Project Report

On

CURRENCY EXCHANGE RATE FORECASTING USING STATISTICAL TECHNIQUES

Submitted

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MASTER OF SCIENCE

in

APPLIED STATISTICS AND DATA ANALYTICS

by

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CERTIFICATE

This is to certify that the dissertation entitled, CURRENCY EXCHANGE RATE FORECASTING USING STATISTICAL TECHNIQUES is a bona fide record of the work done by APARNA R under my guidance as partial fulfillment of the award of the degree of Master of Science in Applied Statistics and Data Analytics at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of VISMAYA VINCENT, Assistant Professor, Department of Mathematics and Statistics, St. Teresa's College (Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

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ABSTRACT

Forecasting currency exchange rates is essential for managing risk, making financial decisions, and conducting business internationally. In this work, we examine how well two statistical methods Linear Regression and Seasonal Autoregressive Integrated Moving Average, or SARIMA predict currency exchange rates. A time series forecasting technique that takes autocorrelation, trends, and seasonal variations into account is called the SARIMA model. It is especially well-suited to capture the intricate dynamics of long-term swings in exchange rates. In contrast, Linear Regression models the relationship between important predictor variables and exchange rates, offering a more straightforward but nevertheless effective method. All things considered, this study advances knowledge of statistical methods for predicting currency exchange rates and offers perceptions on how well they work in actual financial situations. The results can help traders, financial analysts, and regulators manage currency-related risks and make well-informed decisions.

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CHAPTER 1

INTRODUCTION

1.1 Currency exchange rate

The Currency exchange rate plays a vital role in the global economy. It influences the international trade, investment, and financial stability of an economy. The exchange rate directly affects the businesses those who were invested in global trade. In global markets, it influences the competitiveness of their products and services. It also plays an important role in travel and tourism. Exchange rates are an integral part of the functioning of the global financial system, affecting economic activities, business needs, and financial planning. Accurate currency exchange rate forecasting helps in various fields such as businesses to make a better decision for investments, controlling risk, and many more.

The exchange rate between the Indian Rupee and the US Dollar acts as a critical measure among the various currency pairs traded. Therefore forecasting these exchange rates is important for businesses, policymakers, and financial planning, managing risks, and improving financial outcomes. As the INR-USD exchange rate shows dynamic fluctuations which are influenced by numerous economic factors, international affairs, and market-specific factors, predicting its future movements raises a considerable challenge. There are many traditional ways of predicting things but it doesn't work if the situations are complicated with lots of distinct factors. For reducing this complexity advanced methods like time series analysis and linear regression can be used.

Time series analysis is a statistical method that concentrates on understanding and modeling the time related pattern present in the data. In currency exchange rate forecasting, time series analysis acts as a powerful tool as it is used for assessing historical exchange rate data and then it identify the trend , seasonality and other patterns. It can also make predictions or forecasts based on historical patterns present in the data.

1.2 Objectives

The main objectives of the study are as follows:

1. To identify the trends and patterns using moving average.
2. To predict the future closing price of the exchange rates using Seasonal ARIMA.
3. To predict the future closing price of the exchange rates using Linear Regression.
4. To compare the predicted values of SARIMA model and Linear Regression model.

CHAPTER 2

LITERATURE REVIEW

1. Kumar and Gill(1997) postulates some simple time series models that can be used for quite effective and accurate forecasts in international forex markets of major international currencies in relation to the Australian dollar. After comparing various time series models, the paper observes that Box-Jenkins AR is the best model for forecasting exchange rates.
2. Nanayakkara et al.(2014) studied to develop and compare the accuracy of two models for predicting the daily currency exchange rate between the US Dollar and Sri Lankan Rupee (USD/LKR). The models employed are the Generalized Auto-Regressive Conditional Heteroskedasticity (GARCH) as the time series model and the Feedforward neural network with the Backpropagation algorithm as the Artificial Neural Network (ANN) model. In both models, past lagged observations of the data series and moving average technical indicators are utilized as explanatory variables. The predictive performance of the models is evaluated using commonly used statistical matrix. Based on the performance comparison of the two models, it can be concluded that the ANN-based model outperforms the GARCH model in predicting the exchange rate of USD/LKR and concluded that the GARCH(1,1) model was found as the best model in time series approach with 69% prediction accuracy.
3. Tlegenova (2015) aims to utilize time series analysis to model the yearly exchange rates between USD/KZT, EUR/KZT, and SGD/KZT, using the official yearly data from the National Bank of the Republic of Kazakhstan for the period of 2006 to 2014. The primary objective of this study is to employ the ARIMA model for forecasting the yearly exchange rates of USD/KZT, EUR/KZT, and SGD/KZT. To evaluate the accuracy of the forecasts, the Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Root Mean Squared Error (RMSE) will be utilized as comparison metrics and concluded that the MAPE values for all three currencies were the smallest, i.e. the most effective

4. Lemonjava (2019) studied to forecast future exchange rate trends by using currency rates time-series, representing past trends, patterns and waves. Moving average, exponential smoothing models and Auto Regressive Integrated Moving Average (ARIMA) are that class of models that are widely used in this field. We aim to use these models to estimate their predictability and compare their projected results in forecasting the GEL exchange rate against the USD.
5. Njoki(2019) studied to fit a Seasonal Autoregressive Integrated Moving Average Model(SARIMA)(p, d, q)(P, D, Q) to United States Dollar vs Kenya Shilling exchange rate since it is the most dominant exchange rate in Kenya. Autoregressive Integrated Moving Average (ARIMA) and Seasonal Autoregressive Integrated Moving Average (SARIMA) models were fitted in the data. The study concluded that SARIMA(1, 1, 0)(0, 0, 2)[12] was the best fitted model on the basis of BIC and AIC
6. Joshi et al.(2020) studied the suitability of ARIMA model for forecasting exchange rate in context of India with regard to rupee/dollar, rupee/euro and rupee/yen. The data is collected on monthly basis for exchange rate of rupee verses dollar for the period January 2005 to July 2017 from the website of Reserve Bank of India (RBI) and is referred to as Model Data in the analysis. To validate the model, the test data is collected on monthly basis from August 2017 to December 2019 for the exchange rate of rupee verses EURO and rupee verses YEN from the website of RBI. The study concludes that ARIMA (1,1,5) is the most appropriate model for exchange rate forecasting.
7. Ahmed et al.(2021) examine the effects of currency exchange rate under Random Walk Model, Single Exponential Smoothing, Double Exponential Smoothing and Holt-Winter Models and the forecasting performances of the models are judged by the measure of accuracy both symmetric and asymmetric loss functions are used Mean Square Error (MSE), Mean Absolute Deviation (MAD) and Mean Absolute Percent Error (MAPE) and assessed an Autoregressive Integrated Moving Average (ARIMA) model that could be used to predict the exchange rate of the South Asian Association for Regional Cooperation .These studies outlined that the ARIMA model is comparatively accurate model to forecast the exchange rate.
8. Dev et al.(2022) examines the behavior of Australia's (AUD) daily foreign exchange rates against the US Dollar from January 2016 to December 2020 and forecasts the 2021

exchange rate using the ARIMA model. For better accuracy, technical indicators such as Interest Rate Differential, GDP Growth Rate and Unemployment Rate are also taken into account. In exchange rate forecasting, there are various types of performance measures based on which the accuracy of the forecasted result is computed. This paper examines seven performance measures and found that the accuracy of the forecasted results is adequate with the actual data.

9. Akhtar et al. (2022) addresses the challenges of exchange rate prediction by employing various methods and comparing their accuracy. Specifically, the Auto-Regressive Integrated Moving Average (ARIMA) and Generalized Auto-Regressive Conditional Heteroscedasticity (GARCH) models are utilized to forecast the daily exchange rates between the US dollar and Pakistan rupee (USD/PKR). Both models incorporate lagged observations of the data series and utilize moving average technical analysis. Additionally, explanatory factors are included as indicators, and the prediction performance is assessed using commonly known statistical metrics. The analysis reveals the presence of conditional heteroscedasticity, leading to the incorporation of GARCH modeling to capture the volatility effect. Based on the preliminary findings, it can be inferred that the ARCH model outperforms the GARCH model in terms of predicting the USD/PKR exchange rate.
10. Quershi et al. (2023) n this work, machine learning models, i.e., the Multi-layer perceptron model (MLP), Extreme learning machine (ELM) model and classical time series models are used, Autoregressive integrated moving average (ARIMA) and Exponential Smoothing (ES) model to model and predict the real exchange rate data set (REER). This study selects a model that meets the Key Performance Indicators (KPI) criteria. This model was selected as the best candidate model to predict the behavior of the real exchange rate data set.

CHAPTER 3
MATERIALS AND METHODS

3.1 Data Source

The dataset used in this study is taken from a website called Yahoo Finance. The dataset comprises the monthly exchange rates data between two currencies that is INR and USD from December 2003 to May 2023.

The dataset contains 6 variables. It contains the value of INR for 1 USD for a given time. Below are all the features of the data:

1. Date: The date represents the specific day of the exchange rate data. It is important to follow the chronological order of the observations of the exchange rate.
2. Open: The opening price refers to the exchange rate at the start of a specific trading period, such as the opening price for the day or the week. It represents the initial value at which the USD-INR conversion rate was traded.
3. High: The high price represents the highest exchange rate observed during a specific trading period. It means the maximum value reached by the USD-INR conversion rate during this period.
4. Low: The low price represents the lowest exchange rate observed during a specific trading period. It indicates the minimum value reached by the USD-INR conversion rate during this period.
5. Close: The closing price represents the exchange rate at the end of a specific trading period, such as the closing price for the day or the week. It shows the final value at which the USD-INR conversion rate was traded.
6. Adjusted Closing: The Adjusted Closing Price takes into account any corporate actions,

such as stock splits or dividends, that may affect the Closing Price. In the context of USD-INR conversions, this feature could represent an adjusted closing exchange rate.

7. Volume: Volume refers to the total number of USD-INR currency pairs traded during a specific trading period. It quantifies market activity and liquidity for the given exchange rate.

3.2 Python programming language

Python is the most popular programming language which is known for its understandability, adaptability, and flexibility. Python is used in many fields such as data science, machine learning, web development.

3.3 MS Excel

Microsoft Excel is a spreadsheet software program developed by Microsoft. It is mainly used for data organization, analysis, and visualization. It is used to create spreadsheets with rows and columns for calculations, create charts and used to perform many other operations.

3.4 Time Series

Time series is a series of observations which is collected over time. Time series data can be daily, weekly, monthly, or yearly. Time series analysis involves analyzing the trends and patterns within the data and making predictions and forecasting using the historical data. Time series analysis is mainly used in economic and financial forecasting, weather forecasting and climate analysis, healthcare and medical data analysis, and in many other fields.

A time series can be mathematically represented as:

$\{(t_1,y_1),(t_2,y_2),(t_3,y_3),\ldots\ldots,(t_n,y_n)\}$

where t_i represents the time point and y_i represents the value of the time series at time t_i.

3.5 Simple Moving Average

Simple moving average is one of the statistical method used in time series analysis to regulate the variations in data and identify the trends and patterns. It is calculated by taking the average of a specific number of consecutive values in the data which is known as period.

3.6 Auto-Regressive (AR) Process

An autoregressive(AR) process is a type of stochastic process mainly used in time series analysis. It is a sequence of random variables and these variables are linearly dependent on its own past values.

The general form of an autoregressive process of order *p* is denoted by AR(p) which is expressed as:

$$X_t = \phi_1 X_{t-1} + \phi_2 X_{t-2} + \ldots\ldots + \phi_p X_{t-p} + \varepsilon_t$$

Where,

- X_t is the value at time t.
- $\phi_1, \phi_2, \ldots\ldots, \phi_p$ are the finite set of weight parameters.
- ε_t is the white noise term or errors at time t.

3.7 Moving Average (MA) Process

A Moving Average (MA) process is also a type of stochastic process used in time series analysis. It represents a sequence of random variables where each variable in the sequence is a linear combination of current and past white noise terms.

The general form of a Moving Average process of order *q* denoted as MA(q), can be expressed as:

$$X_t = \Theta_1\varepsilon_{t-1} + \Theta_2\varepsilon_{t-2} + \ldots\ldots + \Theta_q\varepsilon_{t-q} + \varepsilon_t$$

where:

- X_t is the value at time t.
- $\Theta_1, \Theta_2, \ldots\ldots, \Theta_q$ are the moving average coefficients.
- q is the order of the MA process.
- ε_t is the white noise term.

3.8 Auto-Regressive Integrated Moving Average (ARIMA) Model

An Autoregressive Integrated Moving Average (ARIMA) model is a time series forecasting model that combines autoregressive (AR), differencing (I), and moving average (MA) components together. An ARIMA model can be a non-seasonal type which is denoted by ARIMA(p, d, q) where *p, d, q* are the parameters. *p* is the order of the autoregressive model, *q* is the order of the moving average model and *d* is the degree of differencing.

3.9 Seasonal Auto Regressive Integrated Moving Average (SARIMA) Model

A Seasonal Autoregressive Integrated Moving Average (SARIMA) model is an extension of the ARIMA (Autoregressive Integrated Moving Average) model that includes seasonal components. SARIMA models are used when time series data exhibits seasonal patterns or variations. SARIMA models are widely used for forecasting

The SARIMA model is denoted by SARIMA (p, d, q)(P, D, Q, s), where:

p: Autoregressive order for non-seasonal components.

d: Degree of differencing for non-seasonal components.

q: Moving average order for non-seasonal components.

P: Seasonal autoregressive order.

D: Degree of differencing for seasonal components.

Q: Seasonal moving average order.

s: Seasonal period length

3.10 Auto Correlation Function

Auto correlation function is used to measure the correlation between a time series and its lagged values at various time points. ACF is used to determine the order of an autoregressive model.

3.11 Partial Auto Correlation Function

Partial auto correlation function is used to measure the correlation between a timeseries and its lagged values by eliminating the effects of intermediate lags. PACF is used to determine the order of moving average model.

3.12 Stationary Data

A time series data is said to be stationary if it's statistical properties such as mean, variance and autocorrelation should remain constant over time that means the data does not have any trend or seasonality

3.13 Augmented Dickey-Fuller test

The Augmented Dickey-Fuller (ADF) test is a statistical test used to determine whether a time series data is stationary or not. The null hypothesis of the ADF test is that the time series data is non-stationary and the alternative hypothesis is that the time series is stationary. The test generated by the ADF test is compared to critical values to determine whether to accept or reject the null hypothesis. Thus conclude the time series is stationary or non stationary.

3.14 Seasonal data

A time series data is said to be seasonal if the data shows repeating patterns or fluctuations at regular interval over time.

3.14 Akaike Information Criterion(AIC)

The Akaike Information Criterion (AIC) is a statistical measure used in time series analysis for selecting best model. The AIC provides a balance between the goodness of fit of a model and its complexity. Models with lower AIC values are considered as best models.

AIC can be calculated using the following formula:

$$AIC = -2 * ln(L) + 2 * k$$

Where:

L is the maximized value of the likelihood function of the model.

k is the number of parameters in the model.

3.15 Model Fitting

Model fitting is the process of estimating the model's parameters. The main goal of the model fitting process to identify the model that best fits the data

3.16 Forecasting

Forecasting is the process of predicting future trends or outcomes using historical data.

Time series analysis is one of the technique used for forecasting.

3.17 Residual analysis

Residual analysis is a component of model validation. Residuals are the differences between the observed values and the predicted values of the predicted model. Analyzing the residuals assess the model's performance.

3.18 Model evaluation

The accuracy of the model is evaluated using Mean Squared Error(MSE), Root Mean Squared Error (RMSE).

Mean Squared Error(MSE): MSE is the average of the squared difference between predicted values and actual values.

Root Mean Squared Error (RMSE): RMSE is calculated by taking the root of mean squared error.

3.19 Linear Regression

Linear regression is considered a machine learning model. It is a statistical technique used to build the relationship between a dependent variable and one or more independent variables. The main aim of linear regression in machine learning is to find the best-fit linear relationship between the input features and the target variable.

CHAPTER 4
RESULTS AND ANALYSIS

This chapter provide a detailed examination and interpretation of the results obtained from the study of Currency Exchange Rate forecasting using time series analysis.

4.1 Simple Moving Average

Fig 5.1 represents the 12 period moving average of the closing price of the exchange rate data

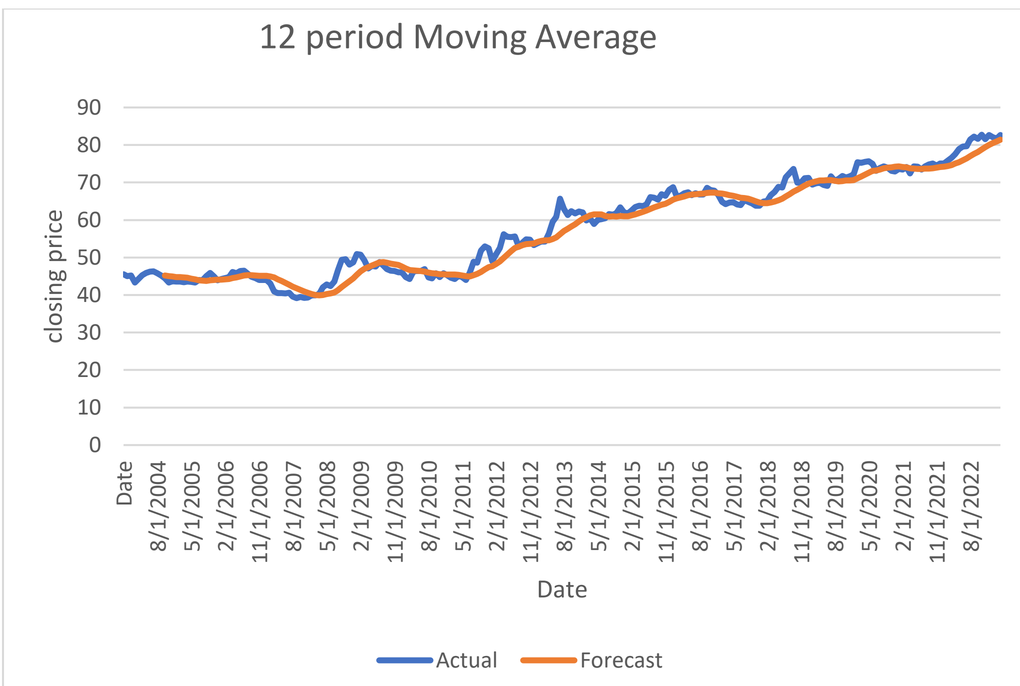

Fig 4.1

From this graph it is clear that there is an upward trend of exchange rate over these years.

4.2 SARIMA Modelling

4.2.1 Time series plot

Fig 5.2 is the time series plot of the closing price of currency exchange rate data from 2003 December to 2023 May.

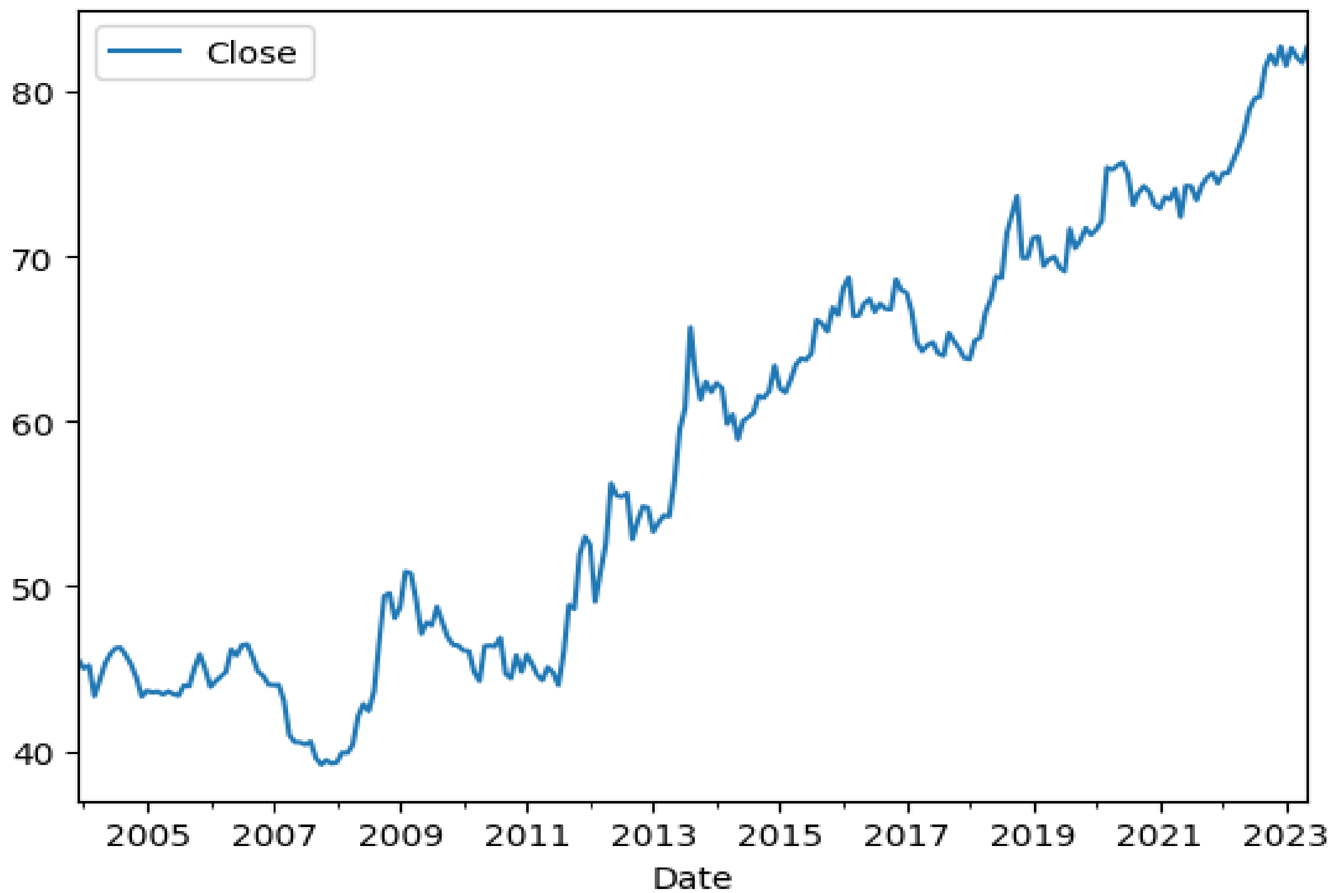

Fig 4.2

4.2.2 Decomposition of time series

Fig 5.3 is the time series decomposition that is it breakdown the time series into its constituent components such as trend, seasonality and residuals.

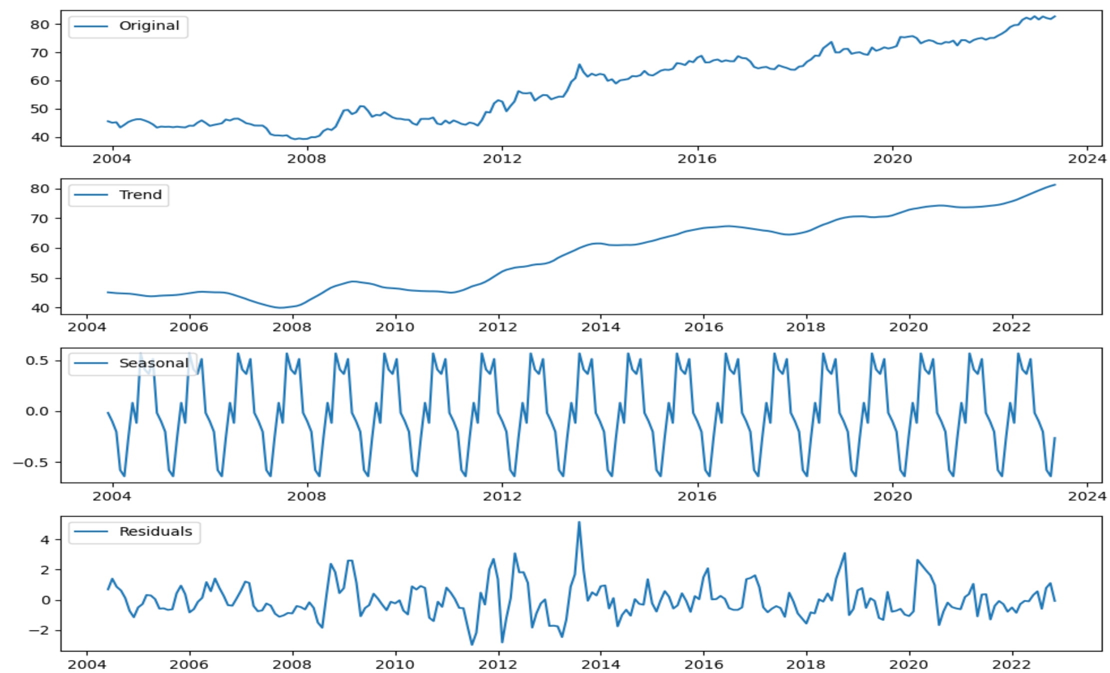

Fig 4.3

From this graph it is clear that the time series data is seasonal.

4.2.3 Autocorrelation and Partial Autocorrelation Function

Fig 4.4 is the ACF and PACF plot

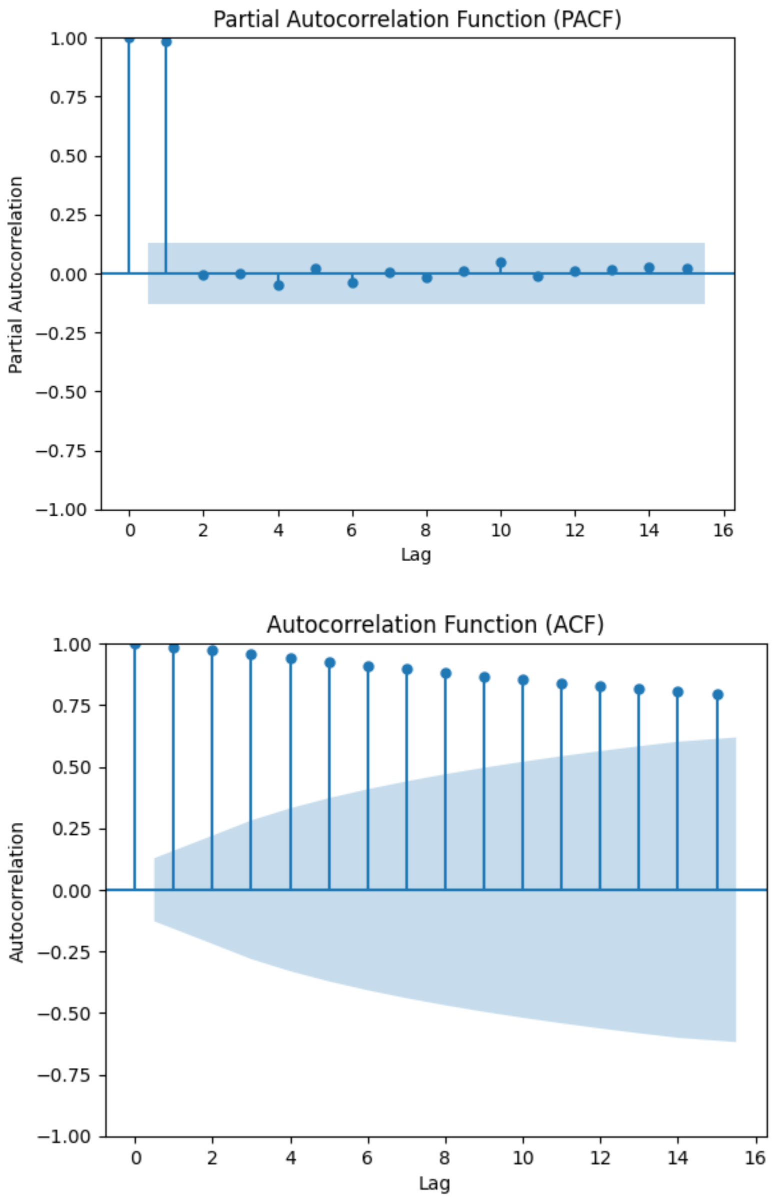

Fig 4.4

4.2.4 Augmented Dickey Fuller test

ADF test is conducted to test whether the test is stationary or non stationary. For that formulate a hypothesis such that

$H_{0:}$ The data is non stationary

Against

H_1: The data is stationary.

The result that got from ADF test is given below

ADF Test Statistic:0.2582970462271449

p-value:0.9753481656686547

Here p value > 0.05.

So reject the null hypothesis. That means the data is non stationary.

The fig 4. is the time series plot after seasonal differencing to make it stationary.

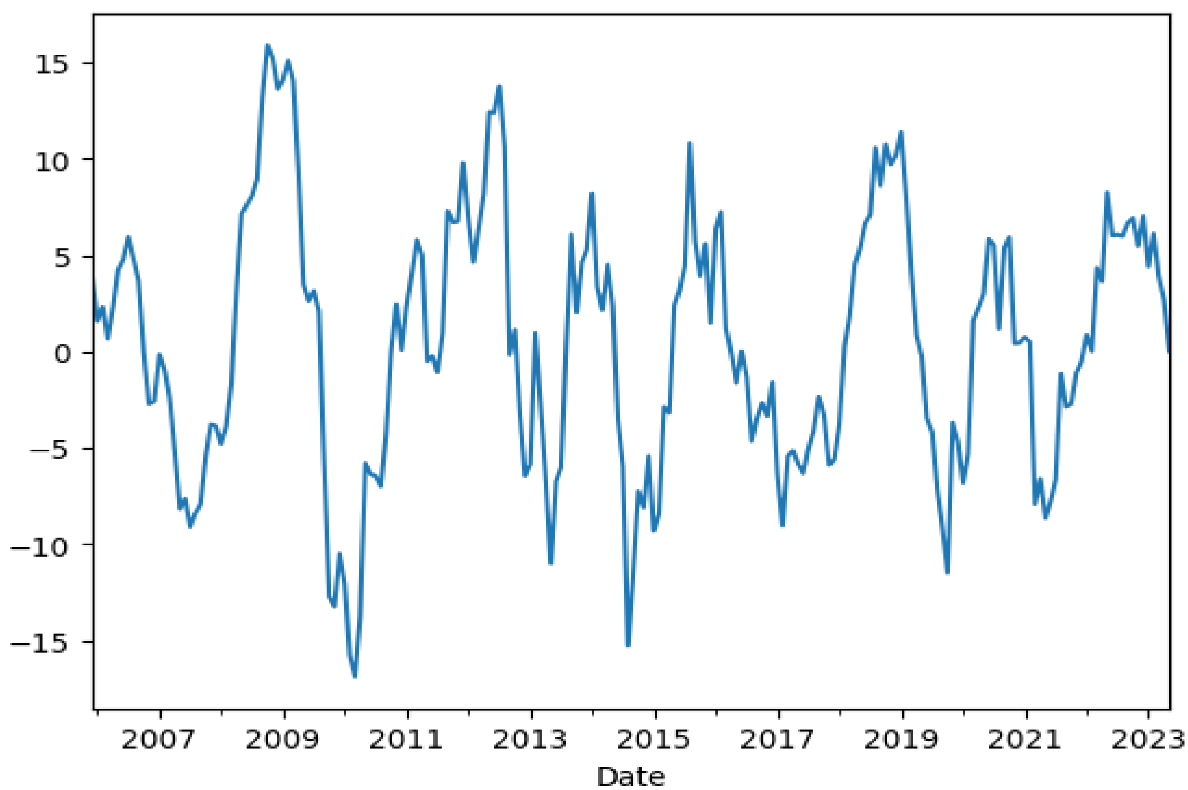

Fig 4.5

4.2.5 SARIMA Models and corresponding AIC values

For getting the best parameters for fitting the model, here grid search method is used and from the given values, the lowest AIC value is considered the best model. Table 4.1 is the table from

which the model parameters is selected.

SL NO.	MODEL	AIC
1	(0, 1, 0) x (1, 0, 1)	715.4849564987983
2	(0, 1, 0) x (1, 1, 0)	762.5959315378665
3	(0, 1, 0) x (1, 1, 1)	698.2035615580675
4	(0, 1, 1) x (0, 0, 0,)	743.155163546701
5	0, 1, 1) x (0, 0, 1)	712.7563037112553
6	(0, 1, 1) x (0, 1, 0)	865.9111351206702
7	**(0, 1, 1) x (0, 1, 1)**	**692.9111351206702**
8	(0, 1, 1) x (1, 0, 0)	717.2628373530031
9	(0, 1, 1) x (1, 0, 1)	714.6891269915088
10	(0, 1, 1) x (1, 1, 0)	763.8778823621487
11	(0, 1, 1) x (1, 1, 1)	696.995727268315

12	(1, 0, 0) x (0, 0, 0)	744.1840796644283
13	(1, 0, 0) x (0, 0, 1)	712.8903498373516
14	(1, 0, 0) x (0, 1, 0)	865.9861240793143

Table 4.1

So the best model is ARIMA(0,1,1)x(0,1,1,12)12

Coefficients:

	coef	Std error	z	P > |z|	[0.025	[0.975]
ma.L1	0.0482	0.060	0.799	0.424	-0.070	0.166
ma.S.L12	-1.0000	593.437	-0.002	0.999	-1164.115	1162.115
Sigma2	1.4162	840.429	0.002	0.999	-1645.794	1648.626

Table 4.2

4.2.6 Diagnostic checking

In this study diagnostic checking is implemented to examine the residuals or errors from the fitted model to detect any remaining patterns or anomalies that might indicate limitations in the model.

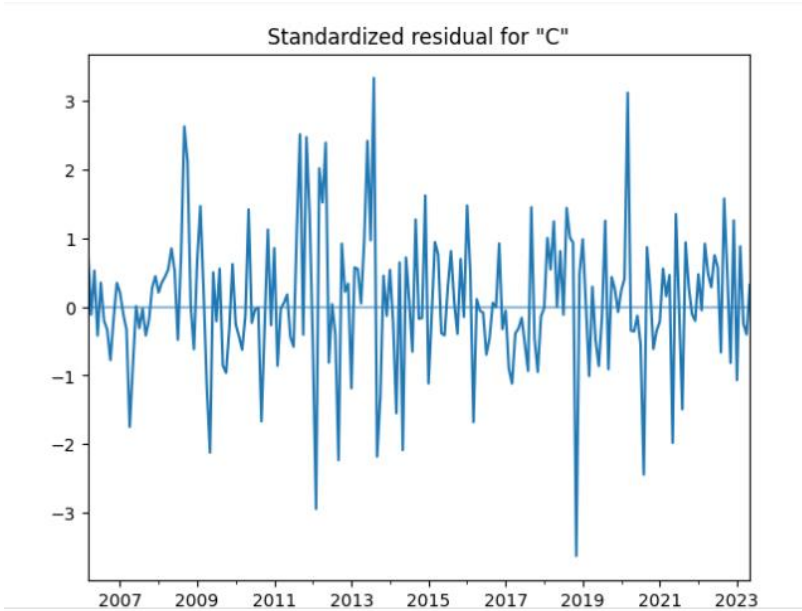

Fig 4.6

From the fig 4.6 the standardized residuals plot is not showing any pattern, just a random fluctuations around zero, indicating that the homoscedasticity assumption is fair and outliers were well-managed.

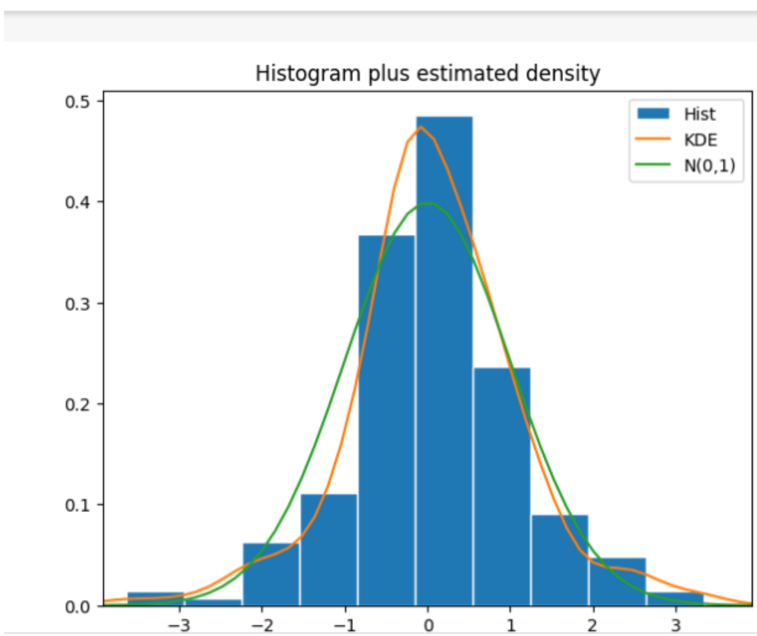

Fig 4.7

Figure 4.7 is the residuals' bell-shaped distribution histogram, which was centered around zero, indicated that the residuals' normality condition was satisfied

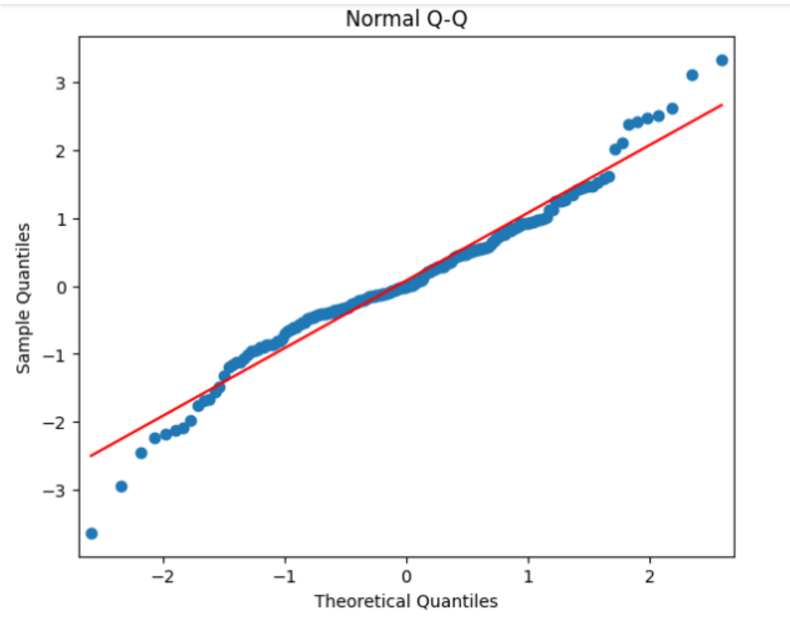

Fig 4.8

Figure 4.8 shows that the residuals' strong adherence to a straight line, as seen by the Q-Q plot, suggests that they are roughly regularly distributed.

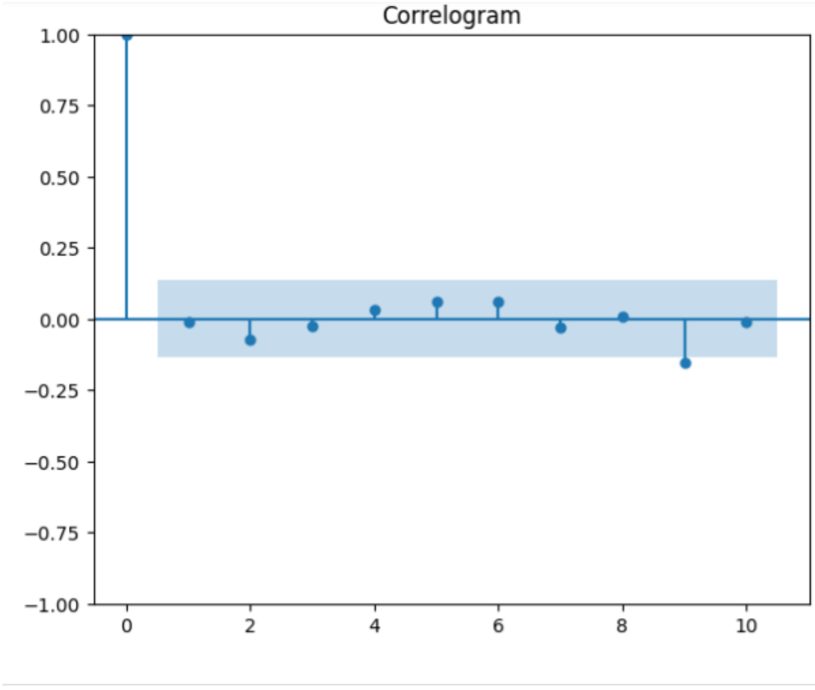

Fig 4.9

. The figure 4.9 is the correlogram which shows random fluctuations around zero in the autocorrelation function, which supports the assumption of independence of residuals.

4.2.7 In Sample Forecast

In-sample forecast is based on historical data that the model has been trained on. This means that the model has already learned from past patterns and trends to make predictions on data points already have. Table 4.3 is the actual and in sample forecasted values.

Date	Close	Predicted Close
2021-01-01	72.906601	73.169469
2021-02-01	73.595901	72.916876
2021-03-01	73.445297	73.254308
2021-04-01	74.105797	73.539431
2021-05-01	72.393501	74.819224
2021-06-01	74.287598	72.632413
2021-07-01	74.251999	74.289265
2021-09-01	74.321999	73.173680
2021-10-01	74.797203	74.441684
2021-11-01	75.054901	75.183333
2021-12-01	74.431198	74.680442
2022-01-01	75.039001	74.458584
2022-02-01	75.068001	75.126811
2022-03-01	75.827797	74.703276
2022-04-01	76.588997	75.998900
2022-05-01	77.520897	77.170321

2022-07-01	79.571503	78.866858
2022-08-01	79.682297	80.492604
2022-09-01	81.480598	79.552716
2022-10-01	82.239197	81.660681
2022-11-01	81.630898	82.629891
2022-12-01	82.739502	81.200290
2023-01-01	81.579903	82.884674
2023-02-01	82.652000	81.575487
2023-03-01	82.100502	82.401030
2023-04-01	81.745399	82.236834
2023-05-01	82.683899	82.294546

Table 4.3

Plot of actual vs predicted closing

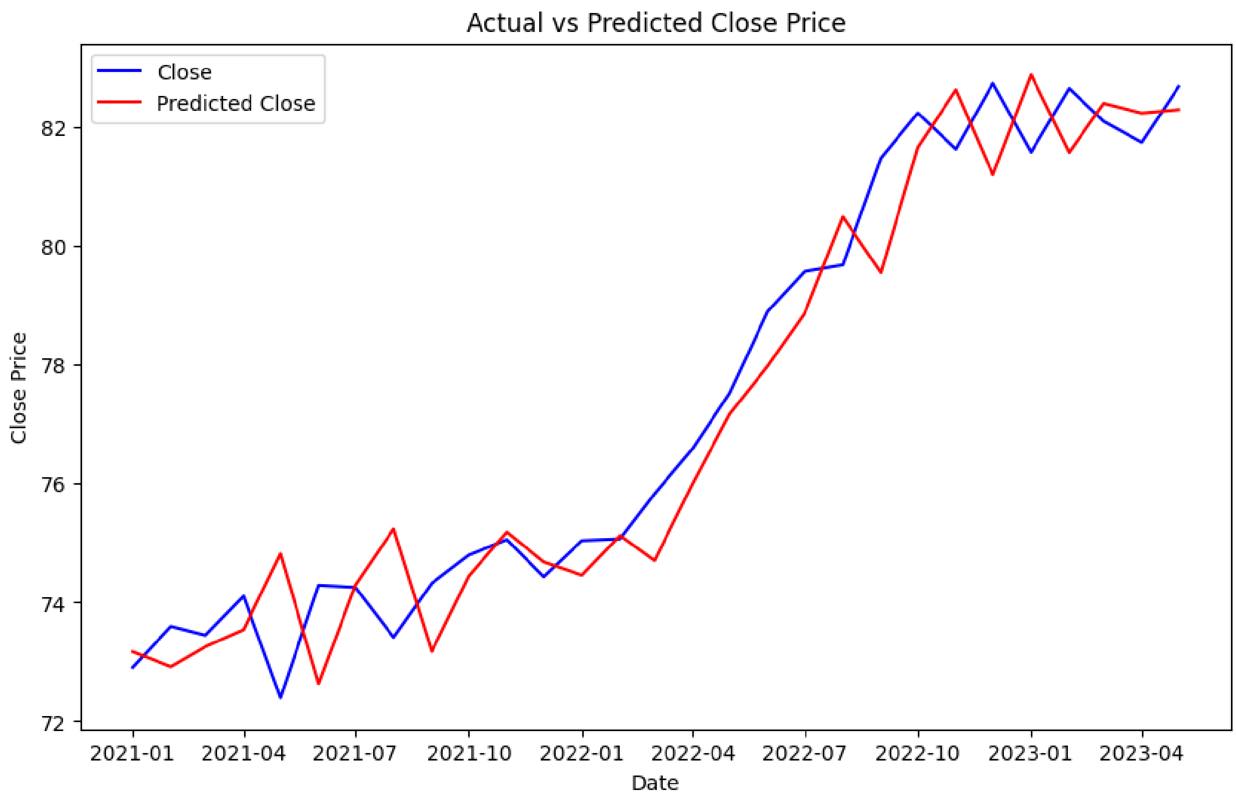

Fig 4.10

4.2.8 Future forecast

Table 4.4 is the forecasted value of the closing price from June 2023 to May 2025 which also contains the LCL and UCL that is the upper control limit and lower control limit.

Date	Future prediction	LCL	UCL
2023-06-01	83.19	80.66	85.51
2023-07-01	83.15	79.43	86.39
2023-08-01	84.00	79.75	88.09
2023-09-01	84.012	78.98	88.50
2023-10-01	84.13	78.53	89.11
2023-11-01	84.45	78.54	90.08
2023-12-01	84.14	77.69	90.11
2024-01-01	84.15	77.39	90.64
2024-02-01	84.26	77.01	91.04
2024-03-01	83.94	76.43	91.19
2024-04-01	84.07	76.20	91.67
2024-05-01	84.66	76.40	92.53
2024-06-01	85.15	76.59	93.29
2024-07-01	85.11	76.26	93.51
2024-08-01	85.96	76.89	94.68

2024-09-01	85.97	76.65	94.96
2024-10-01	86.09	76.55	95.37
2024-11-01	86.40	76.68	95.99
2024-12-01	86.09	76.18	95.97
2025-01-01	86.10	75.94	96.20
2025-02-01	86.21	75.82	96.54
2025-03-01	85.89	75.37	96.53
2025-04-01	86.02	75.23	96.84
2025-05-01	86.61	75.59	97.62

Table 4.4

Plot of forecasted values

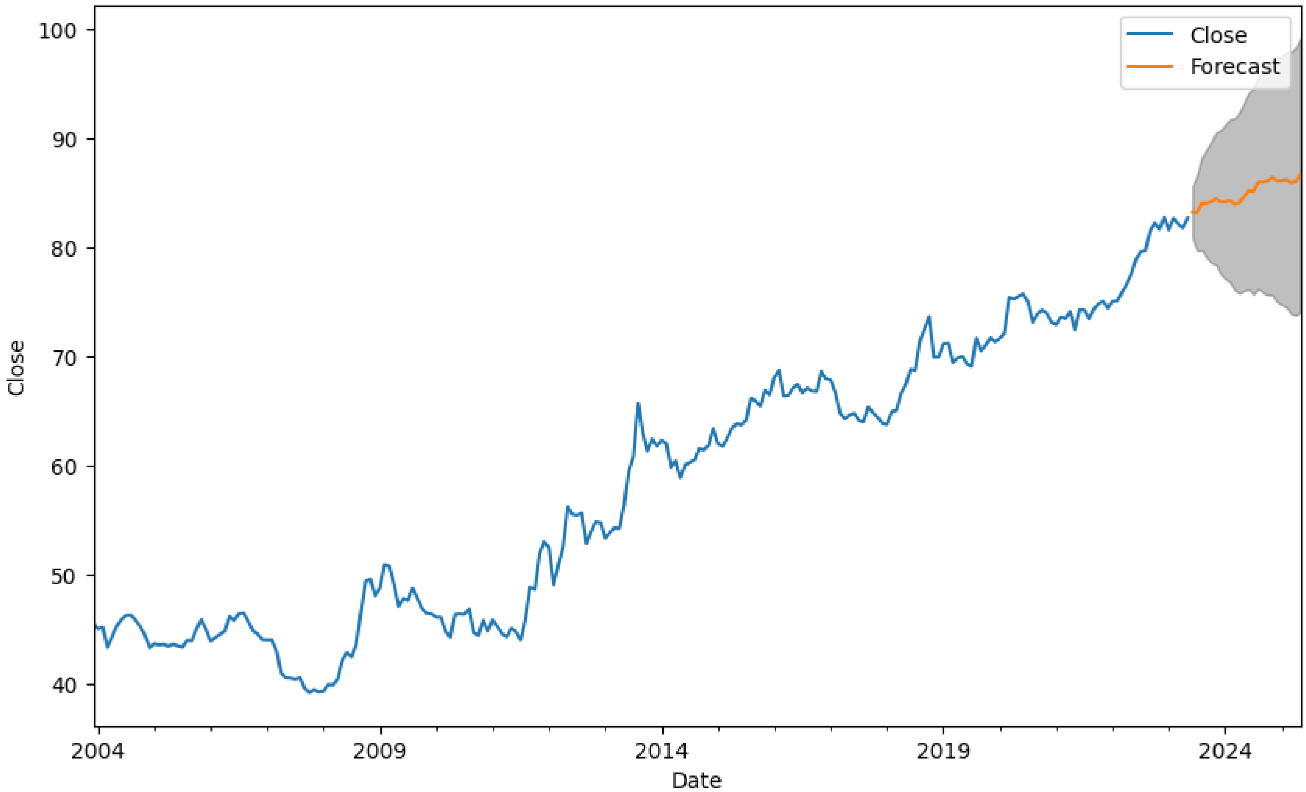

Fig 4.11

Fig 4.8 is the plot of actual and forecasted value.

4.3 Linear Regression

In this analysis, linear regression was used to forecast currency exchange rates.

Table 4.5 is the forecasted values from June 2023 to May 2025.

Date	Future prediction
2023-06	79.34
2023-07	79.52
2023-08	79.71
2023-09	79.88
2023-10	80.07
2023-11	80.24
2023-12	80.43
2024-01	80.61
2024-02	80.78
2024-03	80.96
2024-04	81.14
2024-05	81.32
2024-06	81.50

2024-07	81.68
2024-08	81.87
2024-09	82.04
2024-10	82.23
2024-11	82.40
2024-12	82.59
2025-01	82.77
2025-02	82.93
2025-03	83.12
2025-04	83.29
2025-05	83.48

Table 4.5

Plotting Predictions Using Linear Regression

Fig 4.8 is the plot of the predicted vs. actual closing price.

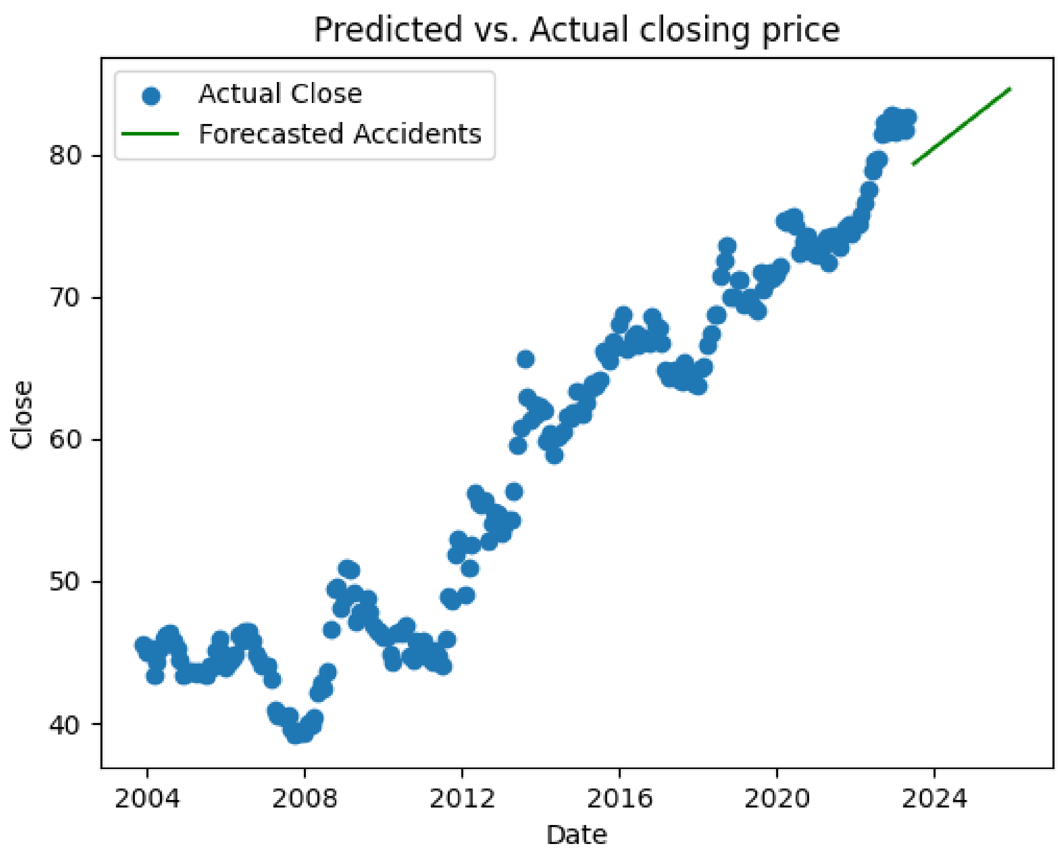

Fig 4.12

4.4 Comparison of models

Model	**MSE**	**RMSE**
SARIMA	**1.27**	**1.1291330705524072**
Linear Regression	**12.477684674493686**	**3.5323766325936545**

Table 4.6

Table 4.6 is the comparison of the MSE and RMSE values of two models that is the SARIMA model and Linear Regression model.

CHAPTER 5
CONCLUSION

In this study, the main objectives were to analyze currency exchange rate data, identify trends and patterns using moving average, and implement SARIMA and linear regression models to predict future exchange rates. The SARIMA model utilized its capacity to capture seasonal variations and successive correlations, resulting in reliable forecasts. On the other hand, the linear regression model, effectively captured linear trends and variations in the data, contributing to reliable predictions as well. By comparing the mean squared error (MSE) and root mean squared error (RMSE) of both models, it was observed that the SARIMA model exhibited slightly lower MSE and RMSE values compared to the linear regression model. This indicates that the SARIMA model exhibited slightly higher predictive accuracy in forecasting future exchange rates.

REFERENCES

1. Akhtar, S., Ramzan, M., Shah, S., Ahmad, I., Khan, M. I., Ahmad, S., ... & Qureshi, H. (2022). Forecasting exchange rate of Pakistan using time series analysis. *Mathematical Problems in Engineering*, *2022*.

2. Arzo Ahmed, S. N., & Moloy, M. D. J. (2021). Modeling and forecasting of time series data using different techniques. *Multicultural Education*, *7*(11).

3. Dev, D. S., Ray, A., & Austin, J. (2022, November). ARIMA Model based Time Series Modelling and Prediction of Foreign Exchange Rate against US Dollar. In *2022 International Conference on Advancements in Smart, Secure and Intelligent Computing (ASSIC)* (pp. 1-7). IEEE.

4. Joshi, V. K., Band, G., Naidu, K., & Ghangare, A. (2020). Modeling exchange rate in india–empirical analysis using ARIMA model. *Studia Rosenthaliana (Journal for the Study of Research)*, *12*(3), 13-26.

5. Kumar, K., & Gill, D. (1997). Forecasting Exchange Rate: A time Series Analysis. *South Asian Journal of Management*, *4*(2), 7-13.

6. Lemonjava, G. (2019). Time Series Models for Forecasting Exchange Rates. *Globalization & Business*.

7. Nanayakkara, K. A. D. S. A., Chandrasekara, N. V., & Jayasundara, D. D. M. (2014). Forecasting exchange rates using time series and neural network approaches. *European International Journal of Science and Technology*, *3*(2), 65-73.

8. NJOKI, K. M. (2019). *Forecasting Foreign Exchange Rates in Kenya Using Time Series: A Case of Usd/Kes Exchange Rates* (Doctoral dissertation, Maseno University).

9. Qureshi, M., Ahmad, N., Ullah, S., & ul Mustafa, A. R. (2023). Forecasting real exchange rate (REER) using artificial intelligence and time series models. *Heliyon*, *9*(5).

10. Tlegenova, D. (2015). Forecasting exchange rates using time series analysis: the sample of the currency of Kazakhstan. *arXiv preprint arXiv:1508.07534*.