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Forecasting PT Bank Central Asia Tbk Stock Price Using ARIMA Model

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Abstract— One of the most widely used financial market instruments is the stock. When deciding on how to raise money, the corporation may choose to issue shares. However, because stocks have the potential to generate an enormous amount of profit, this makes it a popular investment option among investors. The method used for forecasting the stock price of PT Bank Central Asia Tbk is the Autoregressive Integrated Moving Average (ARIMA) model. The analysis reveals that ARIMA (3,2,0) is the best model for predicting the stock price of PT Bank Central Asia Tbk, boasting the lowest Mean Absolute Percentage Error (MAPE) at 14.03% compared to other models. The investor might use this forecasting as a guide for future decisions to make efficient and effective about stocks on PT Bank Central Asia Tbk.
Keywords— Forecasting ;ARIMA; Stock Price; PT Bank Central Asia Tbk

I. INTRODUCTION

One of Indonesia's biggest private banks is PT Bank Central Asia Tbk. The headquarters of PT Bank Central Asia Tbk are in Jakarta, Indonesia, and it was established in 1955. PT Bank Central Asia Tbk is a subsidiary of PT Dwimuria Investama Andalan [1]. To this day, PT Bank Central Asia Tbk has the largest total market capitalization in Indonesia. One of the most widely used financial market instruments is the stock. Stocks are a symbol of a person's or party's (business entity) capital investment in a corporation or limited liability company. When deciding on how to raise money, the corporation may choose to issue shares. Conversely, stocks are a favored investment instrument due to their ability to generate appealing levels of profit [2].

In the context of forecasting stock prices, researchers have collected and analyzed related work, utilizing ARIMA(p,d,q) modeling. This modelling approach requires the data to be stationary in term of both mean and variance. The ARIMA(p,d,q) model selection process involves examining the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) values. These values assist in identifying the suitable modeling form. By establishing an appropriate model, future predictions can be made based on the obtained results.

In numerous earlier research, ARIMA was utilized to forecast stock prices in the financial sector. In 2022, Hidayana et al. forecast the stock price of the best ten stocks according to the criteria that apply on the IDX by using the ARIMA Model, GJR, and GARCH, the period between December 17, 2018, to December 14, 2021, which include the names of stock BBCA, BBNI, BBRI, BMRI, ASII, ICBP, PGAS, PTBA, TLKM, and UNVR [3]. One of the best ten stocks that have relatively better performance is BBCA. Their result shows that the best model for BBCA is ARIMA (1,0,3), GJR, and GARCH (1,1). The Value-at-Risk value for BBCA is 0.047088. A similar study was also conducted by Ganesan and Kannan in 2021 to forecast the stock price of ICICI Bank and Reliance Industries. For Reliance Industries the best model for 1 year is ARIMA (0,2,1) and for 6 months is ARIMA (1,0,0), while for ICICI Bank the best model for 1 year and 6 months is ARIMA (0,1,0) [4]. Another study in 2021 regarding predicting stock price fluctuations of PT Bank Central Asia Tbk also use ARIMA Model from October 1, 2020, until February 26, 2021. The results showed that the appropriate ARIMA Model for the closing price is ARIMA (0,2,1). The model's expected outcome is a reduction in the closing price of PT Bank Central Asia Tbk shares during the course of the ensuing 60 days [5]. This forecasting is very useful for the investor as a guideline in the future for making effective and efficient decisions about stocks on PT Bank Central Asia Tbk.

II. METHOD

Indeed, the Box-Jenkins method is a widely used approach for constructing ARIMA models. The general notation for the Box-Jenkins model is ARIMA (p, d, q). The symbol of p, d and q represent of degree of Autoregressive (AR), degree of Differencing process, and degree of Moving Average (MA), respectively.

The Box-Jenkins method follows a systematic procedure comprising four iterative stages in building ARIMA models for time series data:

1. Identification: This stage involves identifying the appropriate values of p, d, and q by analyzing the autocorrelation and partial autocorrelation functions of the time series. It aims to understand the underlying patterns and dependencies within the data.
2. Estimation: In this stage, the ARIMA model parameters (p, d, q) are estimated using techniques such as Maximum Likelihood Estimation (MLE) based on the available data.
3. Diagnostic check: Once the model parameters are estimated, a diagnostic check is performed to assess the model's goodness of fit. This involves analyzing the residuals to ensure they are uncorrelated, normally distributed, and exhibit no significant patterns.
4. Forecasting: After the model has passed the diagnostic check, it can be used for forecasting future values. The ARIMA model's parameters and the estimated residuals are employed to generate predictions for future time points.

The Box-Jenkins method provides a systematic and iterative framework for modeling and forecasting time series data, aiding in capturing the underlying patterns and making accurate predictions [7].

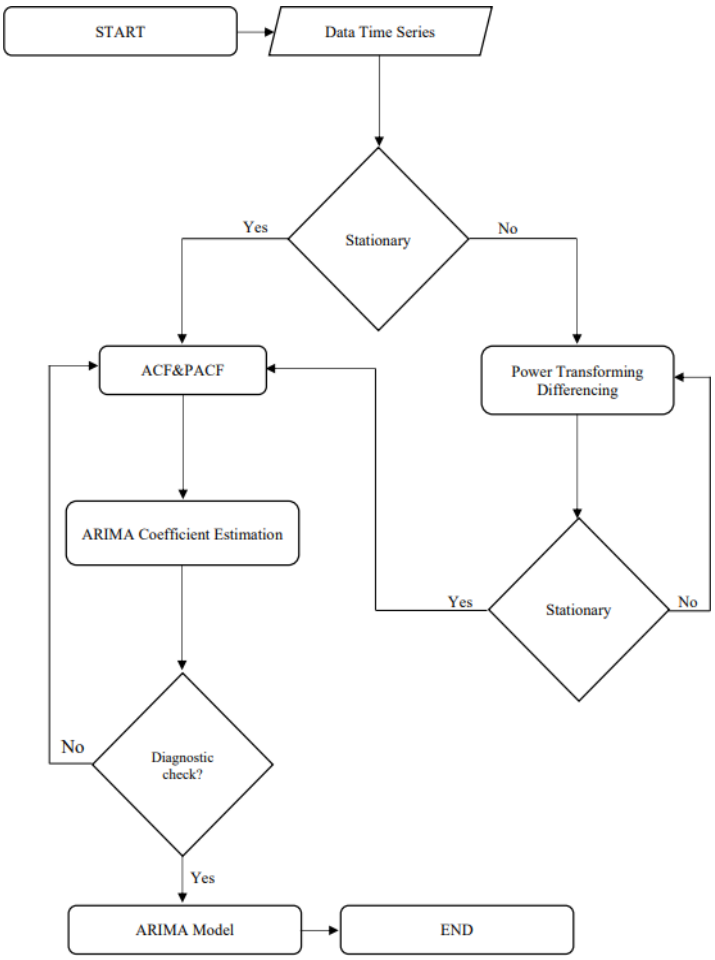

Figure. 1 ARIMA modeling flowchart

III. Analysis and Discussion

A. Data Preparation

The analysis of PT Bank Central Asia Tbk's weekly stock price data from April 04, 2022, to January 09, 2023 with a total of 41 data shown in TABLE 1 [8]. The accuracy of forecasting outcomes is significantly influenced by the quantity of historical data available. In this case, having 41 data points is deemed sufficient for obtaining reliable forecasting results. All calculations and analysis were performed with the help of R software. Some important R libraries in this work related to times series are forecast, TSA and tseries.

TABLE 1
DATA SHEET OF THE STOCK PRICE OF PT BANK CENTRAL ASIA TBK

Date	Close	Date	Close
2022-04-04	7850	2022-08-22	8000
2022-04-11	7700	2022-08-29	8225
2022-04-18	7875	2022-09-05	8375
2022-04-25	8125	2022-09-12	8450
2022-05-02	8125	2022-09-19	8375
2022-05-09	7325	2022-09-26	8550
2022-05-16	7400	2022-10-03	8200
2022-05-23	7575	2022-10-10	8250
2022-05-30	7600	2022-10-17	8650
2022-06-06	7350	2022-10-24	8750
2022-06-13	7500	2022-10-31	8775
2022-06-20	7475	2022-11-07	8850
2022-06-27	7250	2022-11-14	8825
2022-07-04	7150	2022-11-21	8975
2022-07-11	7000	2022-11-28	8900
2022-07-18	7325	2022-12-05	8575
2022-07-25	7350	2022-12-12	8600
2022-08-01	7875	2022-12-19	8500
2022-08-08	7925	2022-12-26	8550
2022-08-15	7900	2023-01-02	8300
		2023-01-09	8050

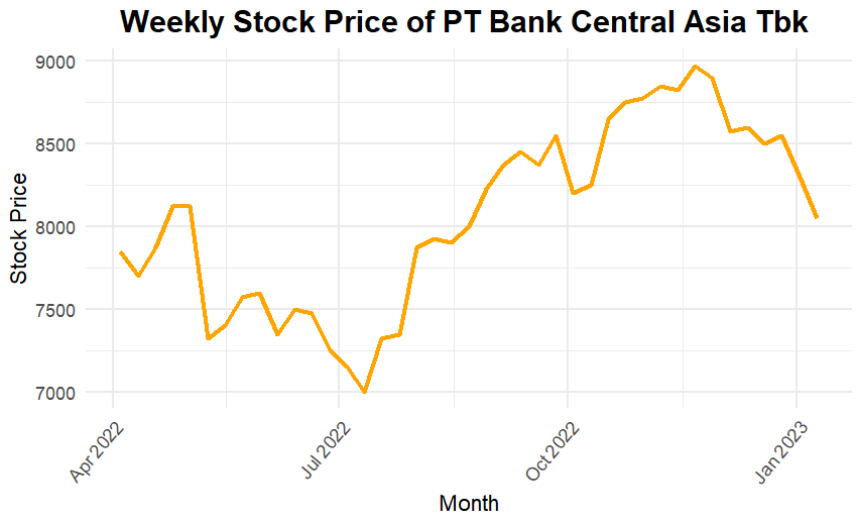

Figure. 2 Graph of Stock Price of PT Bank Central Asia Tbk.

B. Stationarity Check

The data's stationarity can be assessed using the Augmented Dickey-Fuller (ADF) Test. In this test, the level of significance 5% is selected, thus the p-value of the ADF Test is below 0.05, then the data is considered stationary. In this case, the ADF Test yields a p-value of 0.6043, indicating that the data is non-stationary since it exceeds the 0.05 threshold. Therefore, it is necessary to perform differencing on the data until stationarity is achieved. After applying second differencing, the p-value becomes 0.01, confirming that the data is stationary.

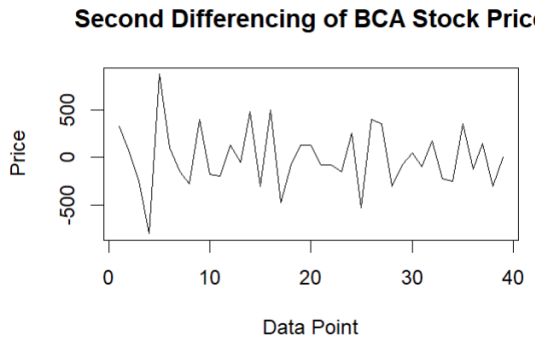

Figure. 3 The Second Derivative Graph of the Stock Price of PT Bank Central Asia Tbk.

C. ARIMA Model Specifications

This section discusses how to determine the ARIMA model specifications. There are three parameters to specify the model namely p, d and q.

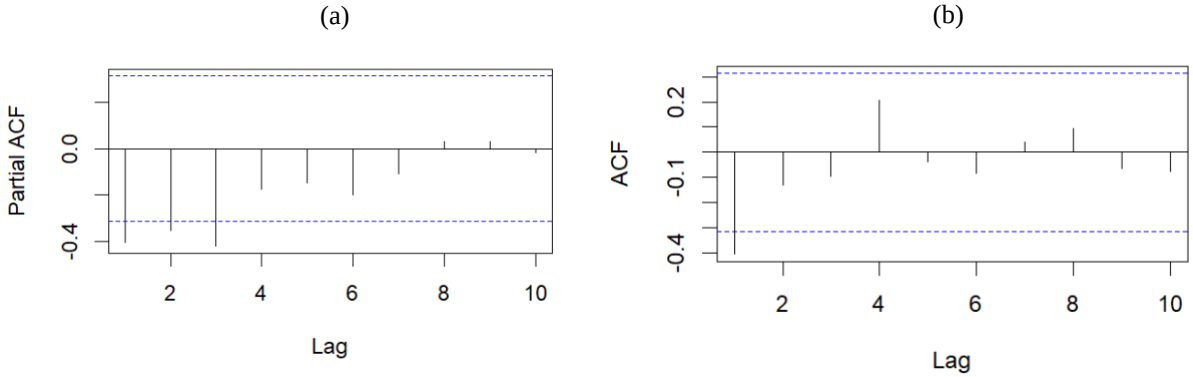

Figure. 4 PACF and ACF Plot

According to the results of differencing, partial autocorrelation plot at Figure 4 (a) and autocorrelation plot at Figure 4 (b) obtained that p=3, d=2, and q=1. Based on parsimony principle, here are some of the ARIMA model candidate than can be constructed at TABLE 2.

TABLE 2
ARIMA (3,2,1) MODELS

ARIMA Model	P	d	q
(3,2,1)	3	2	1
(3,2,0)	3	2	0
(2,2,1)	2	2	1
(2,2,0)	2	2	0
(1,2,1)	1	2	1
(1,2,0)	1	2	0
(0,2,1)	0	2	1
(0,2,0)	0	2	0

D. Parameter Estimation

Estimates of the parameters that can be made after establishing the ARIMA model include AR1, AR2, AR3, MA1, MSE, Log-likelihood, and AIC. The result of calculation of parameter estimation are available at TABLE 3.

TABLE 3
PARAMETER ESTIMATION RESULT

ARIMA Model	AR1	AR2	AR3	MA1	MSE	Log Likelihood	AIC
(3,2,1)	-0.1967	-0.3196	-0.2297	-0.6972	52293	-268.02	544.04
(3,2,0)	-0.7255	-0.6201	-0.4325		57377	-269.56	545.13
(2,2,1)	-0.0360	-0.2112		-0.8477	53781	-268.59	543.19
(2,2,0)	-0.5644	-0.3678			71924	-273.65	551.31
(1,2,1)	0.0462			-0.9999	52432	-269.05	542.09
(1,2,0)	-0.4053				83634	-276.45	554.89
(0,2,1)	0.0021	-0.2499	-0.1637	-1.0000	52410	-269.09	540.17
(0,2,0)					100545	-279.95	559.89

E. Residual Analysis

In this residual analysis, the purpose of the Shapiro Test is to assess the normality of a given dataset, it is a statistical test that determines whether a sample of data comes from a normally distributed population. The Ljung-Box test is a statistical test used in time series analysis to assess the presence of autocorrelation in a series of residuals.

TABLE 4
RESIDUAL ANALYSIS RESULT

No.	ARIMA Model	Shapiro Test	Ljung Box Test	AIC	Description
1	(3,2,1)	0.0045	0.9468	544.04	Rejected
2	(3,2,0)	0.05224	0.6537	545.13	Accepted
3	(2,2,1)	0.01473	0.8622	543.19	Rejected
4	(2,2,0)	0.0743	0.3045	551.31	Accepted
5	(1,2,1)	0.04565	0.9857	542.09	Rejected
6	(1,2,0)	0.273	0.3345	554.89	Accepted
7	(0,2,1)	0.04361	0.7885	540.17	Rejected
8	(0,2,0)	0.6903	0.007074	559.89	Rejected

Based on TABLE 4, Three models were found to have passed both the Shapiro and Ljung Box tests. They are ARIMA (3,2,0), ARIMA (2,2,0) and ARIMA (1,2,0) and these are candidate model. The best model among these is the one with the lowest AIC value and it is ARIMA (3,2,0). By the parameter values at TABLE 3, the equation of this model can be expressed as follows

$$W_t = -0.7255\, W_{t-1} - 0.6201\, W_{t-2} - 0.4325\, W_{t-3} + e_t. \tag{1}$$

Substitution this by $W_t = Y_t - 2\, Y_{t-1} + Y_{t-2}$ give

$$Y_t - 2\, Y_{t-1} + Y_{t-2} = -0.7255\, (Y_{t-1} - 2\, Y_{t-2} + Y_{t-3}) - 0.6201\, (Y_{t-2} - 2\, Y_{t-3} + Y_{t-4}) - 0.4325\, (Y_{t-3} - 2\, Y_{t-4} + Y_{t-5}) + e_t$$

$$= -0.7255\, (Y_{t-1} - 2\, Y_{t-2} + Y_{t-3}) - 0.6201\, (Y_{t-2} - 2\, Y_{t-3} + Y_{t-4}) - 0.4325\, (Y_{t-3} - 2\, Y_{t-4} + Y_{t-5}) + 2\, Y_{t-1} - Y_{t-2} + e_t$$

$$= (-0.7255 + 2)Y_{t-1} + (1.451 - 0.6201 - 1)Y_{t-2} + (-0.7255 - 0.6201 - 0.4325)\, Y_{t-3} + (-0.6201 + 0.865)\, Y_{t-4} + (-0.4325)Y_{t-5} + e_t$$

or

$$Y_t = 1.2745\, Y_{t-1} - 0.1691\, Y_{t-2} - 1.7781\, Y_{t-3} + 0.2449\, Y_{t-4} - 0.4325\, Y_{t-5} + e_t \tag{2}$$

To show the distribution of ARIMA residuals (3,2,0) visually whether follow a normal distribution or not, the Normal QQ Plot is presented at Figure 6.

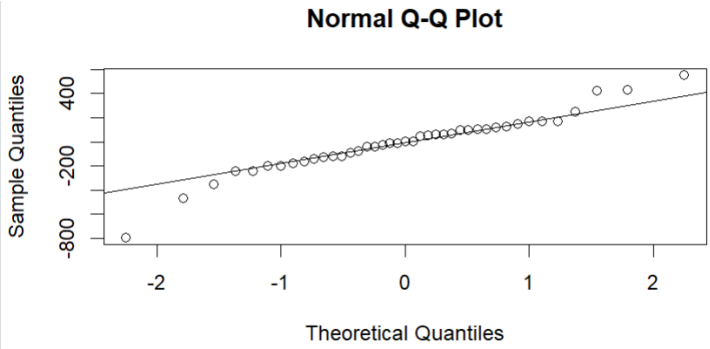

Figure. 6 Model 2 Q-Q Normal Plot

The Figure 6 can demonstrate visually that the residual model 2 follows a normal distribution because the points on the graph approach a straight line.

F. Forecasting

The following is the plot of the forecasted weekly stock price of BBCA for 8 days, starting from January 16, 2023 to March 06, 2023.

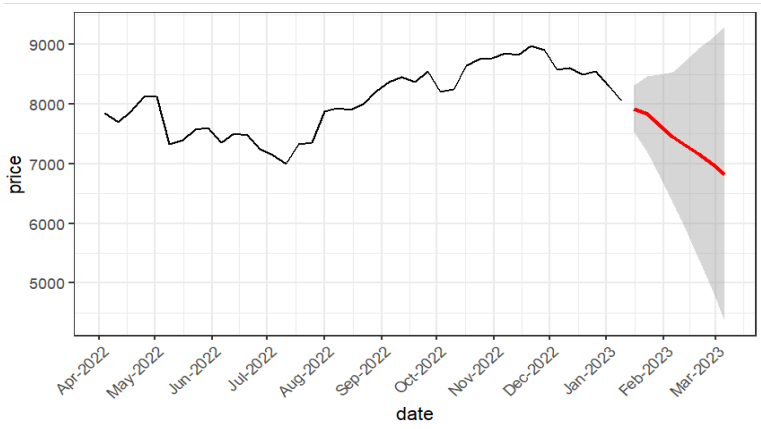

Figure. 8 Forecasting Graph

G. Comparison

The table below shows the comparison between the actual data and the predicted data, and the error value is calculated using four parameters: MSE, RMSE, MAE, and MAPE.

TABLE 6
COMPARISON OF ACTUAL DATA AND PREDICTED DATA OF MODEL 6 ARIMA (1,2,0)

Date	Lower Bound	Upper Bound	Predicted Data	Actual Data	MSE	RMSE	MAE	MAPE
2023-01-16	7324.3169	8275.683	7800	8300	250000	250000.00000	500	6.02%
2023-01-23	6654.6056	8445.394	7550	8700	1322500	1322500.00	1150	13.22%
2023-01-30	5866.3752	8733.625	7300	8700	1960000	1960000.000	1400	16.09%
2023-02-06	5011.6547	9088.345	7050	8825	3150625	3150625.00	1775	20.11%
2023-02-13	4086.4753	9513.525	6800	8725	3705625	3705625.00	1925	22.06%
2023-02-20	3101.4616	9998.538	6550	8675	4515625	4515625.0	2125	24.50%
2023-02-27	2059.7184	10540.282	6300	8475	4730625	4730625	2175	25.66%
2023-03-06	965.5998	11134.4	6050	8400	5522500	5522500.00	2350	27.98%
		RESULT			**3144687.5**	**1773.33**	**1675**	**19.46%**

TABLE 7
COMPARISON OF ACTUAL DATA AND PREDICTED DATA OF MODEL 4 ARIMA (2,2,0)

Date	Lower Bound	Upper Bound	Predicted Data	Actual Data	MSE	RMSE	MAE	MAPE
2023-01-16	7469.224	8351.476	7910.35	8300	151827.1225	151827.12250	389.65	4.69%
2023-01-23	6936.635	8480.211	7708.423	8700	983224.9469	983224.95	991.577	11.40%
2023-01-30	6386.780	8615.325	7501.052	8700	1437476.307	1437476.307	1198.95	13.78%
2023-02-06	5769.297	8870.026	7319.661	8825	2266045.505	2266045.50	1505.34	17.06%
2023-02-13	5101.290	9149.931	7125.611	8725	2558045.173	2558045.17	1599.39	18.33%
2023-02-20	4400.302	9457.995	6929.148	8675	3047999.206	3047999.2	1745.85	20.13%
2023-02-27	3661.269	9816.139	6738.704	8475	3014723.8	3014724	1736.3	20.49%
2023-03-06	2885.422	10206.078	6545.750	8400	3438243.063	3438243.06	1854.25	22.07%
		RESULT			**2112198.14**	**1453.34**	**1377.66**	**15.99%**

TABLE 8
COMPARISON OF ACTUAL DATA AND PREDICTED DATA OF MODEL 2 ARIMA (3,2,0)

Date	Lower Bound	Upper Bound	Predicted Data	Actual Data	MSE	RMSE	MAE	MAPE
2023-01-16	7527.165	8315.165	7921.165	8300	143516	143515.95723	378.835	4.56%
2023-01-23	7195.905	8472.423	7834.164	8700	749672	749671.98	865.836	9.95%
2023-01-30	6783.708	8499.637	7641.673	8700	1120056	1120056.039	1058.33	12.16%
2023-02-06	6353.716	8541.035	7447.376	8825	1897848	1897847.89	1377.62	15.61%
2023-02-13	5882.035	8721.392	7301.714	8725	2025743	2025743.04	1423.29	16.31%
2023-02-20	5408.43	8926.584	7167.507	8675	2272535	2272535.1	1507.49	17.38%
2023-02-27	4894.129	9097.090	6995.610	8475	2188595	2188595	1479.39	17.46%
2023-03-06	4361.152	9284.691	6822.921	8400	2487178	2487178.17	1577.08	18.77%
		RESULT			**1610643**	**1269.11**	**1208.48**	**14.03%**

The forecasting error at TABLE 8 give MSE is 1610643, RMSE is 1269.11, MAE is 1208.48, and MAPE 14.03%.

IV. CONCLUSION

Based on the forecasting results obtained from the historical data of PT Bank Central Asia Tbk's weekly stock prices, spanning from April 04, 2022, to January 09, 2023, it is observed that the forecasted values show a gradual decrease. This predicted that the closing price of PT Bank Central Asia Tbk shares is indicates to decrease in the next 8 days. The best model used to predict the stock price for the next 8 days with MSE 1610643, RMSE 1269.11, MAE 1208.48, and MAPE 14.03% is the ARIMA (3,2,0) model. Based on the residual analysis, the ARIMA (3,2,0) formula is:

$$Y_t = 1.2745\, Y_{t-1} - 0.1691\, Y_{t-2} - 1.7781\, Y_{t-3} + 0.2449\, Y_{t-4} - 0.4325\, Y_{t-5} + e_t$$

The accuracy of this forecasting is not good ss indicate by MAPE value of this forecasting is greater than 10 %. To improve this work, next time is needed to consider other method like ARCH/GARCH, AFRIMA and even the deep learning approach like Long Short Term Memory (LSTM) .

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