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Trend Forecasting of the Top 3 Indonesian Bank Stocks Using the ARIMA Method

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Abstract: The number of investors in Indonesia increases annually. This is due to the growing popularity of investing, particularly stock investment. There are currently three largest equities in the banking industry, namely BBCA, BBRI, and BMRI. Stock prices fluctuate and form multiple patterns of price movements; therefore, investors must be able to recognize the patterns and trends of securities on the capital market in order to plan long-term investments, maximize potential profits, and reduce the risk of investment losses. In addition to knowing the trajectory of the stock market's trend, investors rely heavily on forecasting. Forecasting is necessary so that investors can anticipate future prices. The Autoregressive Integrated Moving Average (ARIMA) method is a frequently used method for forecasting time series data. In general, ARIMA is represented by the formula ARIMA (p, d, q), where p represents the Autoregressive (AR) order, d represents the difference, and q represents the Moving Average (MA) order. The trend of BBCA, BBRI, and BMRI stock data was effectively predicted using the ARIMA method. The results of this study are presented as diagrams of actual and forecasted data for the next 12 periods, as well as predictions of the optimal purchase price points for stocks. The ARIMA model of each stock also generates a low MAPE error value, with MAPE values of 4% for BBCA, 5% for BBRI, and 7% for BMRI. The MAPE value derived by each model is incorporated into the MAPE value with a high degree of precision, as it falls below 10%.

Keywords: ARIMA Method ; Forecasting Trend; Top 3 Indonesian Bank

INTRODUCTION

Stocks are ownership-based securities issued by a company (Permana, 2022). There are currently three issuers (commercial entities) in Indonesia's banking sector that control market capitalization (market cap): BBCA, BBRI, and BMRI. According to the website of the Indonesia Stock Exchange (Bursa Efek Indonesia, 2022), specifically the "50 Biggest Market Capitalization" market data, PT Bank Central Asia Tbk's BBCA shares are ranked first with a market capitalization of Rp.1,134,993 trillion. The second position is held by PT Bank Rakyat Indonesia Persero Tbk's BBRI shares, which are valued at Rp.747.216 trillion. BMRI, owned by PT Bank Mandiri Indonesia Persero Tbk, has a market capitalization of Rp.486.255 trillion.

Stock prices will periodically fluctuate up and down which can create various patterns of price movements(Zahro et al., 2021). Therefore, an investor must be able to know stock trends that are currently happening in the capital market, by knowing stock trends, investors will be able to identify

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investment opportunities, control risks, and be able to plan long-term investments so that investors can optimize profit potential and reduce the risk of loss in investing.(Makkulau & Yuana, 2021; Yang, 2019). In addition to knowing the direction of stock trends, forecasting is also needed by investors to maximize decision making in buying and selling shares.

Forecasting is an approach or method used to predict future values or events(Anwar et al., 2023; Muhammad Rizal et al., 2021). In stock investing, forecasting can assist investors in predicting stock price movements for several future periods(Elsaraiti et al., 2021; Prasetya et al., 2020). By using the right forecasting method, investors can make more informed decisions in buying and selling shares. This helps investors to identify lucrative investment opportunities and mitigate potential risks, thereby increasing the chances of success in the stock market(Yasmin, 2021). One method of forecasting time series data that is often used is the Autoregressive Integrated Moving Average (ARIMA) method.(Abidin et al., 2022). In general, this ARIMA consists of the ARIMA formula (p, d, q), p is the Autoregressive order (AR), d is the difference, and q is the order of the Moving Average (MA).(Rusyida & Pratama, 2020). Stock data is included in a consistent financial time series. Therefore, the ARIMA method is suitable because it depends on data consistency between time periods. The ARIMA method is the best method for predicting time series data compared to other similar methods, such as the Artificial Neural Network (ANN) method, fuzzy time series, Adaptive Neuro-Fuzzy Inference System (ANFIS), and exponential smoothing method.(Fattah et al., 2018; Wibawa et al., 2018). The ARIMA method has several advantages, such as reliability and efficiency in forecasting time series financial data. The ARIMA method is also accurate in making short-term predictions. In addition, the ARIMA method can be applied to predict large-scale data, and is able to analyze data in random, trending, and seasonal situations.(Ferdinandus et al., 2023; Kumar et al., 2022; Wibawa et al., 2018).

Based on the above explanation, this study aims to predict the trend of share data of the three largest banks in Indonesia using the ARIMA method with the hope that it will be useful for investors so that they can make the most appropriate decisions on buying and selling shares based on the results of forecasting stock trends.

LITERATURE REVIEWS

Research on stock forecasting using the ARIMA method includes, among others, Dona Ayu Rezaldi and Sugiman in 2021 conducting research on forecasting to predict the stock price of PT. Telekomunikasi Indonesia with the ARIMA model (0,2,1) which produces forecasting data for the close price of PT. Telekomunikasi Indonesia for the period June 2020 to May 2021 with an MSE value of 3,070(Rezaldi & Sugiman, 2021). Wici Irawan in 2019 conducted research on forecasting to predict the share price of PT. Univeler, Tbk with the ARIMA model (1,1,1) which produces a graph comparing forecast data and actual data(Irawan, 2019). Arni Astuti Kurniasi, et al in 2021 conducted research on forecasting to predict the LQ45 stock price using the ARIMA model (3,1,2) which produces a graph comparing forecast data and actual data(Kurniasi et al., 2021). Wilda Yulia Rusyida and Versiandika Yudha Pratama in 2020 conducted research on forecasting to predict the share price of PT. Garuda Indonesia, Tbk with the ARIMA model (1,1,1) which produces daily stock forecasting data for PT. Garuda Indonesia, Tbk for the period April 21 to July 13 2020 with an RMSE value of 38.03(Rusyida & Pratama, 2020). Riana Susanti and Askardiya Radmoyo Adji in 2020 conducted research on forecasting to predict the JCI stock price using the ARIMA model (7,3,1) which produced a graph comparing forecasting data and actual data with an RMSE value of 30.33293. In general, the study concluded that the ARIMA method is suitable and can be used for forecasting time series stock data.

METHODS

In this study, the analysis process uses the ARIMA method and is assisted by RStudio software. The following are the steps for implementing the ARIMA method.

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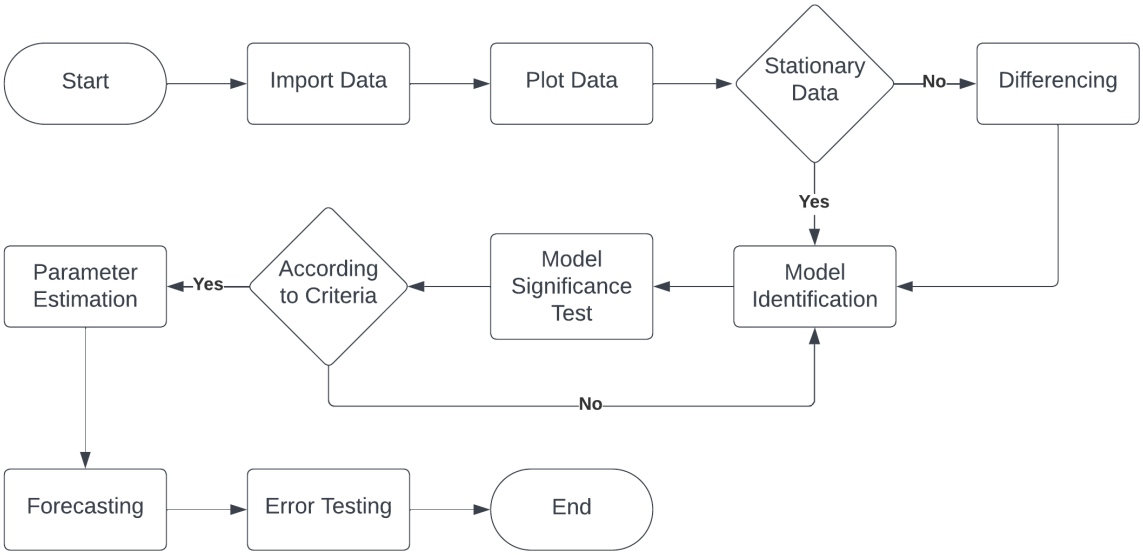

Fig.1 ARIMA Procedure Flowchart

In this study, the ARIMA method was carried out through several stages, including the following:

Imported Data

The initial stage in conducting data analysis in RStudio is to import data. Import data in RStudio can be done by utilizing the "import dataset" tool that has been provided in the RStudio software.

Plot Data

In the early stages of plotting the data, the first step is plotting the closing price data for the BBCA, BBRI, and BMRI shares. In RStudio, plotting data can be done using the plot() command. The resulting plot results must be observed to determine whether the data is stationary or not.

To ensure the stationarity of the data, this can be done by carrying out the Augmented Dickey Fuller (ADF) test, or in RStudio it can be run by typing the adf.test() command.

ADF test stationary test hypothesis in RStudio, namely:

H0 = data is not stationary

H1 = stationary data

Test criteria:

p-values< α = 0.05 = reject H0 and accept H1

p-values> α=0.05 = reject H1 and accept H0

The data is said to be stationary if the p-value is less than the value α=5% or α=0.05. If the data exceeds the value of α, then the data is not stationary.

After the data becomes stationary, the next step is to plot the stationary data into ACF (Autocorrelation Function) and PACF (Partial Autocorrelation Function) plots to see the pattern formed. If the pattern that is formed is in accordance with the rules for determining the ARIMA order, then it can proceed to the next stage. However, if the ACF and PACF patterns that are formed are not in accordance with the rules for determining the ARIMA order, it is necessary to process the differencing data until the patterns match.

Initial Identification

The identification stage is carried out in order to obtain an initial estimate of the ARIMA order. The initial ARIMA model can be determined by looking at the ACF plots and PACF plots that are formed.

Model Significance Test

After interpreting the parameters, the next step is to test the significance of the model to ensure that the ARIMA order is normally distributed and is white noise.

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This stage is divided into two tests:

a) Model significance test
Testing the significance of parameters by conducting a partial test (t-test). In R, the command used to perform this t-test is coeftest().
Coeftest hypothesis in RStudio, namely:
p-values≤ α=0.05 = significant coefficient
p-values> α=0.05 = insignificant coefficient
The parameter value in this coeftest can be seen from the significant code to the right of the parameter.

b) Model fit test
There are two model suitability tests that must be carried out, the first test is carried out with the residual white noise assumption test. Then, the second test is the normal distribution residual test.
The Ljung-Box test hypothesis in RStudio, namely:
p-values> α=0.05 = white noise
p-values< α=0.05 = no white noise
The Shapiro-Wilk normality test hypothesis in RStudio, namely:
p-values> α=0.01 = normally distributed
p-values< α=0.01 = not normally distributed

Parameter Estimation

An important process in ARIMA modeling is parameter estimation. This stage aims to determine the best order to be used in forecasting. In RStudio, the command "arima(x, order=c(p, d, q), method = 'ML')" is used to estimate these parameters. Where "x" is the time series data to be modeled, "order = c(p, d, q)" is the initial guess for the ARIMA order, and "method = 'ML'" is the estimation method used. At this stage, the important thing that must be considered is the AIC (Akaike Information Criterion) value, following the findings of Lily Zuhrat, et al in 2019, that the best regression model is the model that has the smallest AIC and BIC (Bayesian Information Criterion) values(Zuhrat et al., 2019).

Forecasting

The forecasting stage can be carried out if all the parameters of the ARIMA model are significant and all residual assumptions have been met. To perform forecasting in RStudio, use the command forecast(model, h).

Error Testing

At this accuracy testing stage, the error value will be checked in the forecasting results of each model used in forecasting. The error checking method used in this study is the MAPE method.

MAPE formula:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n} \left| \frac{A_i - F_i}{A_i} \right| x\ 100\% \quad (1)$$

In RStudio, use the command mape = mean (abs (actual data - (forecasting data))/(actual data))*100 or you can also use the accuracy(modelarima) command. To find out the level of forecasting accuracy in RStudio, the 100-mape command is added(Apriliani et al., 2020).

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RESULTS

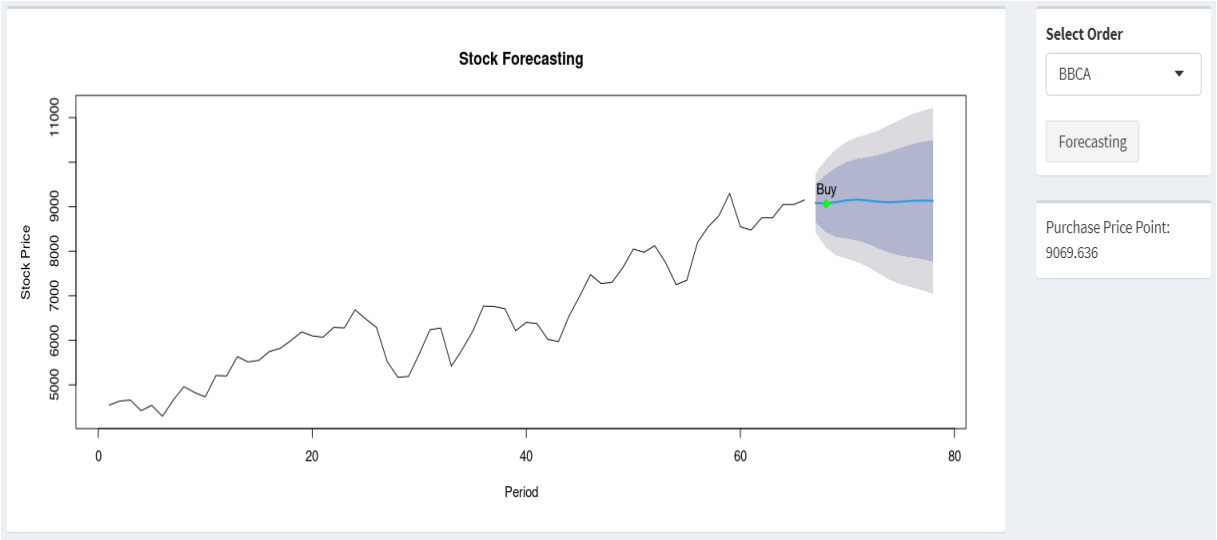

Fig. 2 BBCA Stock Forecasting

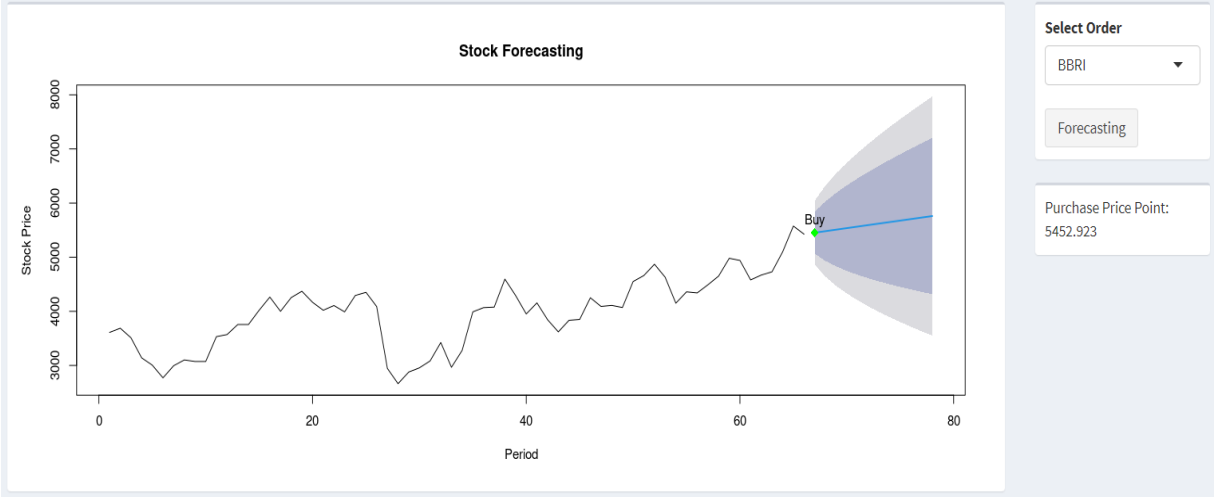

Fig. 3 BBRI Stock Forecasting

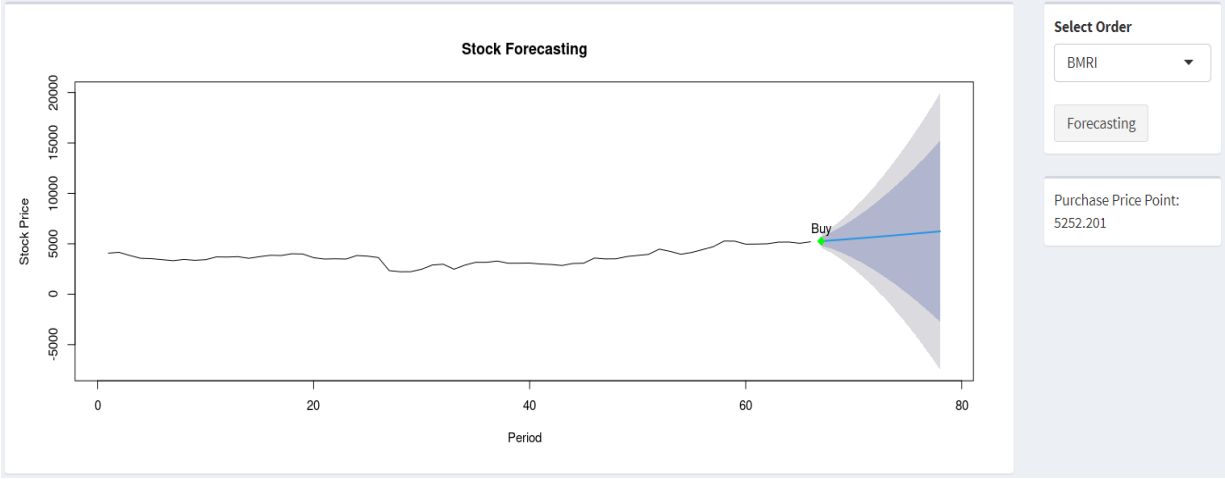

Fig. 4 BMRI Stock Forecasting

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DISCUSSIONS

Research Stage

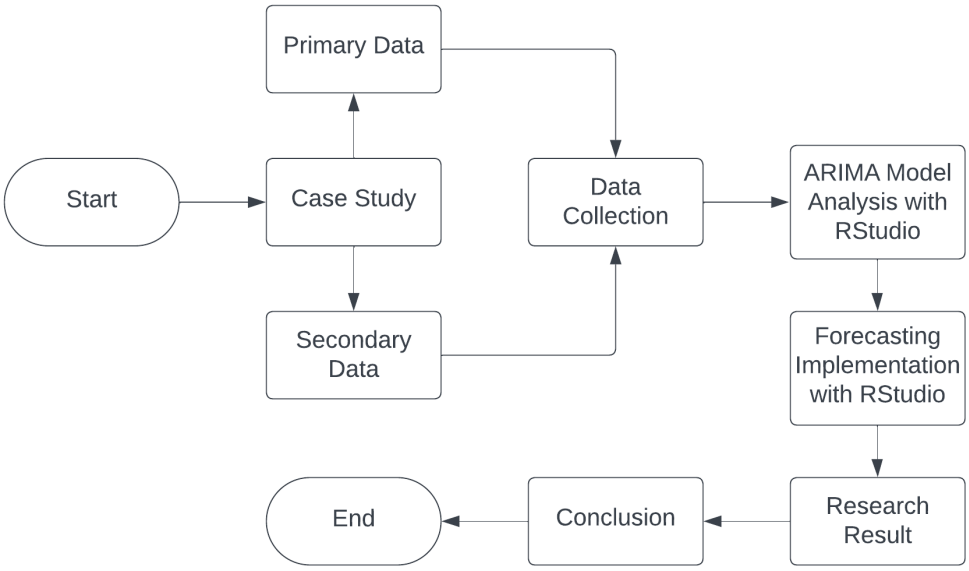

Fig. 5 ARIMA Procedure Flowchart

The stages of research are a series of initial processes in a research. This research starts from the initial study, namely understanding the problems that exist in the research. Next, look for historical data on BBCA, BBRI, and BMRI stocks on the investing.com site(Investing.com, 2022)and data on BBCA, BBRI, and BMRI stocks are obtained monthly from 2018 to 2023. After the data is collected, then an analysis of ARIMA modeling is carried out according to the BBCA, BBRI, and BMRI stock dataset using RStudio software. After obtaining the ARIMA model that is in accordance with the BBCA, BBRI, and BMRI stock datasets, forecasting is then carried out using the RStudio software to produce research output, namely in the form of forecasting values and graphs for several future periods. The final stage in this research is to draw conclusions from the research that has been done.

Research Data Sources

This study uses the main data that researchers get from the investing.com site(Investing.com, 2022)in the form of time series data in the form of historical data on BBCA, BBRI, and BMRI stocks from January 2018 to June 2023.

Table 1 Sample Stock Data

date	**BBCA**	**BBRI**	**BMRI**
	Closing Price	***Closing Price***	***Closing Price***
01/01/2018	4,545	3,610	8,150
01/02/2018	4,635	3,688	8,300
01/03/2018	4,660	3,512	7,675
01/04/2018	4,420	3.141	7.125
01/05/2018	4,540	3,005	7,050
01/06/2018	4,295	2,771	6,850
01/07/2018	4,655	2,995	6,650
01/08/2018	4,960	3.102	6,900
01/09/2018	4,830	3,073	6,725
…	…	…	…
01/06/2023	9.150	5,425	5,200

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Calculation of Differentencing

The differencing process serves to stationary the data. In RStudio, the differencing process can be done by typing the diff() command. The following is the differencing formula(Elsaraiti et al., 2021):

$$Y_t' = Y_t - Y_{t-1} \quad (1)$$

Where:

Y_t'= value of differencing data at time t

Y_t= data at time t

Y_{t-1}= data at time t-1 (before t)

Table 2 Sample Differencing Calculations 1 BBCA

Y_t	Y_{t-1}	Y_t'
4,545		
4,635	4,545	90
4,660	4,635	25
4,420	4,660	-240
4,540	4,420	120
4,295	4,540	-245
4,655	4,295	360
4,960	4,655	305
…	…	…
	9.150	

ACF and PACF

After the data is stationary, the next step that can be done is to plot the Autocorelation Function (ACF) and Partial Autocorelation Function (PACF) to identify the initial patterns that are formed.

Table 3 ARIMA Order Determination

Process	Autocorrelation Function(ACF)	Partial Autocorrelation Function (PACF)
AR(p)	Follows a sine wave pattern (dies down)	Cuts off instantly to zero after lag p (cuts off after lag)
MA(q)	Cuts off instantly to zero after lag p (cuts off after lag)	Follows a sine wave pattern (dies down)
ARMA(p,q)	Follows a sine wave pattern (dies down)	Follows a sine wave pattern (dies down)

Differentencing Results

Table 4 Differentencing Results

Information	BBCA	BBRI	BMRI
*Differentencing*1	stationary	stationary	stationary
Differentencing pattern 1	identified	not identified	not identified
*Differentencing*2	-	stationary	stationary
Differentencing pattern 2	-	identified	not identified
*Differentencing*3	-	-	stationary
Differentencing patterns 3	-	-	identified
d	d=1	d=2	d=3

Based on the differencing results in table 4, BBCA shares can be identified only through the first differencing process (D=1), BBRI shares can be identified through the second differencing process (D=2), and BMRI shares can be identified through the third differencing process (D=3).

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Pattern Identification Results

Table 5 Pattern Identification Results

Information	BBCA	BBRI	BMRI
ACF	*die down*	*cut after lag p*	*cut after lag p / dies down*
PACF	*die down*	*die down*	*die down*
Process ARIMA	ARMA (p, q)	MA (q)	MA (q) / ARMA (p, q)

Based on the results of pattern identification in table 5, BBCA shares are identified with the order of ARMA (p,q), BBRI shares are identified with the order of MA (q), and BMRI shares are identified with the order of MA (q) or ARMA (p,q).

ARIMA Order Identification Results

Table 1 ARIMA Order Identification Results

Model	BBCA	BBRI	BMRI
ARIMA 1	(2, 1, 2)	(0, 2, 1)	(0, 3, 1)
ARIMA 2	(1, 1, 2)	(0, 2, 2)	(0, 3, 2)
ARIMA 3	(2, 1, 1)	-	(1, 3, 1)
ARIMA 4	-	-	(1, 3, 2)

Based on the identification results of the ARIMA order in table 6, BBCA shares with order ARMA (p,q) have three identifiable order values, namely ARIMA 1 (2,1,2), ARIMA 2 (1,1,2), and ARIMA 3 (2,1,1). In BBRI shares with order MA (q) there are two order values that can be identified, namely ARIMA 1 (0,2,1), and ARIMA 2 (0, 2, 2). Meanwhile, in BMRI shares with order MA (q) or ARMA (p,q) there are four orders that can be identified, namely ARIMA 1 (0,3,1), ARIMA 2 (0,3,2), ARIMA 3 (1,3,1), and ARIMA 4 (1,3,2).

Model Significance Test Results

Testing the significance of parameters by conducting a partial test (t-test). In RStudio, the command used to perform this t-test is coeftest().

Coeftest hypothesis in RStudio, namely:

p-values$\leq \alpha$=0.05 = significant coefficient

p-values$> \alpha$=0.05 = insignificant coefficient

The parameter value in this coeftest can be seen from the significant code to the right of the parameter.

Table 2 Significance Test Results

Model	BBCA	BBRI	BMRI
ARIMA 1	all significant parameters	all significant parameters	all significant parameters
ARIMA 2	the parameter ma2 is not significant	the parameter ma2 is not significant	all significant parameters
ARIMA 3	all significant parameters	-	all significant parameters
ARIMA 4	-	-	parameter ar1 is not significant

Based on the results of the significance test in table 7, there are two models on BBCA stock that meet the significance test hypothesis, namely the ARIMA 1 and ARIMA 2 models. For BBRI shares, there is one model that meets the significance test hypothesis, namely the ARIMA 1 model. Meanwhile, on BMRI shares, there are three models that meet the significance test hypothesis, namely the ARIMA 1, ARIMA 2, and ARIMA 3 models.

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Ljung-box test results

The ljung-box test function is to find outassumption of residual white noiseon the ARIMA model of each stock.

The Ljung-Box test hypothesis in RStudio, namely:

p-values> α=0.05 = white noise

p-values< α=0.05 = no white noise

Table 3 Ljung-box test results

hypothesis	BBCA	BBRI	BMRI
p-values> α=0.05	ARIMA 1, ARIMA 2	ARIMA 1	ARIMA 2, ARIMA 3
p-values<α=0.05	-	-	ARIMA 1

Based on the results of the ljung-box test in table 8, it can be seen that the ARIMA 1 and ARIMA 2 models for BBCA shares are white noise. For BBRI stocks, the ARIMA 1 model is also white noise. Meanwhile, for BMRI stocks, only the ARIMA 2 and ARIMA 3 models are white noise.

Results*Shapiro-Wilk Normality Test*

The Shapiro-Wilk normality test functions to ensure that the ARIMA order of each stock is normally distributed.

Shapiro-wilk normality test hypothesis in RStudio, namely:

p-values> α=0.01 = normally distributed

p-values< α=0.01 = not normally distributed

Table 4 Shapiro-Wilk Normality Test Results

hypothesis	BBCA	BBRI	BMRI
p-values> α=0.01	ARIMA 1, ARIMA 2	ARIMA 1	ARIMA 3
p-values<α=0.01	-	-	ARIMA 2

Based on the results*shapiro-wilk normality test*In table 9, it can be seen that the ARIMA 1 and ARIMA 2 models for BBCA shares are normally distributed. For BBRI shares, the ARIMA 1 model is also normally distributed. Meanwhile, for BMRI shares, only the ARIMA 3 model is normally distributed.

Parameter Assessment Results

Parameter estimation is an important step in the ARIMA procedureserves to determine the best order to be used in forecasting. At this stage, an important point to pay attention to is the AIC value, according to(Zuhrat et al., 2019)the best regression model is the model that has the smallest AIC and BIC values.

Table 5 Parameter Assessment Results

Stock	Model	AIC
BBCA	ARIMA 1	917.85
BBRI	ARIMA 1	889,22
BMRI	ARIMA 3	978,24

Based on the parameter estimation in table 10, one best model can be obtained from each stock that will be used in the forecasting process, namely the ARIMA 1 BBCA share model, the ARIMA 1 model BBRI shares, and the ARIMA model 3 BMRI shares.

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Forecasting Results

Based on the modeling analysis described above starting from the data import stage to the parameter assessment stage, it can be concluded that for BBCA shares, the ARIMA model that is suitable for use is the ARIMA model (2, 1, 2). For BBRI shares, the ARIMA model used is ARIMA (0, 2, 1). Meanwhile, for BMRI shares, the model used is ARIMA (1, 3, 1). To perform forecasting in RStudio, use the command forecast(model, h).

Forecasting results for BBCA, BBRI and BMRI stocks can be seen in Figure 2, Figure 3 and Figure 4. The forecasting results also display the ideal price point for purchasing shares based on the value of the stock forecast for the next 12 periods.

Error Testing

At this error testing stage, the error value will be checked in the forecasting results of each model used in forecasting. The error checking method used in this study is the MAPE method. In RStudio, MAPE can be checked using the summary() or accuracy() commands.

Table 11 MAPE Error Testing Results

Stock	Model	MAPE
BBCA	ARIMA(2,1,2)	4.124813
BBRI	ARIMA(0,2,1)	5.787964
BMRI	ARIMA(1,3,1)	7.479325

Based on the results of the MAPE error testing in table 11, it can be seen that the results of the forecasting model error testing of each stock are included in a very good level of accuracy because the error rate is below 10%.

CONCLUSION

Based on the results of forecasting the closing price of BBCA, BBRI, and BMRI shares using the ARIMA model, the following conclusions can be drawn: A) All ARIMA models used in forecasting are significant and meet the residual assumptions, namely ARIMA 1 BBCA share, ARIMA 1 BBRI share, and ARIMA 3 BMRI shares. B) Forecasting produces graphs of actual data and forecasting data for the next 12 periods with the ideal stock purchase price point based on forecasting results. C) The applied ARIMA method has a very good level of accuracy because the MAPE value obtained from each stock is below 10%. D) The results of the closing stock price forecasting can be used as a consideration for making transactions on the stock buying and selling platform. However,

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