EXCHANGE RATE DYNAMICS: TIME SERIES ANALYSIS AND FORECASTING

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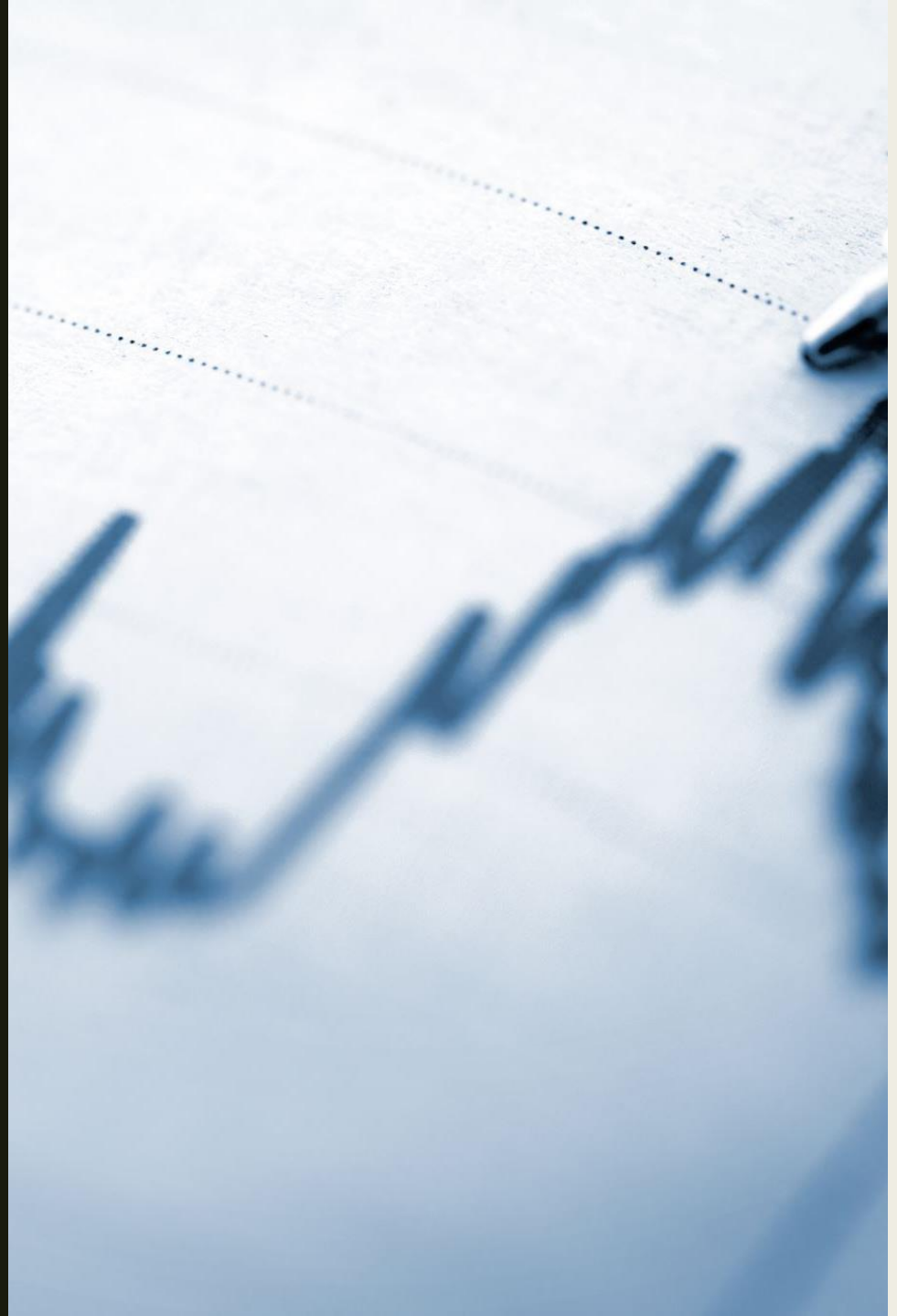
INTRODUCTION

Objective:

To analyse historical exchange rate data of major currencies and forecast using time series analysis (ARIMA, SARIMA, and SARIMAX) techniques.

Mentioned Currencies:

Euro (EUR), Japanese Yen (JPY), Indian Rupees (INR), UK Pound Sterling (GBP), and Chinese Yuan (CNY)



MOTIVATION

In today's global economy, exchange rates are pivotal for:

- Navigating Volatility
- Risk Management
- Investment Opportunities
- Policy Implications
- Exports and Imports

DATA FLOW

Source of Data: Federal Reserve Economic Data (FRED) API

Mentioned Currencies: Euro (EUR), Japanese Yen (JPY), Indian Rupees (INR), UK Pound Sterling (GBP), Chinese Yuan (CNY).

Data Attributes: Date and Exchange Rate Value.

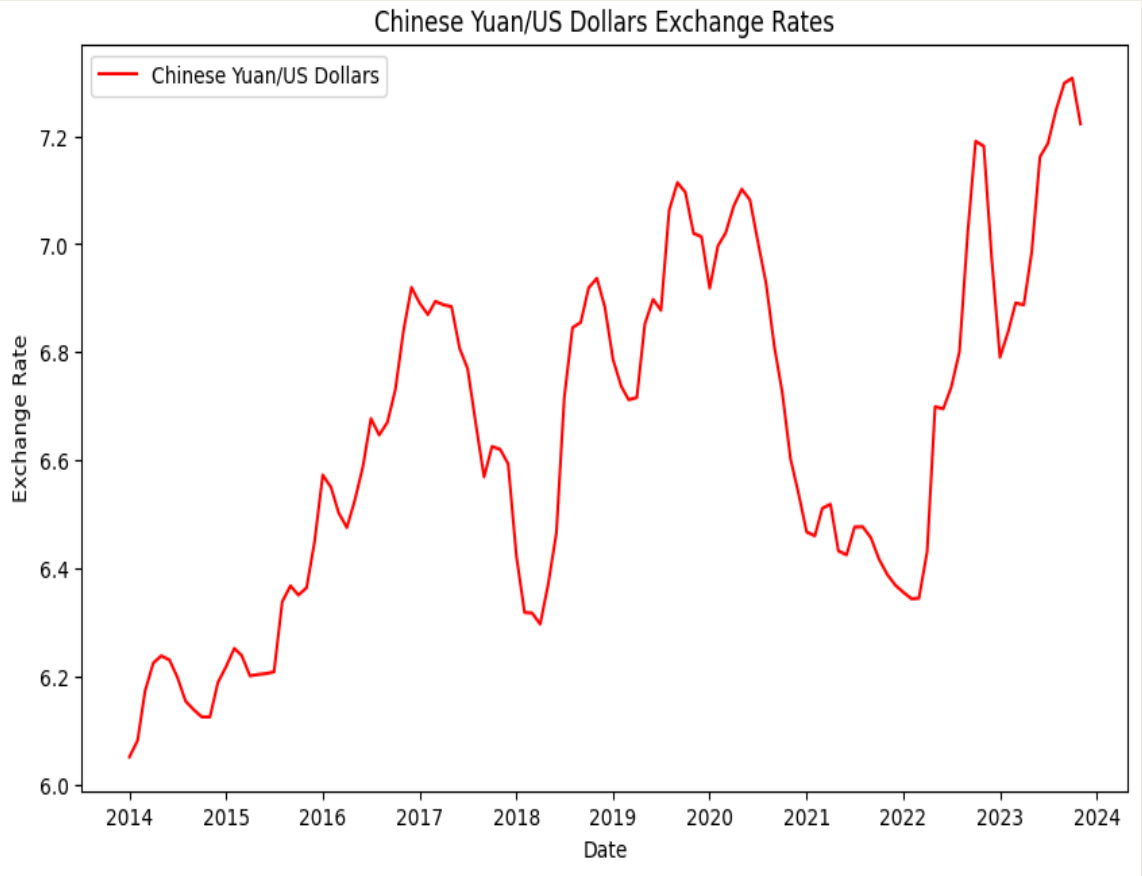
Data Cleaning and Preprocessing

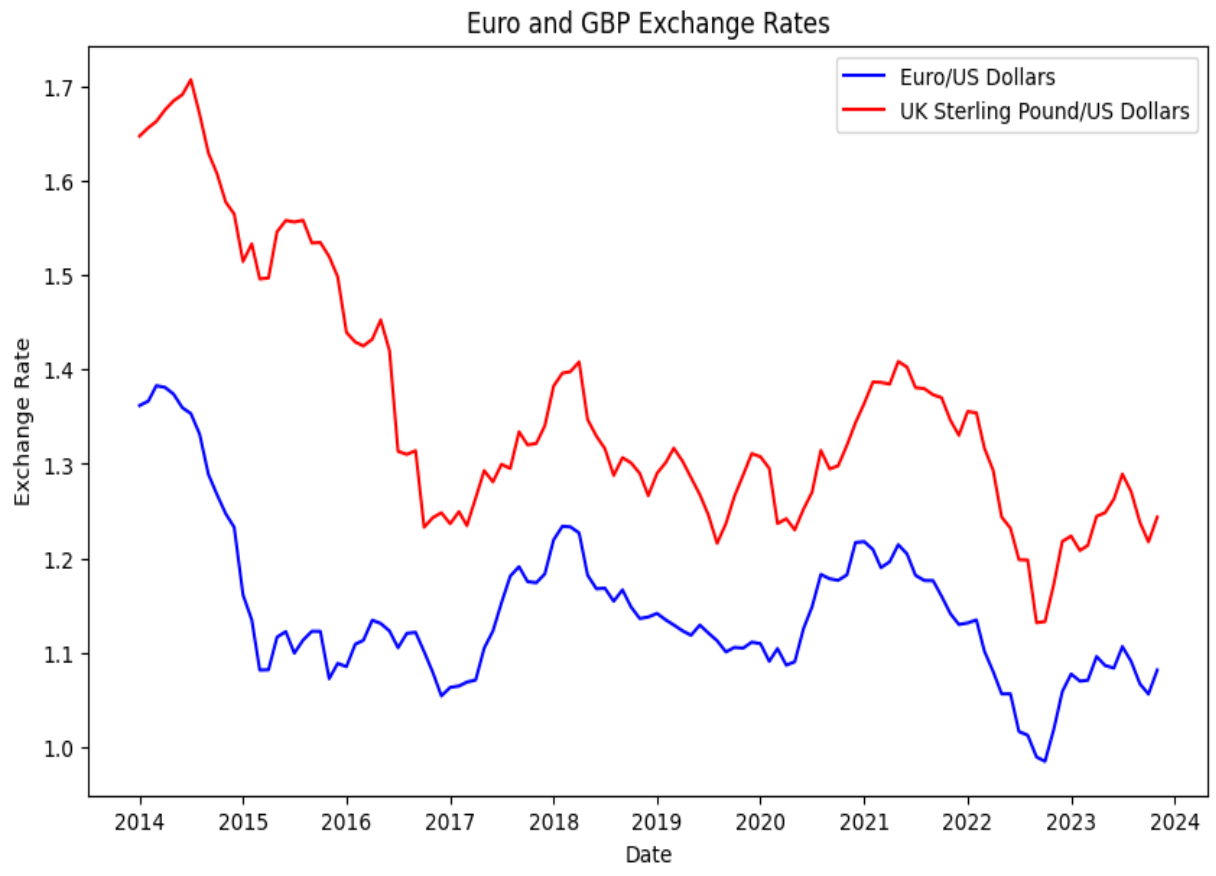
Time Series Analysis: Stationarity Testing and Seasonal Decomposition

Time Series Forecasting: ARIMA, SARIMA, SARIMAX

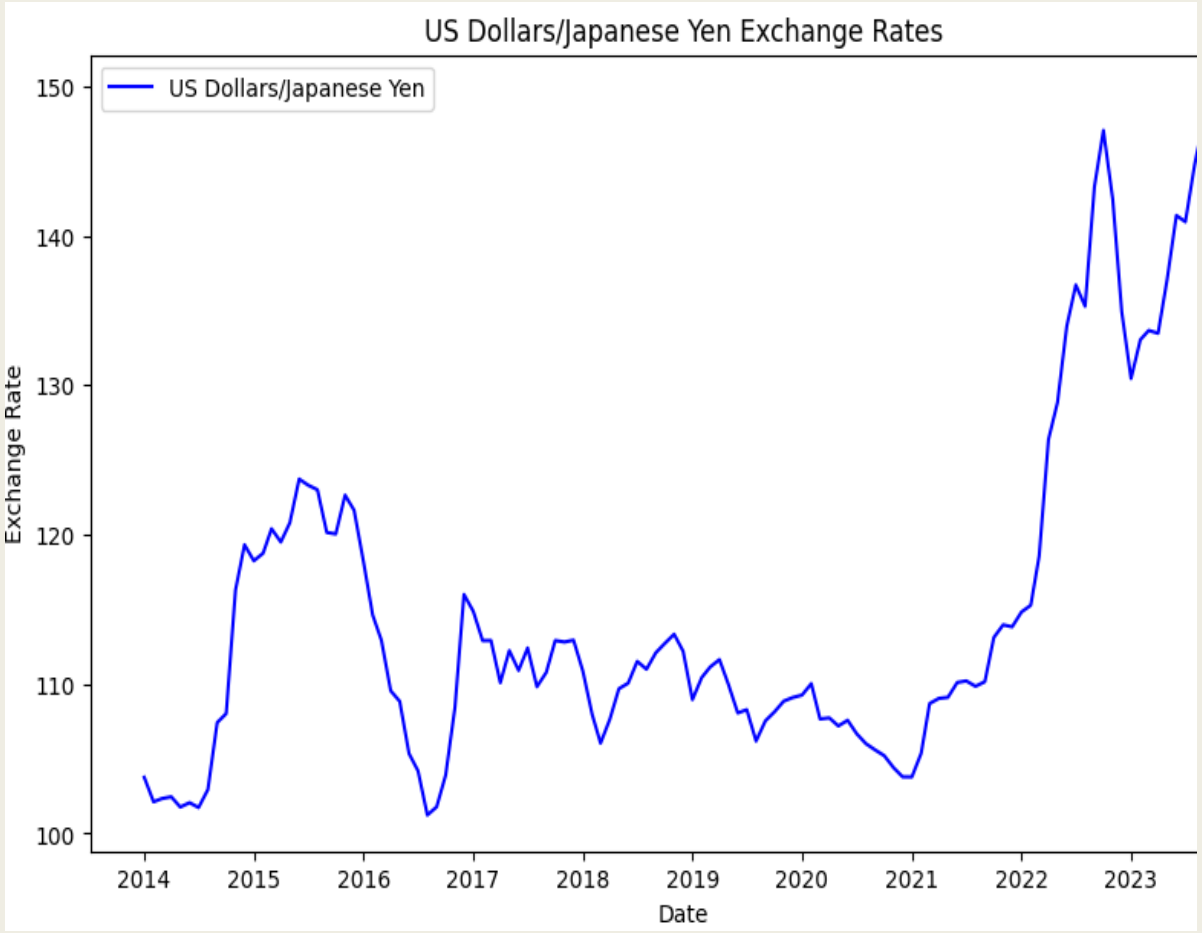
Line Plots of Historical Exchange Rates

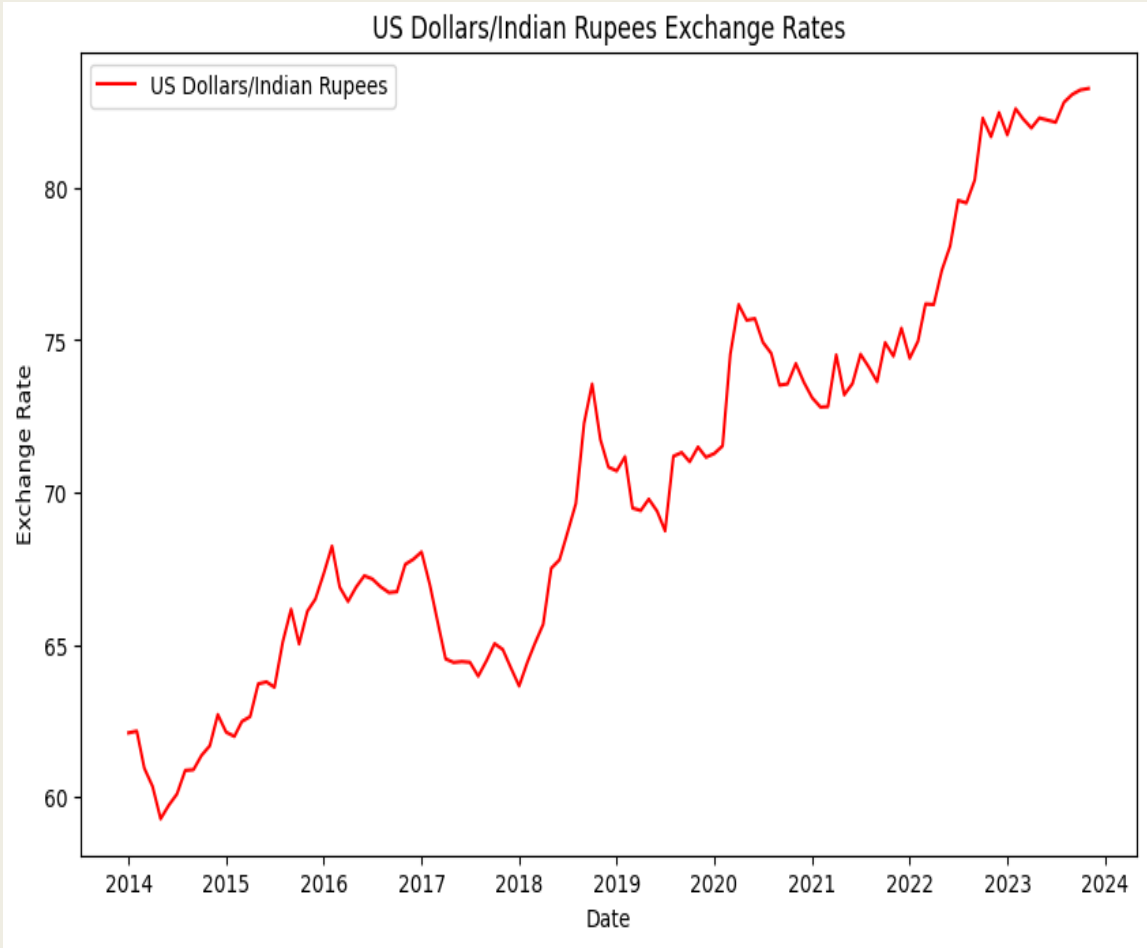
Currencies with greater value than USD





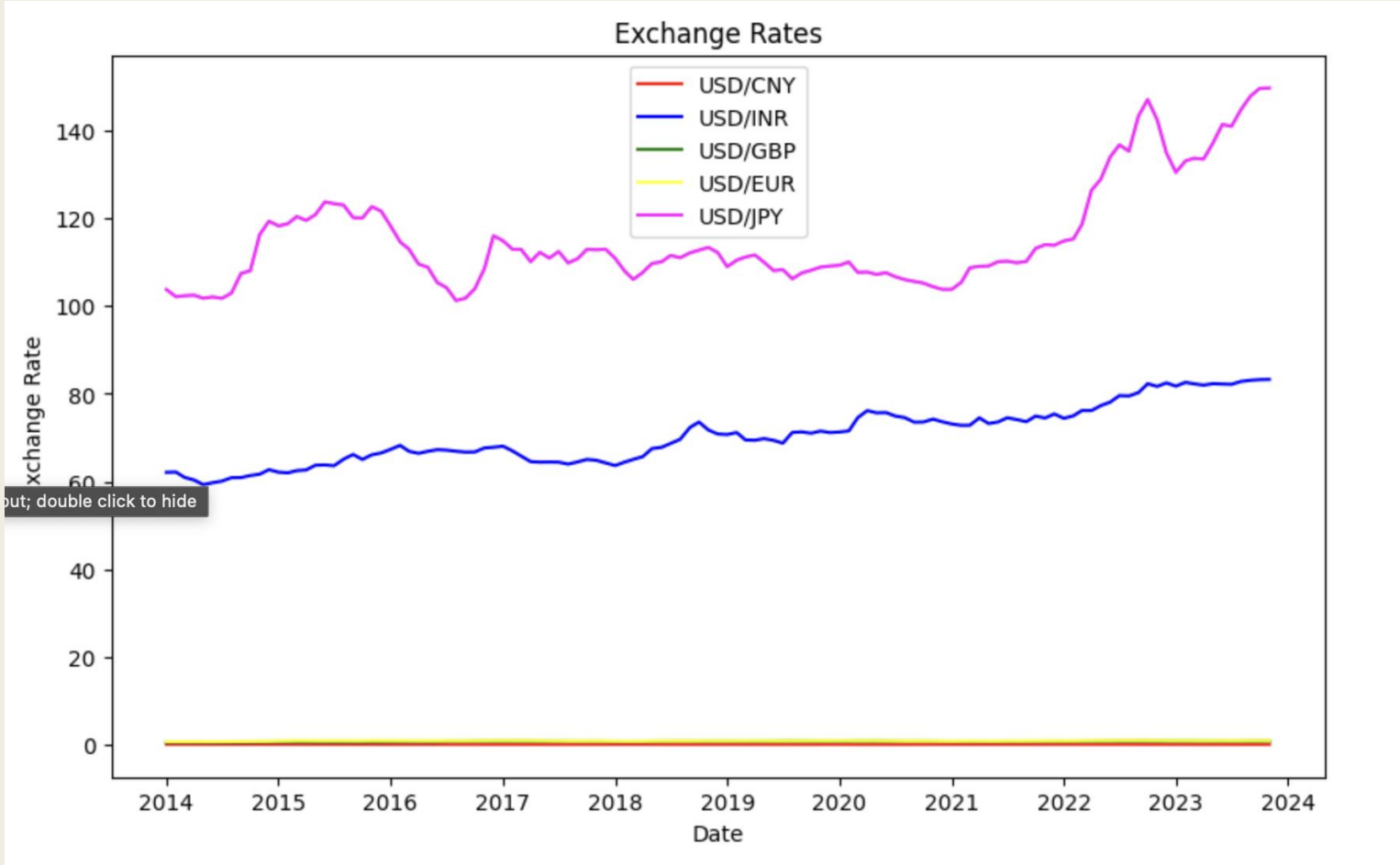
Currencies with lesser value than USD





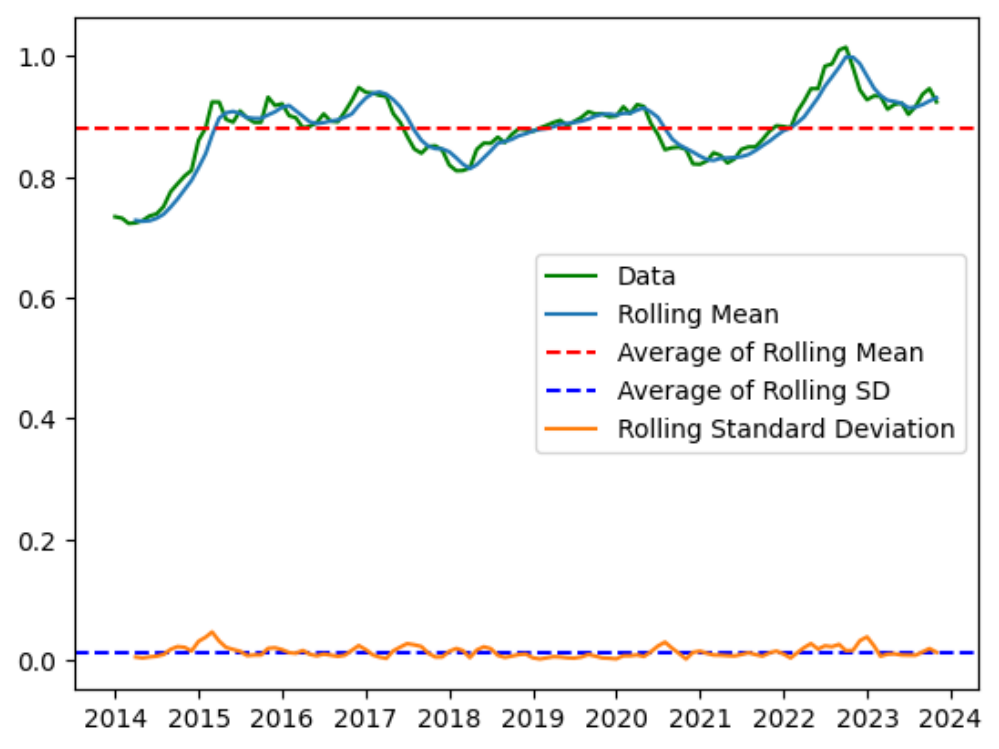
Standardizing Exchange Rates

1 USD = x Foreign Currency



Stationarity Testing

Methodology : a) Mean and Standard Deviation



Conclusion:
The data does not have a constant mean throughout the time range and therefore, is **Non-stationary.**

b) Augmented Dickey-Fuller Test

- ADF Statistic: -2.901696809734111
- p-value: 0.04515103709076673

The p-value (0.0452) is only slightly below the 5% significance level, and the ADF statistic (-2.9017) is only slightly more negative than the critical value at the 5% significance level. It is almost 0.05, the Null Hypothesis is accepted, i.e., the data is Non-stationary. Therefore, it's essential to interpret the results cautiously and consider the specific context of the analysis.

Dealing with Non-Stationarity

- **Decomposing the time series**
- **Differencing the Exchange rates**
- **Auto-Correlation and Partial Auto-Correlation Function**

Interpretation:

- *The differenced dataset has a constant mean and standard deviation over time, thus, it is a weakly stationary dataset.*
- *The p-value for the ADF test is almost 0, therefore, the Null Hypothesis is rejected and the dataset is considered to be Stationary.*
- *Both tests prove that the data has been converted to* ***stationary.***

PREDICTION AND FORECASTING

- ARIMA modeling on the differenced data
- SARIMA modeling on the differenced data with the seasonal orders
- SARIMAX modeling on the differenced data considering indicators of Inflation, Interest Rates, and Current Account Deficits as exogenous variables. We consider the USD/INR exchange rate only for SARIMAX forecasting.

US Dollars (USD) to EURO Exchange Rates (2014 - 2024)

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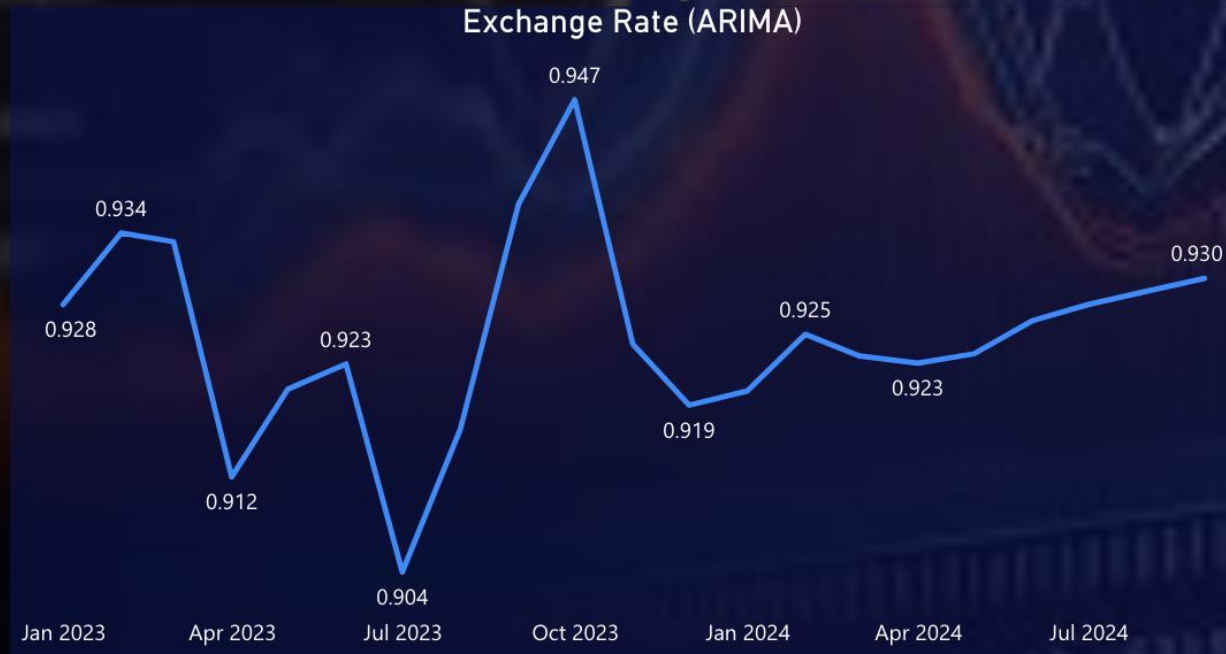
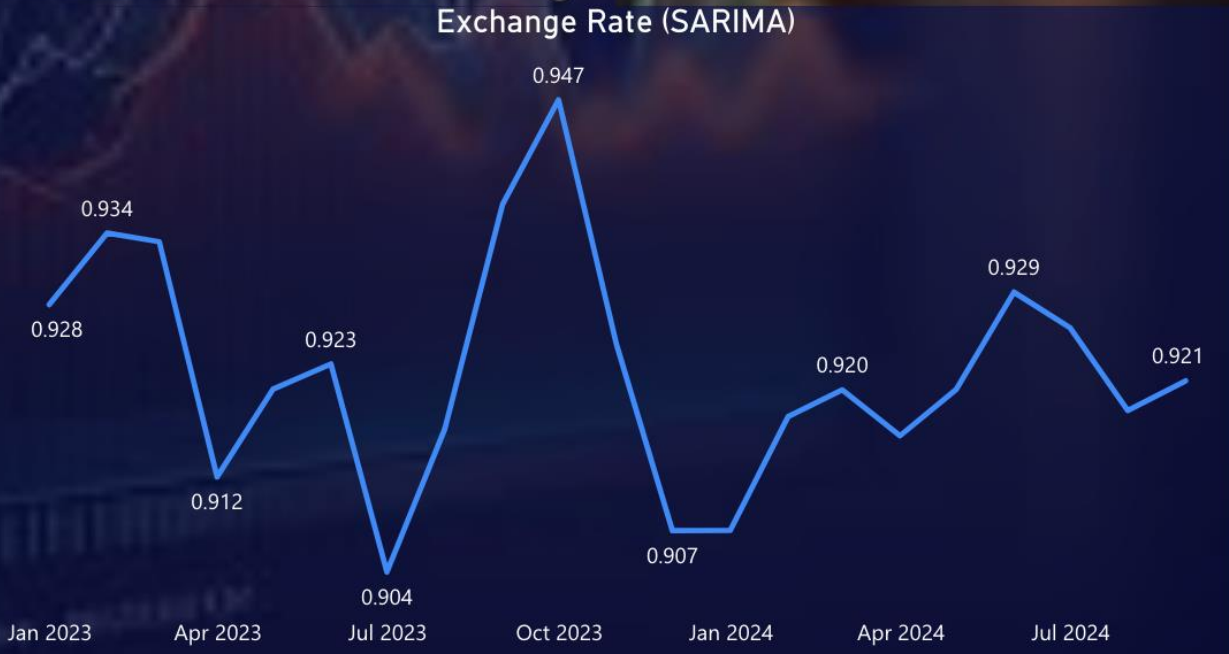
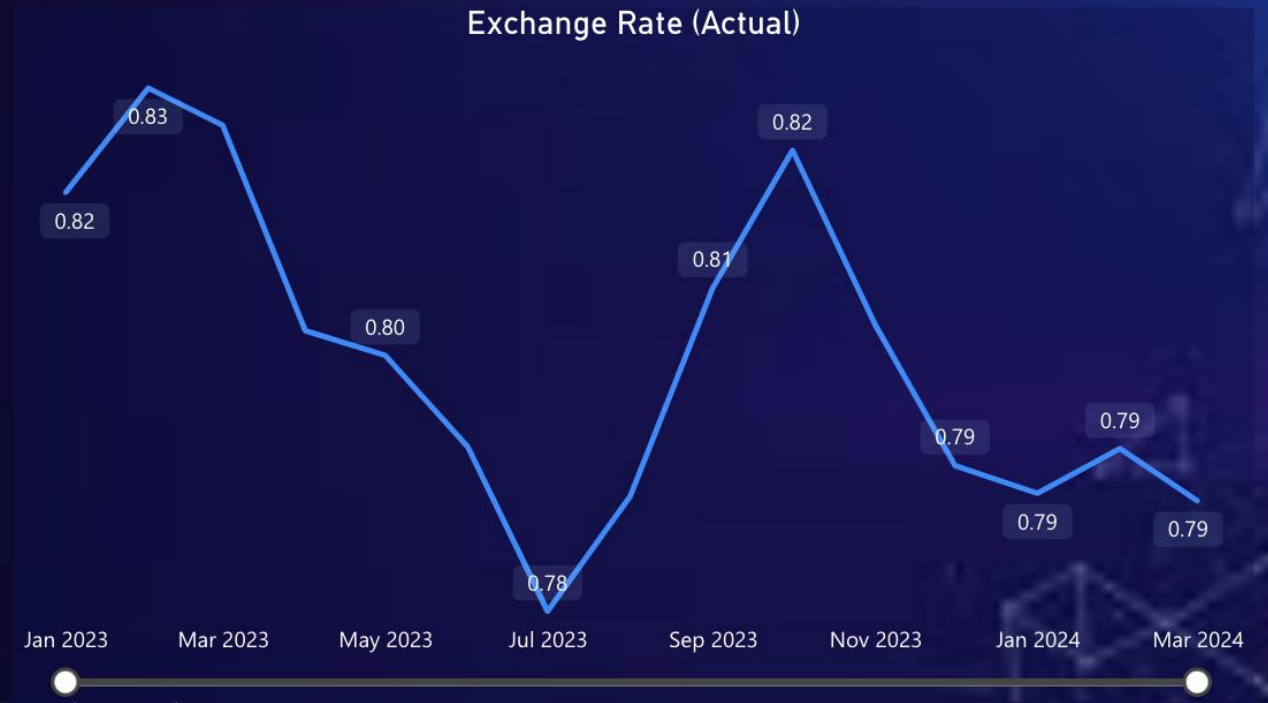




US Dollars (USD) to UK Sterling (GBP) Exchange Rates (2014 - 2024)



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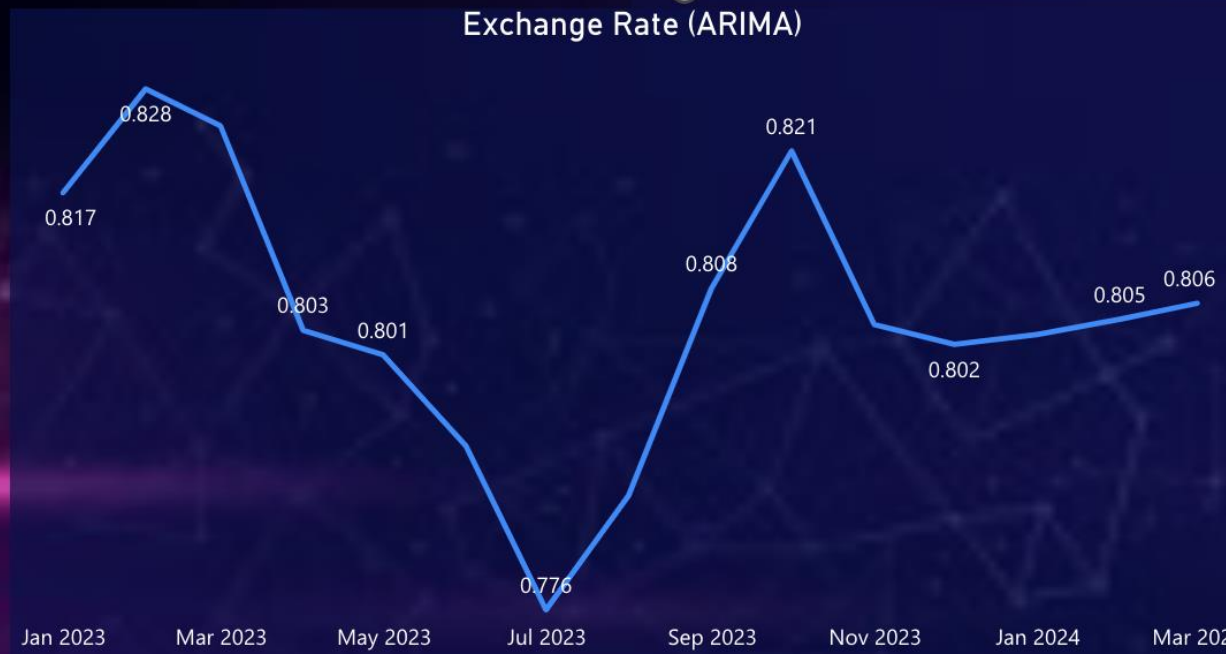
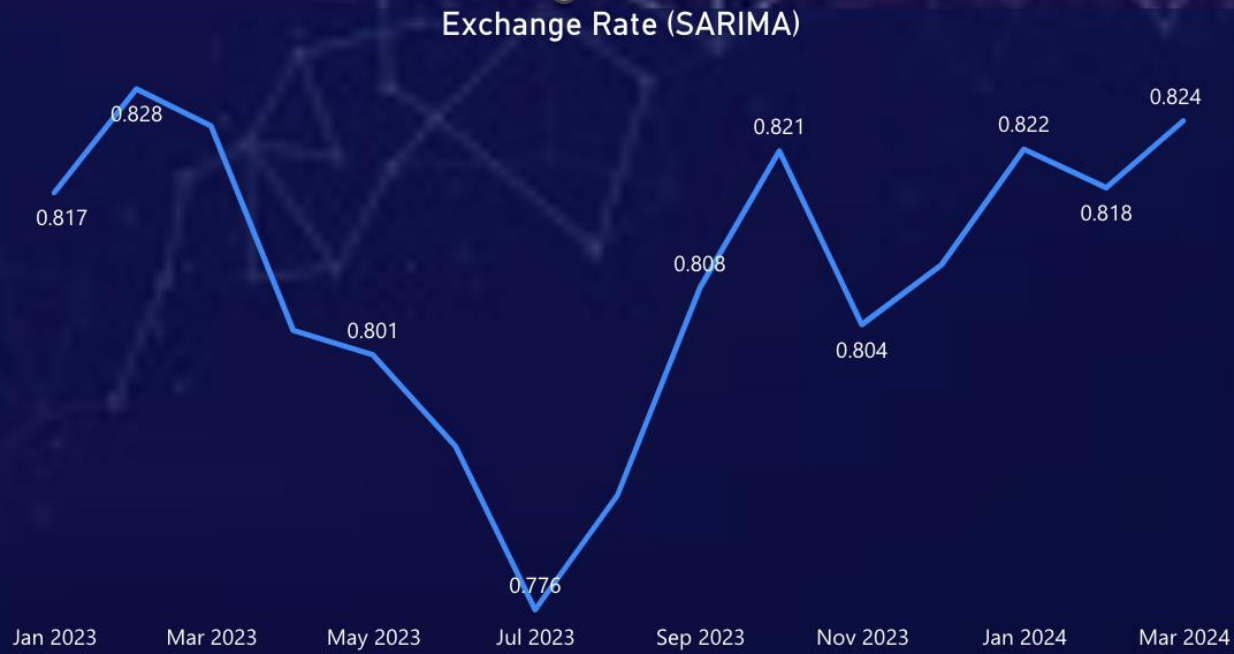
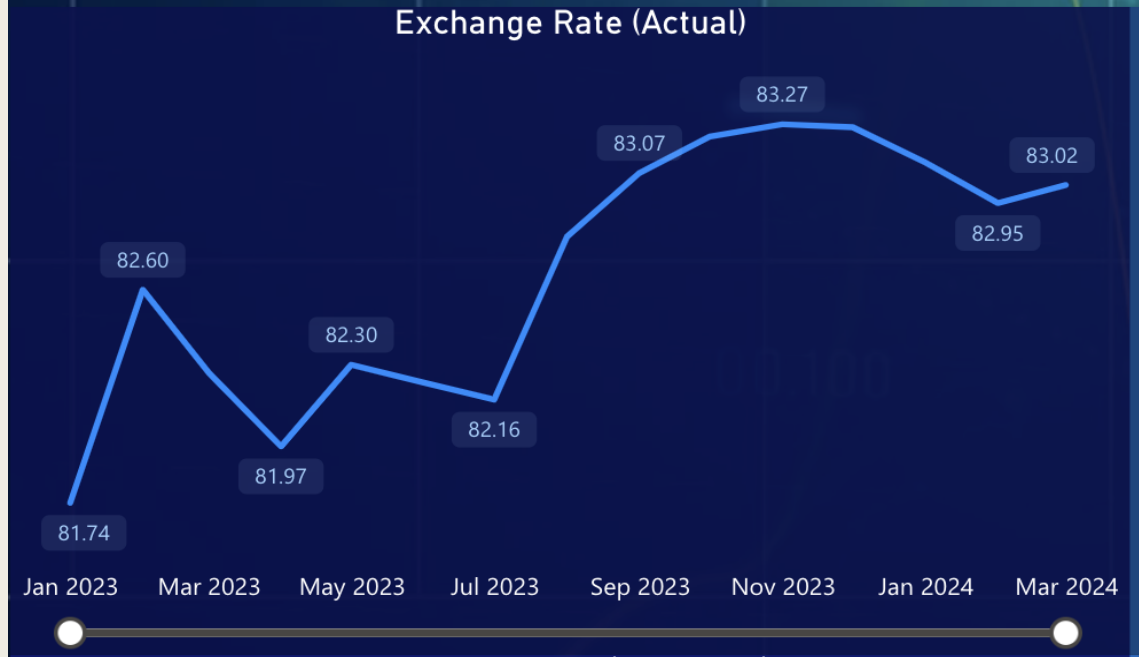
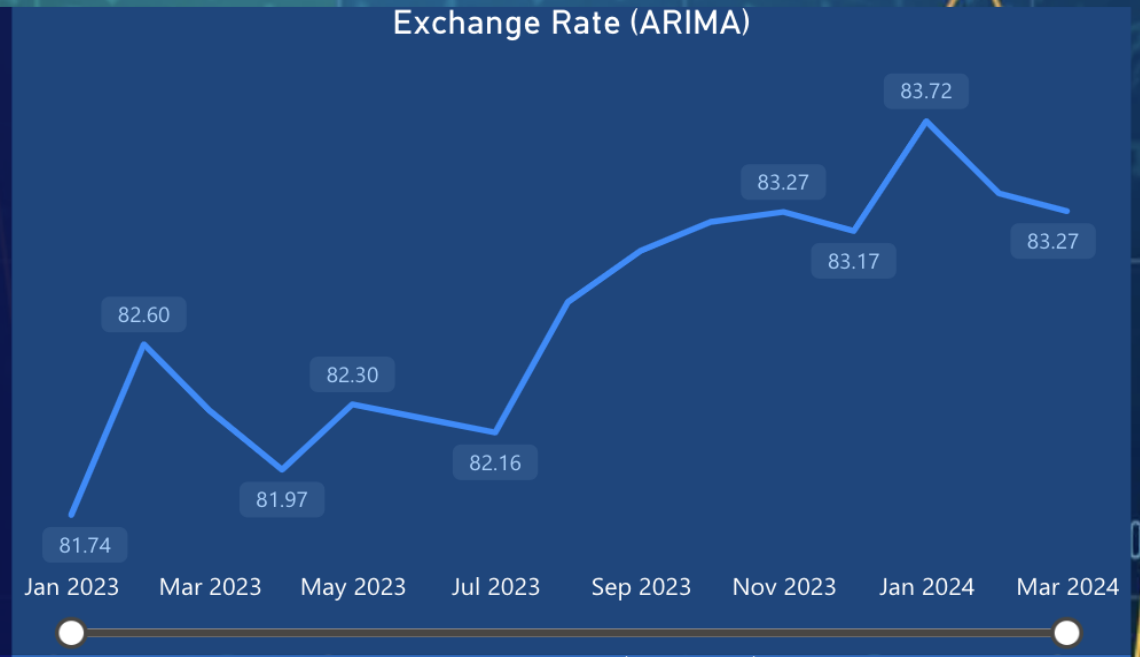
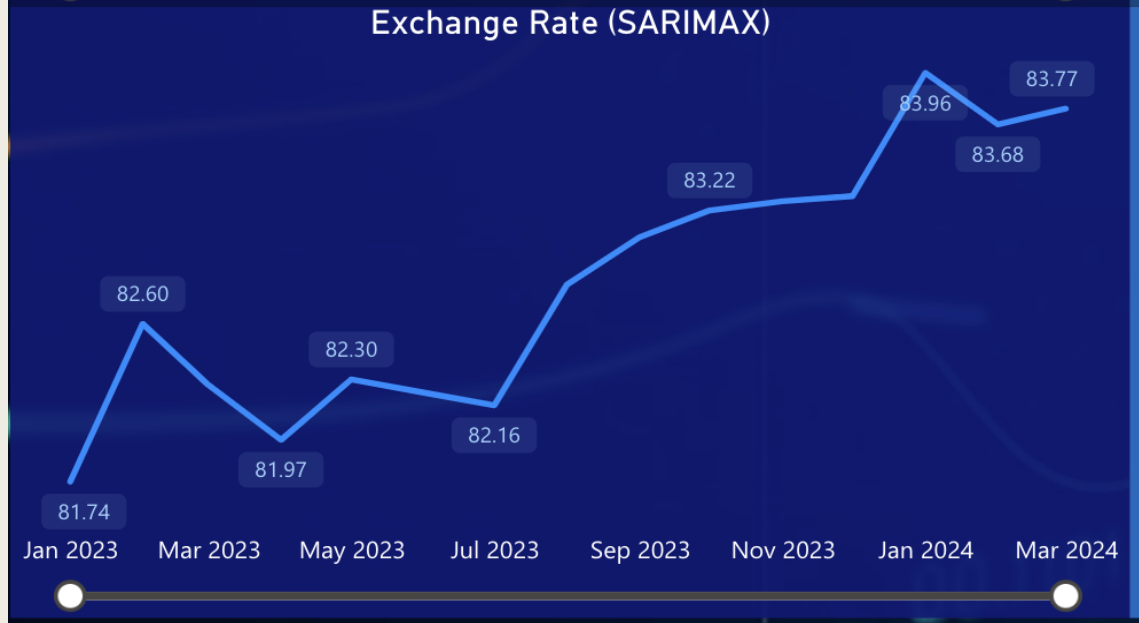


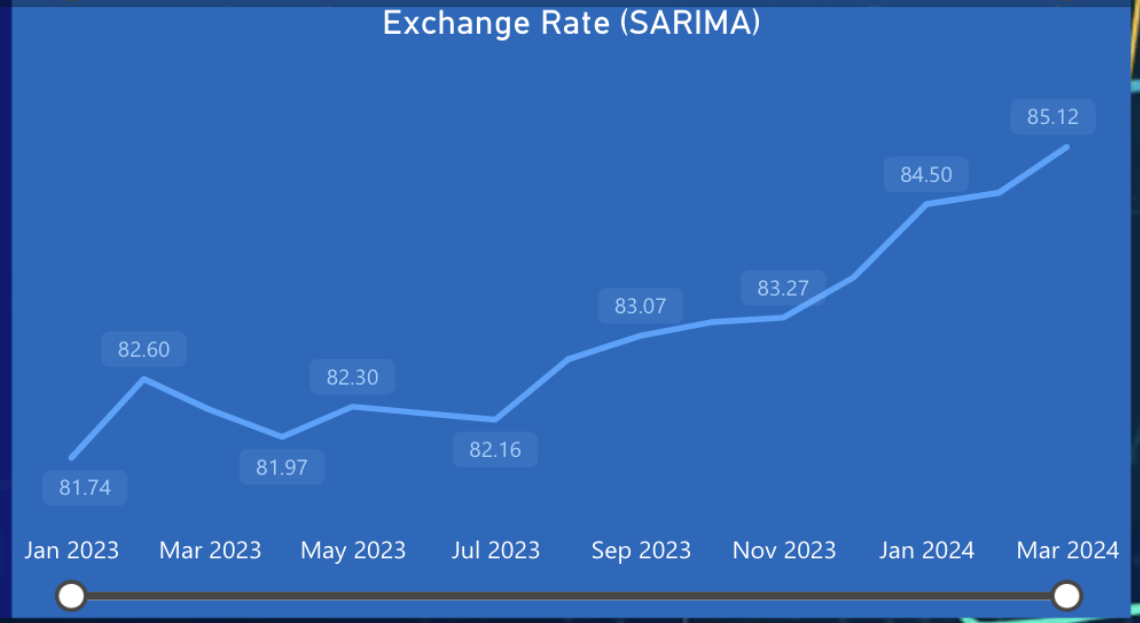


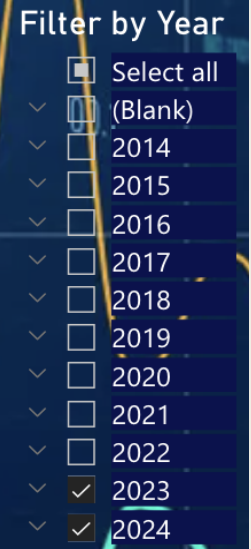
US Dollars (USD) to Indian Rupees (INR) Exchange Rate (2014 - 2024)



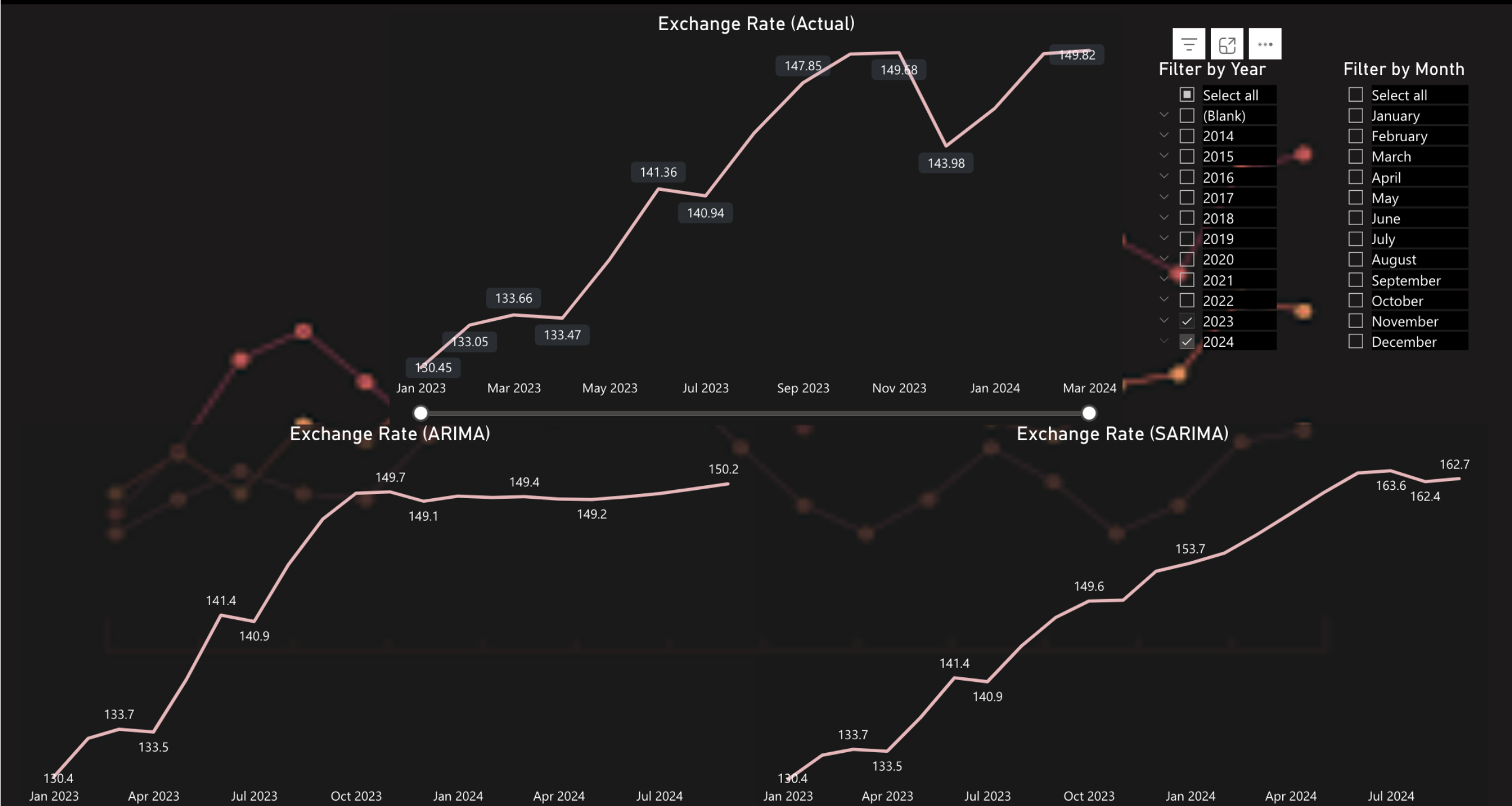




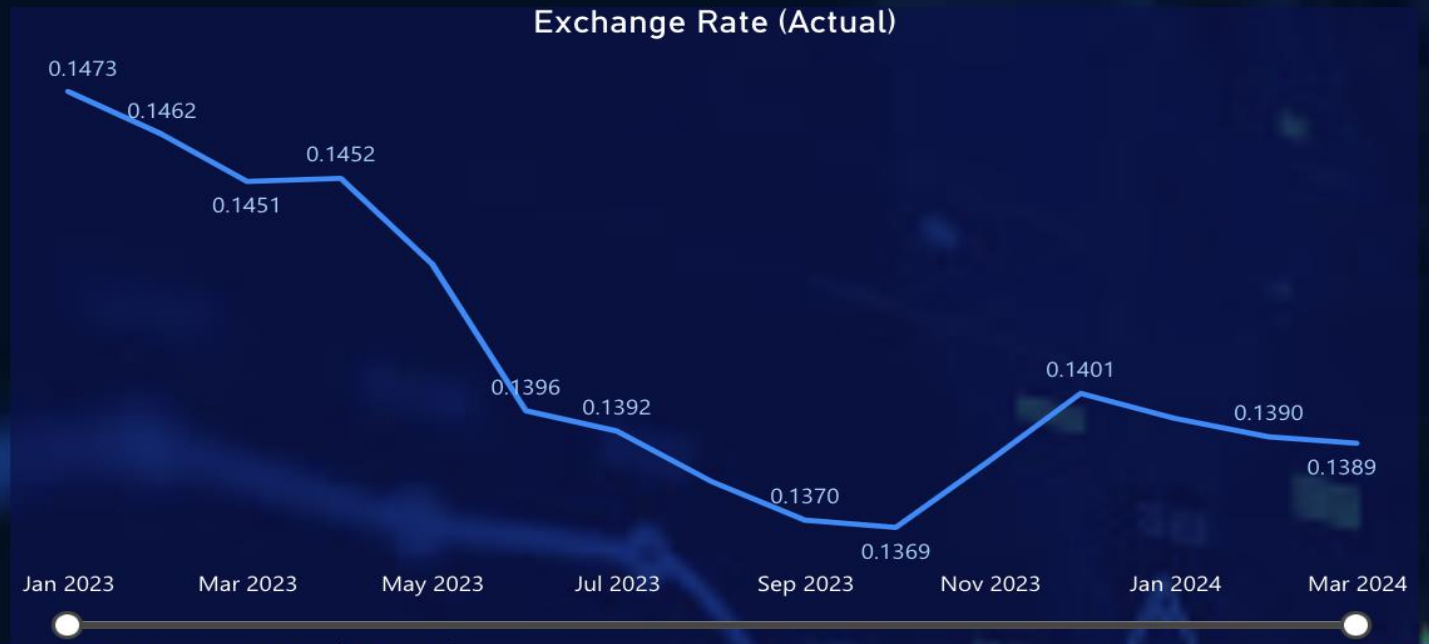




US Dollars (USD) to Japanese Yen (JPY) Exchange Rates (2014 - 2024)



US Dollars USD) to Chinese Yuan (CHY) Exchange Rates (2014 - 2024)



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FINDINGS

- The models perform based on the dataset.
- ARIMA works better for Euro, INR, and JPY.
- SARIMA works better with GBP and CHY.
- The performance metrics show very small differences in the performance, however, the models give contradicting outputs when observed closely.

ARIMA				SARIMA			
Currency	MAE	MSE	RMSE	Currency	MAE	MSE	RMSE
Euro	0.012929	0.000251	**0.015857**	Euro	0.014350	0.000278	0.016687
UK Pound	0.013713	0.000249	0.015792	UK Pound	0.014054	0.000251	**0.015840**
Indian Rupees	0.561540	0.470815	**0.686160**	Indian Rupees	0.650252	0.572051	0.756340
Japanese Yen	2.547739	10.217898	**3.196545**	Japanese Yen	2.834048	11.263803	3.356159
Chinese Yuan	0.001559	0.000004	0.002056	Chinese Yuan	0.001310	0.000003	**0.001841**

Model	ARIMA			SARIMA			SARIMAX		
Metric	MAE	MSE	RMSE	MAE	MSE	RMSE	MAE	MSE	RMSE
Indian Rupees	0.561540	0.470815	0.686160	0.650252	0.572051	0.756340	0.456647	0.422422	**0.64994**

INSIGHTS

- Among all the currencies, the Chinese Yuan tends to be in the strengthening phase against US Dollars.
- The strengthening phase of Chinese Yuan will be a good opportunity for investing in U.S. exporting companies dealing with Chinese Exports as they can sell the goods at a lower price in China.
- The Chinese buyers can get more goods from the US Exporters for the same Chinese Yuan during the Weak Dollar phase.
- The US can attract more tourists from China during the weak dollar phase and it can be a boon for the tourism industry in US.
- For the other countries and EU, it's a strong dollar period and they would gain from exporting goods to US.
- A US Investor investing in Chinese company will gain; A US investor investing in India, UK or EU will suffer loss!

CONCLUSION

"The foreign exchange rate between two countries determine the trade relations and investment strategies between the traders and investors in these countries.

When a weak dollar uplifts the investment, exporting and tourism industry in the US, it affects imports and domestic population by inflation."