Forecasting of Bitcoin Cryptocurrency Price using the Autoregressive Integrated Moving Average (ARIMA) Method

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Abstract. Bitcoin is a type of cryptocurrency that has the largest market capitalization as a digital investment tool. Bitcoin prices often fluctuate, making it necessary to forecast in order to help investors in predicting the profit of their digital investment. One of the methods that can be used for predicting the price of Bitcoin based on the daily preices is Autoregressive Integrated Moving Average (ARIMA). The aim of this research is to create the best ARIMA model and predict the current price of Bitcoin. The data used in this research is secondary data obtained from websites supervised by the Commodity Futures Trading Supervisory Agency starting from January 1, 2023 to September 30, 2023. The research results show that the ARIMA model (0,2,1) provides a MAPE value of 3.17%, which means the ARIMA model's forecasting ability is very good.

Keywords: ARIMA, Bitcoin, Cryptocurrency, Forecasting.

1 Introduction

Technological developments have an impact on various types of investment [1**]**. One type of investment that is changing is from traditional money to digital money or digital investment [2**]**. One type of digital money investment is cryptocurrency [3**]**. Cryptocurrency technology is one of the financial technologies that is developing to overcome technological developments, transaction methods without physical interaction, have advantages in transactions [4**]**. Cryptocurrency is a digital investment tool that can be used by investors in facing technological developments.

Investors need to know the prices of digital investment tools used in investing, including cryptocurrency prices. Cryptocurrency prices depend on supply and demand in the market, and do not depend on real world currency exchange rates, where there are levels of fluctuation at various times that will determine the level of return on investment in this cryptocurrency in the future [5**]**.

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The price of Bitcoin often fluctuates so that Bitcoin investors need to pay attention to the time period when the price of Bitcoin rises and falls in order to make a profit [6]. Bitcoin price has the largest market capitalization as a digital investment tool [7]. Bitcoin price fluctuations result in the need for price forecasting. This is useful for getting forecast prices for the coming period. Forecast prices can be utilized by inside investors predict the profits of its digital investments.

Statistically, one method for predicting Bitcoin price fluctuations is the autoregressive integrated moving average (ARIMA) method [8]. The advantages of ARIMA are that it is flexible, has a fairly high level of forecasting accuracy, is suitable for forecasting a number of variables quickly, simply, accurately and cheaply because it only requires historical data to make the forecast [9].

Previous research conducted discussed Bitcoin price forecasting using data from December 3, 2019 to June 11, 2021 [10]. Previous research conducted discusses Bitcoin daily price forecasting using data from the date January 10, 2018 to March 10, 2018 [11]. Apart from that, research regarding Bitcoin daily price forecasting was also carried out using data from September 1, 2017 to April 30, 2021 [6]. Meanwhile, this research uses daily price data for the latest Bitcoin cryptocurrency. The data used in this research is greater than the data in previous research. This research aims to obtain an ARIMA model. This ARIMA model can be used to predict Bitcoin prices for the next period. It is hoped that the ARIMA model can be used by Bitcoin investors in predicting profits from their digital investments.

2 Methodology

The source of daily Bitcoin price data is obtained from websites supervised by the Commodity Futures Trading Supervisory Agency. The data analyzed in this research is the daily price of Bitcoin from January to September 2023. There are 273 daily Bitcoin price data for that period. The data is divided into two, namely training data and testing data. The amount of training data is 243 data and testing data is 30 data. The forecasting method used is autoregressive integrated moving average (ARIMA). The statistical software used as a tool is Minitab 16. The analysis steps for this research are data description, checking data stationarity, estimating parameters (p, d, q), residual diagnosis, applying model ARIMA (p, d, q) to testing data, and forecasting.
The following are the steps for data analysis:

1. Data Plot Description

   Plot description data is carried out to determine the descriptive nature of the research data, apart from that, it is also used to determine the pattern of the research data [12].

2. Checking Data Stationarity

   Checking Data Stationarity consists of two steps, namely variance and average [13]. Box-Cox transformation is used to check the stationarity of the data against the variance and the ACF plot is used to check the stationarity of the data against the mean [14]. Data that is not stationary regarding the variance is overcome by carrying out transformations, while data that is not stationary about the average is overcome by carrying out a differencing process. [15].

3. Parameter Estimation

   Parameter estimation was carried out using Minitab software. Hypothesis testing is used to determine the significance of a parameter, namely by dividing the coefficient and the SE coefficient [16].

4. Residual Diagnosis

   After estimating and obtaining parameter estimates, so that the temporary model can be used for forecasting, it is necessary to carry out a feasibility test on the model. This stage is called residual diagnosis, where at this stage it is tested whether the model specifications are correct or not [7].

5. Applying Model ARIMA (p, d, q) to testing data

   The ARIMA (p, d, q) model that has been obtained is then applied to the testing data. Next, a comparison is made between the actual Bitcoin price and the predicted Bitcoin price to calculate the MAPE value. The MAPE value is used to determine the accuracy of forecasting results [18].

6. Forecasting

   Forecasting Bitcoin prices for the future based on past or previous data.

3. Findings

3.1 Data Plot Description

The data plot was created to present the trend of daily Bitcoin price data for 243 days. The plot of daily data for 243 days, from January to August 2023, is presented in Figure 1.

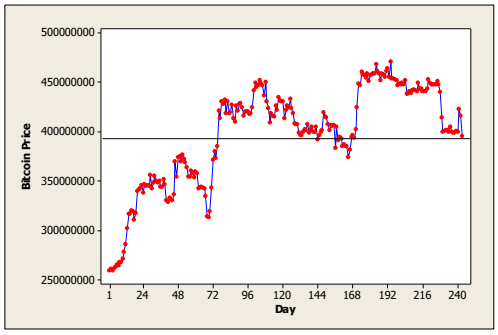

Fig. 1. Time Series Plot of Bitcoin Price

Figure 1 shows that the daily price of Bitcoin for 243 days experienced unstable increases and decreases relative to the average price. Therefore, Figure 1 shows that Bitcoin's daily price data is not stationary on average. This can be seen from the form of an upward and downward graphic trend. Meanwhile, data is said to be stationary if the trend is flat and is around the average axis [19].

3.2 Checking Data Stationarity with Box-Cox Plot

In forecasting, time series data must meet stationarity requirements [20]

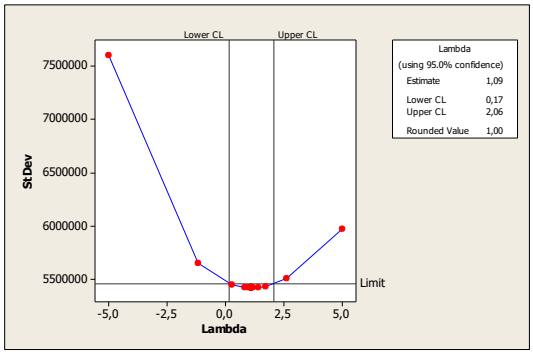

Fig. 2. Box-Cox Plot of Bitcoin Price

Figure 2 shows the stationarity of the data regarding variance. It can be seen that the Rounded Value shows a value of 1.00. Data that has a Rounded Value of 1.00 is stationary regarding variance [21]. Data that is stationary regarding variation does not need to undergo a transformation process. Next, a stationarity check will be carried out on the average.

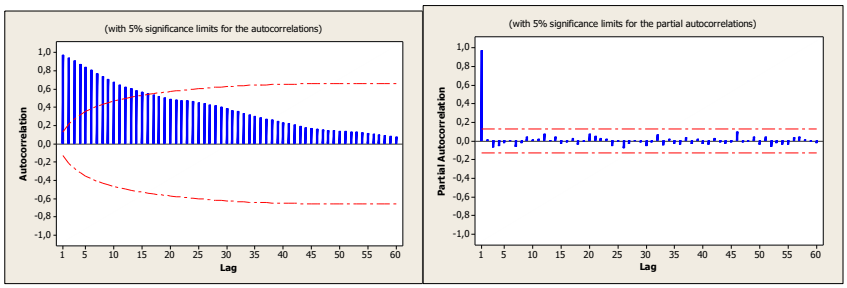

Fig. 3. Autocorrelation Function and Partial Autocorrelation Function of Bitcoin Price

Figure 3 shows the sequence of lags 1 to 16 that fall outside the significance limit. Thus there are more than the first 3 lags that are outside the significance limit. Figure 3 shows that the first lag of the PACF plot is very much higher than the subsequent lags. The ACF and PACF plot indicates that the daily Bitcoin price data is not stationary with respect to the average [20]. Bitcoin price data is not stationary with respect to the average so a differencing process needs to be carried out [22].

The differencing process uses Equation (1)

$$W_t = Z_t - Z_{t-1} \quad (1)$$

with :

W_t : value of the variable time t after differencing

Z_t : value of variable Z at time t

Z_{t-1} : value of variable Z at time t-1

Figure 4 presents a plot of data from the first differencing results.

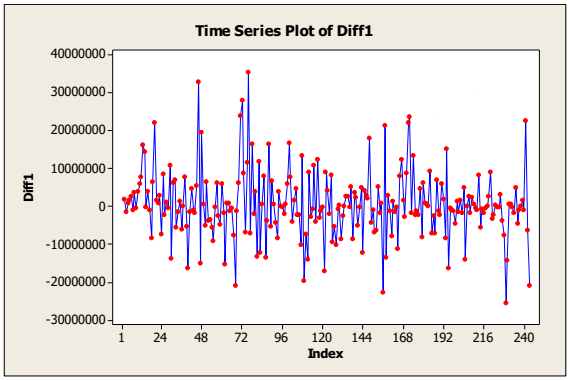

Fig. 4. The First Differencing of Bitcoin Price

Figure 4 shows that the data is stationary with respect to the average in the first order differentiation.

3.3 Parameter Estimation

The next step is to estimate parameters to determine the order (*p*, *d*, *q*) of the ARIMA model. To estimate the ARIMA model can be seen from the Autocorrelation Function (ACF) plot and the Partial Autocorrelation Function (PACF) plot [23].

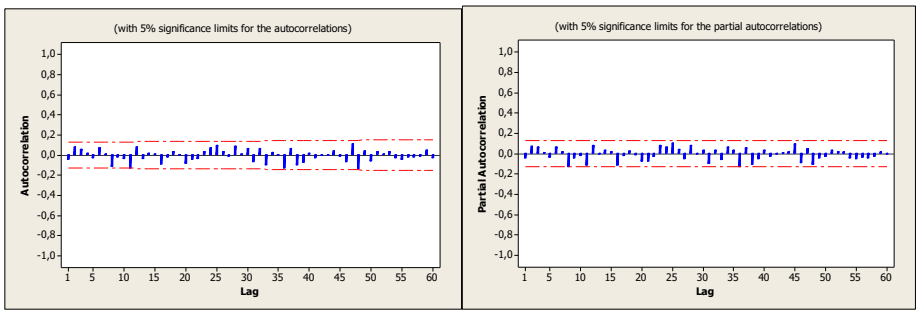

Fig. 5. Autocorrelation Function and Partial Autocorrelation Function for Diff1

Figure 5 shows that not a single lag of the Autocorrelation Function (ACF) value is at the significance limit. Figure 5 shows that there are no lags that exceed the significance limit in Partial Autocorrelation Function (PACF). This shows that there is no process Autoregressive(AR) or Moving Averages (MA) on the data obtained from the results of the first differentiation (24). Therefore, it is necessary to carry out a second differentiation process to estimate the parameters of Autoregressive (AR) or Moving Averages (MA).

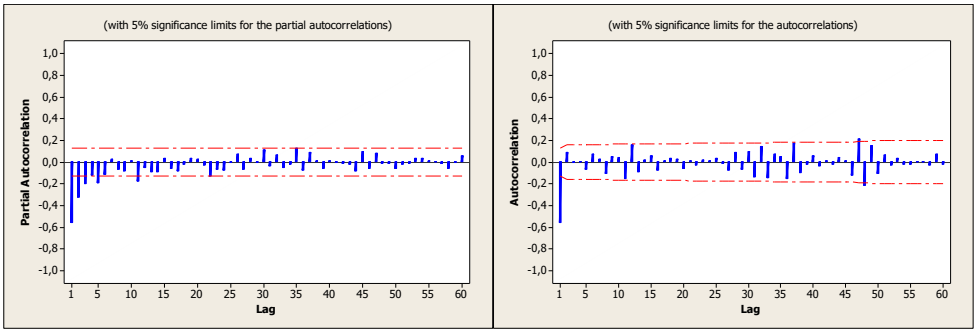

Fig. 6. Partial Autocorrelation Function and Autocorrelation Function for Diff2

Figure 6 shows that PACF graph is cut off after lag 3 (meaning the AR order estimates are at values 0, 1, 2, 3), while the ACF is cut off after lag 1 (meaning the MA order estimates are at values 0 and 1) and so the estimated temporary model is ARIMA (0, 2, 1), ARIMA (1, 2, 0), ARIMA (1, 2, 1), ARIMA (2, 2, 0), ARIMA (2, 2, 1), and ARIMA (3, 2, 0).

Next, parameter estimation is carried out by trial. The following output results were obtained:

a. ARIMA (0, 2, 1)

Table 1. Parameter estimation output of ARIMA (0, 2, 1)

Final Estimates of Parameters				
Type	Coef	SE Coef	T	P
MA 1	0.9872	0.0000	28340.85	0.000

Based on the Table 1, the p-value obtained is 0.000 < 0.05. Therefore, it can be concluded that these parameters are significant.

b. ARIMA (1, 2, 0)

Table 2. Parameter estimation output of ARIMA (1, 2, 0)

Final Estimates of Parameters				
Type	Coef	SE Coef	T	P
AR 1	-0.5602	0.0537	-10.44	0.000

Based on the Table 2, the p-value obtained is 0.000 < 0.05. Therefore, it can be concluded that these parameters are significant.

c. ARIMA (1, 2, 1)

Table 3. Parameter estimation output of ARIMA (1, 2, 1)

Final Estimates of Parameters				
Type	Coef	SE Coef	T	P
AR 1	-0.0503	0.0654	-0.77	0.443
MA 1	0.9885	0.0000	48893.94	0.000

Based on the Table 3, the p-value > 0.05 is obtained. Therefore, it can be concluded that this parameter is not significant.

d. ARIMA (2, 2, 0)

Table 4. Parameter estimation output of ARIMA (2, 2, 0)

Final Estimates of Parameters				
Type	Coef	SE Coef	T	P
AR 1	-0.7637	0.0618	-12.36	0.000
AR 2	-0.3565	0.0625	-5.71	0.000

Based on the Table 4, the p-value obtained is 0.000 < 0.05. Therefore, it can be concluded that these parameters are significant.

e. ARIMA (2, 2, 1)

Table 5. Parameter estimation output of ARIMA (2, 2, 1)

Final Estimates of Parameters				
Type	Coef	SE Coef	T	P
AR 1	-0.0498	0.0655	-0.76	0.448
AR 2	0.0692	0.0655	1.06	0.292
MA 1	0.9875	0.0001	7793.54	0.000

Based on the Table 5, the p-value > 0.05 is obtained. Therefore, it can be concluded that this parameter is not significant.

f. ARIMA (3, 2, 0)

Table 6. Parameter estimation output of ARIMA (3, 2, 0)

Final Estimates of Parameters				
Type	Coef	SE Coef	T	P
AR 1	-0.8406	0.0643	-13.06	0.000
AR 2	-0.5291	0.0788	-6.72	0.000
AR 3	-0.2259	0.0651	-3.47	0.001

Based on the Table 6, the p-value obtained is 0.000 < 0.05. Therefore, it can be concluded that these parameters are significant.

In this test, there were four ARIMA models with all parameters being significant. The ARIMA models include ARIMA (0,2,1), ARIMA (1,2,0), ARIMA (2,2,0), and ARIMA (3,2,0).

3.4 Residual Diagnosis with White Noise Test

After testing the significance of the parameters, the next process is a diagnostic examination of the four models that have been obtained.

1. Model ARIMA (0, 2, 1)
The following output is obtained.

Table 7. White noise test output of ARIMA (0, 2, 1)

Modified Box-Pierce (Ljung-Box) Chi-Square statistic				
Lag	12	24	36	48
Chi-Square	15.0	22.6	39.3	56.9
DF	11	23	35	47
P-Value	0.182	0.482	0.283	0.152

From the Table 7, the p-value for each lag is > 0.05. This means that the residual is White Noise. Thus, the ARIMA model (0, 2, 1) can be used.

2. Model ARIMA (1, 2, 0)
The following output is obtained.

Table 8. White noise test output of ARIMA (1, 2, 0)

Modified Box-Pierce (Ljung-Box) Chi-Square statistic				
Lag	12	24	36	48
Chi-Square	49.5	59.6	73.5	94.5
DF	11	23	35	47
P-Value	0.000	0.000	0.000	0.000

From the Table 8, the p-value for each lag is <0.05. This means that the residual is not White Noise. Thus, the ARIMA (1,2,0) model cannot be used.

3. Model ARIMA (2, 2, 0)
The following output is obtained.

Table 9. White noise test output of ARIMA (2, 2, 0)

Modified Box-Pierce (Ljung-Box) Chi-Square statistic				
Lag	12	24	36	48
Chi-Square	28.0	42.4	54.3	68.8
DF	10	22	34	46
P-Value	0.002	0.006	0.015	0.016

From the Table 9, the p-value for each lag is <0.05. This means that the residual is not White Noise. Thus, the ARIMA (2, 2, 0) model cannot be used.

4. Model ARIMA (3, 2, 0)
The following output is obtained.

Table 10. White noise test output of ARIMA (3, 2, 0)

Modified Box-Pierce (Ljung-Box) Chi-Square statistic				
Lag	12	24	36	48
Chi-Square	26.9	40.8	54.1	70.3
DF	9	21	33	45
P-Value	0.001	0.006	0.012	0.009

From the Table 10, the p-value for each lag is <0.05. This means that the residual is not White Noise. Thus, the ARIMA (3, 2, 0) model cannot be used. From the Residual White Noise testing that was carried out on the four ARIMA models, the ARIMA Model (0, 2, 1) was produced which meets the characteristics of White Noise.

Because all model parameters are significant and the residual assumption is white noise. the ARIMA (0, 2, 1) model can be used for forecasting.

3.5 Application of the model to testing data

The equation for ARIMA (0, 2, 1) uses Equation (2) :

$$Z_t = \mu - 0.9872\ Z_{t-1} + a_t \quad \text{with} \quad (2)$$

Z_t : time-*t* forecast data
Z_{t-1} : time data to *t-1*
μ : constant value
a_t : time-t error

After obtaining the ARIMA model (0, 2, 1), the model was then applied to the testing data, namely the daily price of Bitcoin for September 2023. Following are the results of applying the model to the testing data. Next, it is compared with the actual data in the testing data, which is as follows.

Table 11. Actual and Forecast Bitcoin Price

Period	Actual Bitcoin Price	Forecast Bitcoin Price
244	394,677,458	395,181,418
245	396,219,219	394,984,002
246	398,803,169	394,786,586
247	393,901,746	394,589,170
248	394,079,840	394,391,754
249	394,773,786	394,194,338
250	402,960,181	393,996,922
251	398,090,720	393,799,506
252	398,006,347	393,602,090

253	397,084,231	393,404,674
254	385,869,401	393,207,258
255	396,647,837	393,009,842
256	403,165,907	392,812,426
257	407,391,848	392,615,010
258	408,578,564	392,417,594
259	408,211,328	392,220,178
260	408,021,919	392,022,762
261	411,484,834	391,825,346
262	418,577,976	391,627,930
263	419,432,859	391,430,514
264	408,706,525	391,233,098
265	408,884,468	391,035,682
266	409,085,862	390,838,266
267	403,988,996	390,640,850
268	405,359,463	390,443,434
269	406,176,289	390,246,018
270	409,443,306	390,048,602
271	420,806,080	389,851,186
272	416,253,382	389,653,770
273	418,043,221	389,456,354

It can be concluded that the comparison of Bitcoin price forecast data and actual data is not much different. Equation (3) is used to check the significance of the Arima model.

$$\text{MAPE} = \frac{\sum_{t=1}^{n}\left|\frac{x_t - f_t}{x_t}\right|}{n} x\ 100\% \quad (3)$$

with :

n : time period value
x_t : actual value in period t
f_t : forecasting value in period t

Table 12. Significance of MAPE values

MAPE	Significance
<10%	Forecasting ability is very good
10-20%	Good forecasting ability
20-50%	Forecasting ability is decent/adequate
>50%	Poor forecasting ability

The lower the MAPE value, it can be said that the forecasting model has good capabilities [25].

$$\text{MAPE} = \frac{\sum_{t=1}^{n}\left|\frac{x_t - f_t}{x_t}\right|}{n} \times 100\%$$

$$= \frac{\sum_{t=1}^{30}\left|\frac{x_1 - f_1}{x_1}\right| + \left|\frac{x_2 - f_2}{x_2}\right| + \cdots + \left|\frac{x_{30} - f_{30}}{x_{30}}\right|}{30} \times 100\%$$

$$= \frac{\left|\frac{394677458 - 395181418}{394677458}\right| + \left|\frac{396219219 - 394984002}{396219219}\right| + \cdots + \left|\frac{418043221 - 389456354}{418043221}\right|}{30} \times 100\%$$

$$= 3.17\ \%$$

The MAPE value obtained was 3.17%. This value is <10%, which means the forecasting ability of the ARIMA model is very good.

3.6 Forecasting

Forecasting is carried out to find out the price of Bitcoin for the next days using the model that has been obtained, namely ARIMA (0, 2, 1). The following forecast results were obtained.

Table 13. Forecast Bitcoin Price Next Period

Period	Forecast
274	389,258,939
275	389,061,523
276	388,864,107
277	388,666,691
278	388,469,275
279	388,271,859
280	388,074,443
281	387,877,027
282	387,679,611
283	387,482,195
284	387,284,779
285	387,087,363
286	386,889,947
287	386,692,531
288	386,495,115
289	386,297,699
290	386,100,283
291	385,902,867
292	385,705,451
293	385,508,035

294	385,310,619
295	385,113,203
296	384,915,787
297	384,718,371
298	384,520,955
299	384,323,539
300	384,126,123
301	383,928,707
302	383,731,291
303	383,533,875

Based on the output above, forecast results are obtained for the next days, namely from 1st October 2023 to 30th October 2023. The highest Bitcoin price is data on the 274th day was on 1st October 2023 is 389,258,939 and the lowest, namely data on the 303rd day was on 30th October 2023 is 383,533,875.

4. Conclusion

Based on research it can be concluded that:

1. The price of Bitcoin from 1st October 2023 to 30th October 2023 will experience a slow decline.
2. The price of bitcoin is decreasing, so it is recommended that investors sell shares at the beginning of the period when the price of bitcoin is still high
3. The MAPE value obtained was 3.17%, which means the forecasting ability of the ARIMA model is very good.
4. The weakness of the Arima model is that for forecasting data over long periods the accuracy is not good

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References

[1] Kamal, MF. and Apriani, R.: Pengaruh Perkembangan Teknologi di Era Digital Terhadap Investasi dan Pasar Modal. JUSTITIA J. Ilmu Huk. dan Humaniora, vol. 9, no. 1. pp. 488–496 (2022)

[2] Danuri, M.: Development and transformation of digital technology. Infokam, vol. XV, no. II. pp. 116–123 (2019)

[3] Saputra E.: Dampak Cryptocurrency Terhadap Perekonomian Indonesia. Semin. Nas. R., vol. 9986, no. 1. pp. 491 – 496 (2018)

[4] Khan, U., An ZY., and Imran, A.: A Blockchain Ethereum Technology-Enabled Digital Content: Development of Trading and Sharing Economy Data. IEEE Access, vol. 8, pp. 217045–217056 (2020)
[5] Luxmana, DB. and Oktafiyani, M.: Analisis Fundamental Cryptocurrency Terhadap Fluktuasi Harga Pada Masa Pandemi. Din. Akunt. Keuang. dan Perbank., vol. 11, no. 1. pp. 41–52 (2022)
[6] Pratama, I. G. Hendra, M., Sumarjaya, IW, Suciptawati, and Putu NL.: Peramalan Harga Bitcoin dengan Metode Smooth Transition Autoregressive (Star). E-Jurnal Mat., vol. 11, no. 2. pp. 100 (2022)
[7] Taskinsoy, J.: Bitcoin Could Be the First Cryptocurrency to Reach a Market Capitalization of One Trillion Dollars. SSRN Electron. J.. pp. 1–24 (2020)
[8] Cynthia, A., Sugiman, and Mastur, Z.: Analisis Perbandingan Menggunakan ARIMA dan Bootstrap Pada Peramalan Nilai Ekspor Indonesia. UNNSES J. Math., vol. 5, no. 1. pp. 32–38 (2016)
[9] Yuliyanti, R. and Arliani, E.: Peramalan Jumlah Penduduk Menggunakan Model ARIMA. Kaji. dan Terap. Mat., vol. 8, no. 2. pp. 114–128 (2022)
[10] Listiani, A. and Al Mahkya, D.: Peramalan Cryptocurrency dengan Autoregressive Integrated Moving Average (ARIMA) dan Risiko Kerugian dengan Value at Risk (VaR). J. Sci. Appl. Technol., vol. 6, no. 2. pp. 85 (2022)
[11] Tatsara, N., Amalia, R., and Zohra AF.: Peramalan Harga Bitcoin Menggunakan Metode ARIMA (Autoregressive Integrated Moving Average). J. Data Anal., vol. 1, no. 1. pp. 21–31 (2018)
[12] Nurman, S., Nusrang, M., and Sudarmin: Analysis of Rice Production Forecast in Maros District Using the Box-Jenkins Method with the ARIMA Model. ARRUS J. Math. Appl. Sci., vol. 2, no. 1. pp. 36–48 (2022)
[13] Hidayat, R., and Mustawinar BH.: Peramalan Jumlah Wisatawan Asing dengan Model Arima. Infinity: Jurnal Matematika dan Aplikasinya (IJMA) vol. 2, no. 2. pp. 104–115 (2022)
[14] Mauludiyanto, A., Hendrantoro, G.,. Purnomo, MH, and Suhartono, S.: Pemodelan Arima Dan Deteksi Outlier Data Curah Hujan Sebagai Evaluasi Sistem Radio Gelombang Milimeter. JUTI J. Ilm. Teknol. Inf., vol. 7, no. 3. pp. 107 (2009)
[15] Ismail, IM., and Sulistijanti, W.: Peramalan Jumlah Tamu Dan Pengunjung Dinner Hotel Mega Bintang Sweet Kabupaten Blora Dengan Pendekatan ARIMA. Pros. Semin. Nas. Edusaintek FMIPA UNIMUS, vol. 1, no. 1. pp. 64–70 (2018)
[16] Sismi and Darsyah MY.: Perbandingan Prediksi Harga Saham PT.BRI, Tbk dengan Metode Arima dan Moving Average. Pros. Semin. Nas. Mhs. Unimus, vol. 1, no. 1. pp. 351–360 (2018)
[17] Zulhamidi and Hardianto, R.: Peramalan Penjualan Teh Hijau Dengan Metode Arima (Studi Kasus Pada PT. MK). J. PASTI, vol. XI, no. 3. pp. 231–244 (2017)
[18] Sungkawa, I., and Megasari, RT.: Penerapan Ukuran Ketepatan Nilai Ramalan Data Deret Waktu dalam Seleksi Model Peramalan Volume Penjualan PT Satriamandiri Citramulia. ComTech Comput. Math. Eng. Appl., vol. 2, no. 2. pp. 636 (2011)
[19] Rizal, J., and Syahrul A.: Perbandingan uji stasioner data time series antara metode: control chart, correlogram, akar unit Dickey Fuller, dan derajat integrasi. J. Gradien, vol. 11, no. 1. pp. 1040–1046 (2015)
[20] Martha, S.: Peramalan Data Time Series Menggunakan Metode Box-Jenkins. Statistika, (2010)
[21] Lubis, RMF., Situmorang, Z., and Rosnelly, R.: Autoregressive Integrated Moving Average (ARIMA-Box Jenkins) Pada Peramalan Komoditas Cabai Merah di Indonesia. J. Media Inform. Budidarma, vol. 5, no. 2. pp. 485 (2021)
[22] Wabomba, MS.: Modeling and Forecasting Kenyan GDP Using Autoregressive Integrated Moving Average (ARIMA) Models. Sci. J. Appl. Math. Stat., vol. 4, no. 2. pp. 64 (2016)

[23] Fauzi, A.: Peramalan Menggunakan Model Arima Pada Harga Saham Telkom Dan Lippo. pp. 80 (2015)
[24] Rezaldi DA., and Sugiman: Peramalan Metode ARIMA Data Saham PT . Telekomunikasi Indonesia. Prism. Pros. Semin. Nas. Mat., vol. 4. pp. 611–620 (2021)
[25] Hutasuhut, AH., Anggraeni, W., and Tyasnurita, R.: Pembuatan Aplikasi Pendukung Keputusan Untuk Peramalan Persediaan Bahan Baku Produksi Plastik Blowing dan Inject Menggunakan Metode ARIMA (Autoregressive Integrated Moving Average) di CV. Asia. J. Tek. POMITS, vol. 3, no. 2. pp. A-169 (2014)