. (Baldwin, 2021)

There is a strong positive correlation between the logs of CPI between both home and foreign countries (0.976053), which implies that inflation in one country is positively correlated with inflation in the other. However, we should keep in mind that correlation does not imply causation, meaning the rate of inflation of both countries could be positively correlated but it doesn't necessarily imply that they directly affect or cause a change in each other.

There is also a moderate positive correlation (0.860961) between the nominal exchange rate and the real exchange rate, which implies appreciation in the nominal exchange rate is accompanied by an appreciation in the real exchange rate.

These correlations essentially show that there are positive relationships between exchange rates and inflation rates in both countries. The correlation matrix also potentially suggests that inflation in a country leads to depreciation of its currency i.e. a weaker nominal exchange rate relative to a country with lower rates of inflation.

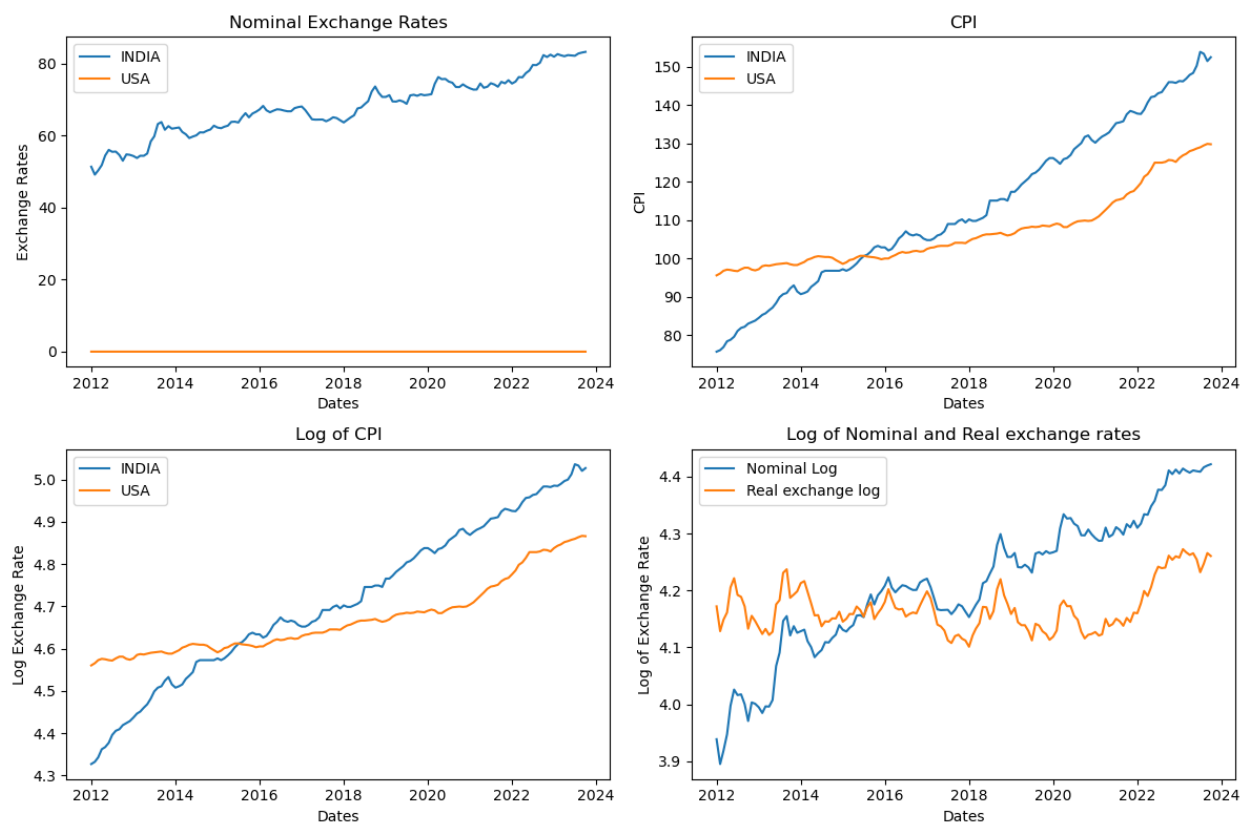


Figure 3: Trend Analysis

The above line charts show the change in Nominal exchange rate, CPI, log of CPI, log of nominal and real exchange rates respectively with in relation to time in years, with blue representing the home country, India and orange representing the foreign country, USA. Based on the graphs we

can see that there's an upward trend in all of them over time, with especially India having a sharper rise in CPI and log of CPI, which essentially indicates a rise in the level of inflation. There is an increase in the CPI and log of CPI for the USA as well, although it's not as sharp on comparing it with India. However, these graphs do not represent or claim that inflation in one country leads to inflation in the other.

A fluctuation in exchange rate however may influence inflation as If the home currency weakens relative to the foreign currency, imported goods may become more expensive and this can put an upward pressure on domestic prices and contribute to inflation.

	Dates	IND (CPI)	USA(CPI)	Nominal ER(IND)	Nominal ER(USA)	RER(e * (P*/P)	Nominal_Log	Real_Log	Home_CPI_Log	Foreign_CPI_Log
0	2012-01-01	75.7	95.6	51.35	0.0195	64.848877	3.938665	4.172060	4.326778	4.560173
1	2012-02-01	76.1	96.1	49.16	0.0203	62.079842	3.895080	4.128421	4.332048	4.565389
2	2012-03-01	76.9	96.8	50.32	0.0199	63.341691	3.918403	4.148544	4.342506	4.572647
3	2012-04-01	78.4	97.1	51.80	0.0193	64.155357	3.947390	4.161308	4.361824	4.575741
4	2012-05-01	78.8	97.0	54.47	0.0184	67.050635	3.997650	4.205448	4.366913	4.574711
5	2012-06-01	79.6	96.8	56.03	0.0178	68.136985	4.025887	4.221520	4.377014	4.572647
6	2012-07-01	81.1	96.7	55.49	0.0180	66.163785	4.016203	4.192133	4.395683	4.571613
7	2012-08-01	81.9	97.2	55.56	0.0180	65.939341	4.017464	4.188735	4.405499	4.576771
8	2012-09-01	82.2	97.6	54.61	0.0183	64.841071	4.000217	4.171939	4.409155	4.580877
9	2012-10-01	83.0	97.6	53.02	0.0189	62.346410	3.970669	4.132706	4.418841	4.580877

Figure 4: Overview of Exchange Rates and Logs

	IND (CPI)	USA(CPI)	Nominal ER(IND)	Nominal ER(USA)	RER(e * (P*/P))	Nominal_Log	Real_Log	Home_CPI_Log	Foreign_CPI_Log
IND (CPI)	1.000000	0.984589	0.992312	-0.981399	0.855897	0.988766	0.852049	0.997703	0.987789
USA(CPI)	0.984589	1.000000	0.975871	-0.948292	0.916664	0.964252	0.913240	0.971551	0.999747
Nominal ER(IND)	0.992312	0.975871	1.000000	-0.993511	0.882711	0.998537	0.879812	0.991315	0.978633
Nominal ER(USA)	-0.981399	-0.948292	-0.993511	1.000000	-0.840633	-0.998186	-0.837871	-0.987687	-0.952957
RER(e * (P*/P))	0.855897	0.916664	0.882711	-0.840633	1.000000	0.863795	0.999922	0.828807	0.909792
Nominal_Log	0.988766	0.964252	0.998537	-0.998186	0.863795	1.000000	0.860961	0.991258	0.967946
Real_Log	0.852049	0.913240	0.879812	-0.837871	0.999922	0.860961	1.000000	0.824884	0.906315
Home_CPI_Log	0.997703	0.971551	0.991315	-0.987687	0.828807	0.991258	0.824884	1.000000	0.976053
Foreign_CPI_Log	0.987789	0.999747	0.978633	-0.952957	0.909792	0.967946	0.906315	0.976053	1.000000

Figure 5: Correlation Matrix

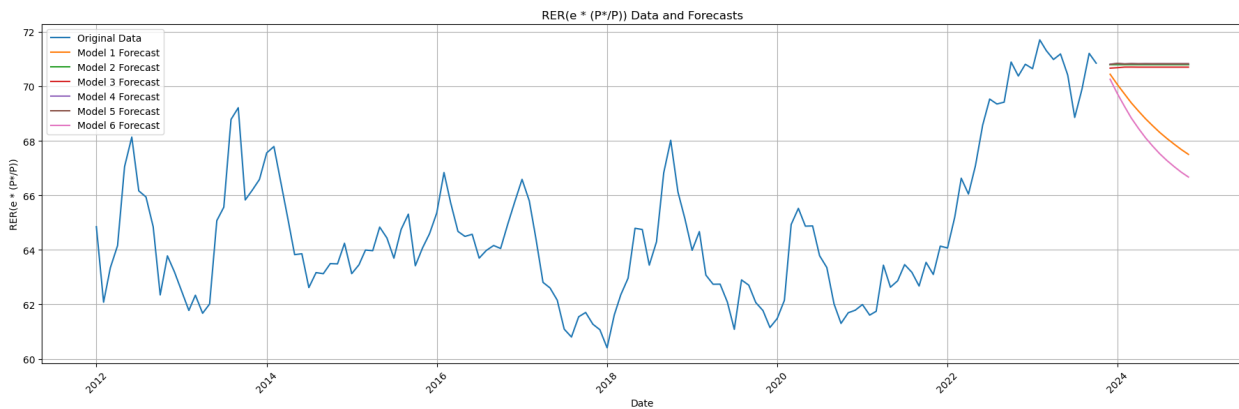


Figure 6: Actual and Forecasted Graph

The above graph shows the actual and forecasted value of the real exchange rate over time. We've used 6 different ARIMA models to evaluate and forecast the real exchange rate. According to the graph Model 6 (ARIMA(1,0,1)) has the lowest - RMSE: 0.006687453621468272 which indicates that it is the best suited model to forecast and predict the fluctuation of the exchange rate.

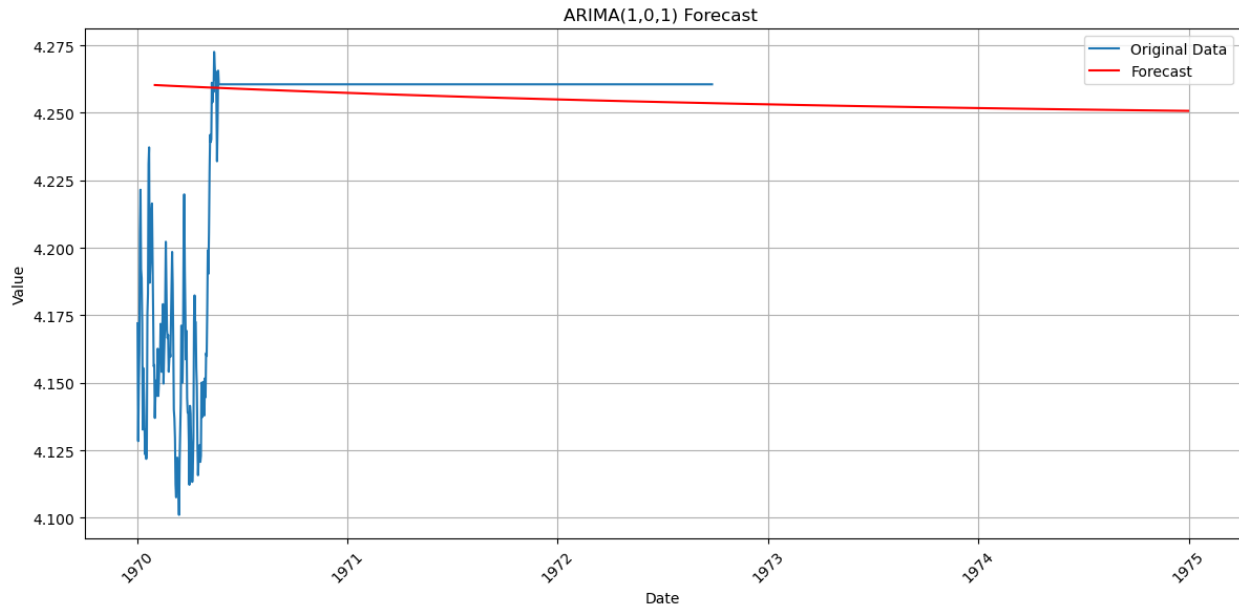


Figure 7. ARIMA (1,0,1) Forecasting Graph

The above graph represents the ARIMA (1,0,1). Based on the graph, the forecast shows a downward trend in the value of the real exchange rate, which implies that the value of the INR(Indian Rupee) with respect to the US Dollar (USD) will depreciate over time.

Conclusion

Our report aims to gauge at a comprehensive exploration of the dynamics surrounding nominal and real exchange rates, as well as the flow of currency within the global economy, specifically between India and the United State. The same report can also be used as a reference point to chalk out the major determining factors of purchase power parity through the metrics such as CPI and nominal and real exchange rates. Through the metaphorical illustration of rivers and tributaries, we conceptualized the movement of currency, showcasing how economic activities and livelihoods are facilitated by the exchange of money.

The report shed light on the significance of factors such as inflation, purchasing power parity, and consumer price indices in shaping currency valuation and economic performance. We observed that nominal exchange rates serve as predictors for the relative value of currencies, while real exchange rates offer a more nuanced understanding by accounting for purchasing power and price levels in both countries.

Furthermore, our study highlighted the unified nature of national economies in the grand scheme of global economies, akin to tributaries converging into a main river. We elucidated how exchange rates act as indicators of the relative strength and competitiveness of different economies, with implications for trade, investment, and overall economic stability.

Our studies revealed the relationship between nominal and real exchange rates, with fluctuations influenced by factors including inflation, interest rates, and demand for currency. We observed how changes in inflation rates can impact currency depreciation or appreciation, subsequently affecting trade flows between countries.

Moreover, understanding purchasing power parity highlighted the challenges in achieving absolute parity between exchange rates and price levels across different nations. While relative PPP implies a proportional adjustment of exchange rates between the home country and the foreign country, it is a subject to change considering the price levels, our analysis found weak correlation between exchange rate movements and inflation differentials.

We recognize the importance of considering multiple factors beyond inflation, such as trade restrictions and global economic conditions, in understanding currency movements and their impact on international trade.

Overall, the correlation matrix analysis for the US and India reveals important connections between exchange rates and inflation rates in both countries.

Furthermore, we find a strong positive correlation between the US dollar's value against the Indian Rupee and India's Consumer Price Index (CPI). This implies that when the value of the USD increases relative to the INR, indicating a stronger value of USD, India's CPI tends to rise as well, pointing towards inflation in India. So an increase in the CPI has a positive effect on inflation.

Similarly, there is a strong positive correlation spotted between the real value of the exchange rate and the CPI of the United States. This indicates that when the real exchange rate of the USD increases, there is a perceivable increase in purchasing power for Americans abroad, the CPI of the United States tends to increase, indicating inflation within the US economy.

Additionally, the strong positive correlation between the CPIs of both the US and India indicates that inflation in one country tends to be positively associated with inflation in the other. However, it's essential to recognize that correlation does not imply causation; while inflation rates may move together, they may not directly influence each other since other factors such as trade policies, interest rates and political and demographic conditions play a major role in shaping the currency movement as well.

Overall, these correlations imply that inflation in either the US or India could lead to depreciation of their respective currencies relative to each other. This understanding underscores the complex relationship between exchange rates and inflation rates in both countries, highlighting the need for careful consideration of these factors in decision-making.

Considering the global economy as a single working unit, our learning reflections suggest an interconnectedness between the intrinsic value of a currency, inflation, the consumer price index and the purchasing power with movements of each of these metrics signaling a change in the other metrics. Our report has aimed to drill down to the intricacies associated with the economic movements pertaining to currency fluctuations by considering indices such as the CPI and purchasing power, which is nothing but the average price of goods in each of selected countries and the subsequent purchasing power that citizens of the country possess, considering the factors.

Knowing how exchange rates change is crucial as it affects trade, investments, and factors into creating a stable economy. By looking at things like inflation and buying power, we can see how much stuff costs in different countries and how much people can afford to buy. This information is useful for governments, businesses, and even regular people because it helps them make better decisions about money.

By garnering an understanding of all the aforementioned insights that this report generates together, the whole economy becomes more flexible and can handle changes better. This helps us deal with challenges and grow in a way that benefits nations as a whole. The more we learn about

how the economy works, the better we can build a system that's fair and stable for all the citizens of the nation.

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Author Contributions

AUTHOR	CONTRIBUTION
Anshul Shetty	Literature review, Creating logs and explaining properties
Nilesh Khatiya	Python models
Sasha David	Data collection. Literature review, Report and editing
Raajit Chattopadhyay	Data collection, Collation of data for report, Purchasing power parity.