Jurnal Informatika Ekonomi Bisnis

http://www.infeb.org

2022 Vol. 4 No. 1 Hal: 1-6 e-ISSN: 2714-8491

The Autoregressive Integrated Moving Average (ARIMA) Model for Predicting Jakarta Composite Index

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Abstract

The purpose of this study is to test the ability of the Autoregressive Integrated Moving Average (ARIMA) model to predict the value of the Jakarta Composite Index (JKSE) which fluctuates greatly due to the Covid-19 pandemic. The population in this study is JKSE daily closing price data for the period January 2020 to April 2021, so the sample in this study is 324 time series data. The results showed that the best ARIMA model for predicting the value of the Jakarta Composite Index was ARIMA (3,1,9). ARIMA (3,1,9) can predict the JKSE value very well because the value of the forecasting results is not much different from the actual value. This is also evidenced by the results of the accuracy test using MAPE which has a result of 1,729 which means the accuracy of forecasting is 98,27%.

Keywords: Autoregressive Integrated Moving Average (ARIMA), Index, Jakarta Composite, Forecasting, Covid-19.

Abstrak

Penelitian ini bertujuan untuk menguji kemampuan model *Autoregressive Integrated Moving Average* (ARIMA) dalam memprediksi nilai Indeks Harga Saham Gabungan (IHSG) yang sangat berfluktuasi akibat pandemi Covid-19. Populasi dalam penelitian ini yaitu data harga penutupan harian IHSG periode Januari 2020 sampai April 2021, sehingga sampel dalam penelitian ini sebanyak 324 data *time series*. Hasil penelitian menunjukkan bahwa model ARIMA terbaik untuk memprediksi nilai Indeks Harga Saham Gabungan yaitu ARIMA (3,1,9). ARIMA (3,1,9) dapat memprediksi nilai IHSG dengan sangat baik karena nilai hasil peramalan tidak jauh berbeda dengan nilai aktualnya. Hal ini juga dibuktikan dengan hasil uji akurasi menggunakan MAPE yang memiliki hasil sebesar 1,729 yang artinya akurasi dari peramalan sebesar 98,27%.

Kata kunci: Autoregressive Integrated Moving Average (ARIMA), Indeks, Harga Saham, Peramalan, Covid-19.

1. Introduction

At the end of 2019 the world was shocked by a variant of the virus that spread in China which was later known as the corona virus. Because the spread of the virus is getting faster by the day and has caused many deaths in China and other countries, the WHO announced that the current outbreak was a Global Pandemic on March 11, 2020 [1].

The Covid-19 pandemic has had a negative impact on the global economy. The International Monetary Fund (IMF) said that the global economy is in crisis and it is estimated that 95% of countries in the world will experience negative economic growth [2]. Based on BPS data, Indonesia's economic growth rate was only 2.97% in the first quarter of 2020, and in the second quarter of 2020 the Indonesian economic growth rate was -5.32% [3].

Indonesia's financial sector has also been affected by the coronavirus pandemic. The exchange rate fell to Rp. 16,500 / USD in March 2020. The coronavirus pandemic has also caused panic in the stock market, affecting the value of the Jakarta Composite Index (JKSE). The JKSE value was at the level of Rp. 6,200 in January 2020 and continued to weaken when the Covid-19 case was confirmed for the first time until it touched the figure of Rp. 3,937 on March 24, 2020 where this was the lowest level [4].

JKSE is the value used to measure the overall performance of all shares listed on the Indonesia Stock Exchange. The movement of the stock composite index of a country can be a tool to measure the economic condition of that country [5]. In general, the JKSE movement was influenced by several factors which were divided into internal factors and external factors. Internal factors include fluctuations in currency exchange rates, inflation and interest rates, economic growth, social, political and security conditions, government policies, unemployment rates, panic factors, and market manipulation [6] [7]. External factors include the value of global stock indexes (Dow Jones Index, Nikkei 225 Index, Shanghai Index, UK Index: FT100), world oil prices, and world gold prices [8]. Geographical factors between adjacent countries will affect stock exchanges in the area, such as the STI Index in Singapore, KLSE in Malaysia, Hang Seng in Hong Kong [6]. Because there are many factors that can affect the movement of the JKSE, prediction and analysis of the movement of the JKSE is a very important indicator for investors before making investment decisions. Investors can use the prediction results as a reference before investing

Diterima: 19-02-2022 | Revisi: 21-02-2022 | Diterbitkan: 31-03-2022 | doi: 10.37034/infeb.v4i1.114

[9]. Investment analysis that is usually done is fundamental analysis and technical analysis. In fundamental analysis it takes a lot of financial data of a company to be analyzed, while for technical analysis it takes only historical data from price and volume pattern charts. Price patterns represent past value movements which will then be used to predict future price movement patterns [10].

There are several technical analysis indicators that can be used as forecasting methods, but the most frequently used forecasting method is the ARIMA (Autoregressive Integrated Moving Average) method [11]. ARIMA is a forecasting method that uses the synthesis of historical data patterns to generate forecasts. The ARIMA model is a combination of the AR (Autoregressive) model, which is a model that describes the movement of variables through the variable itself in the past and the MA (Moving Average) model, which is a model that sees the movement of the variable through its residuals in the past [12].

Several studies have been carried out using the ARIMA method, including [5] which shows that the ARIMA (0.2,1) and GARCH (1,1) models are the right models for JKSE data and after comparing their prediction accuracy, the ARIMA model is able to predict JKSE movements more accurately. Research of [10] concluded that ARIMA (2,1,2) can be used to predict the capital market that will occur in the next period. Research of those who predict cryptocurrencies (bitcoin, XRP, and ethereum) conclude that the ARIMA model outperforms other models in terms of MAE, MSE, and RMSE in predicting the price of cryptocurrencies (Bitcoin, XRP, and Ethereum) in the short term [5] [10] [13].

Based on previous studies, it can be seen that the ARIMA method is the right method used for forecasting using time series data because it has a good level of accuracy. Therefore, this study aims to test the ability of the ARIMA model in predicting the value of the Jakarta Composite Index which fluctuates greatly due to the Covid-19 pandemic. This research is expected to help investors, especially short-term investors, in making investment decisions in the stock market, especially when market conditions are very difficult to predict due to the pandemic. The Jakarta Composite Index (JKSE**)** is a stock index that measures the performance of all shares listed on the IDX and reflects the movement and average value of all issuer shares in Indonesia [14].

2. Method

The population in this study is the JKSE daily closing price data for the period January 2020 to April 2021, so the population in this study amounted to 324 time series data.

The sampling technique used in this study is a non-probability sampling technique with a saturated sampling technique method. The JKSE daily closing price data from January 2020 to April 2021 is the research sample data, so the sample in this study is 324 time series data.

The data used in this study is quantitative data in the form of numbers and obtained from secondary data sources. The secondary data in this study is the JKSE daily data for the period January 2020 to April 2021 obtained from data published by the website www.finance.yahoo.com.

3. Results and Discussion

3.1. Research result

Model identification is done to see whether the data is stationary or not. The stationarity of the data was seen by using the graph method and the ADF test. The results of the JKSE stationarity test using the graphical method are as follows:

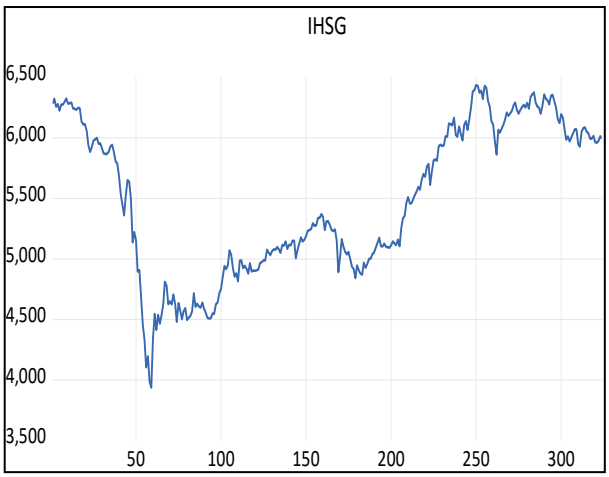

Figure 1. JKSE Stationary Test with Graph Method

Based on Figure 1, it can be seen that the plot of data obtained shows an up and down trend and does not focus on the middle value which indicates that the JKSE data is not stationary..

Based on the ADF test, the stationarity of the JKSE data can be seen as Table 1.

Table 1. ADF At Level Test

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.329761	0.6165
Test critical values:	1% level	-3.450411	
	5% level	-2.870274	
	10% level	-2.571493	

Based on table 1, it is known that the ADF t-statistic value is (-1.329761) > the critical value of 5% (-2.870274). The value of prob* (0.6165) > 0.05 so that the data is not stationary at the level. Because the data is not stationary at the level, it must be continued with a test for unit root in 1st difference which can be seen in the following Table 2.

Table 2. ADF 1st Difference . Test

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.841143	0.0000
Test critical values:	1% level	-3.450617	
	5% level	-2.870359	
	10% level	-2.571538	

Based on table 2, it is known that the ADF t-statistic value is (-8.841143) < critical value 5% (-2.870359). The value of prob* (0.0000) <0.05 so it can be concluded that the data is stationary at the 1st difference level.

The next step to identify the ARIMA model (p,d,q) is to plot the Autocorrelation Function (ACF) and Partial Correlation Function (PACF). The results of the ACF and PACF plots can be seen in the following Figure 2.

Date: 10/22/21 Time: 15:45
Sample (adjusted): 2 324
Included observations: 323 after adjustments

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.070	0.070	1.6036	0.205
		2	-0.070	-0.076	3.2187	0.200
		3	0.160	0.172	11.614	0.009
		4	0.009	-0.025	11.639	0.020
		5	0.093	0.126	14.503	0.013
		6	0.035	-0.015	14.913	0.021
		7	0.001	0.024	14.913	0.037
		8	0.068	0.033	16.451	0.036
		9	-0.101	-0.116	19.839	0.019
		10	-0.023	-0.006	20.014	0.029
		11	0.016	-0.027	20.103	0.044
		12	-0.014	0.023	20.170	0.064
		13	-0.084	-0.102	22.581	0.047
		14	-0.058	-0.019	23.705	0.050
		15	0.103	0.107	27.332	0.026
		16	0.090	0.099	30.113	0.017
		17	0.003	0.037	30.116	0.026
		18	0.117	0.113	34.853	0.010
		19	-0.024	-0.062	35.048	0.014
		20	-0.044	-0.043	35.704	0.017
		21	0.068	0.012	37.294	0.016
		22	0.052	0.029	38.242	0.017
		23	0.038	0.002	38.741	0.021
		24	-0.035	-0.044	39.167	0.026
		25	-0.010	0.021	39.201	0.035
		26	0.070	0.039	40.945	0.031
		27	-0.021	-0.001	41.104	0.040
		28	-0.021	0.001	41.263	0.051
		29	0.043	0.051	41.931	0.057
		30	-0.004	-0.002	41.936	0.072
		31	-0.027	-0.020	42.197	0.087
		32	-0.024	-0.041	42.398	0.103
		33	0.015	-0.025	42.483	0.125
		34	0.094	0.080	45.710	0.087
		35	0.036	0.071	46.195	0.098
		36	0.066	0.090	47.796	0.090

Figure 2. ACF and PACF on Correlogram

Based on Figure 2, it can be seen that in the autocorrelation table representing the MA (q) model there are several lags that cross the Bartlett line including lags 3 and 9. namely lags 3, 5, and 9, so that the potential ARIMA models are obtained, namely ARIMA (3,1,3), ARIMA (3,1,9), and ARIMA (5,1,3).

Table 3. Parameter Estimation

ARIMA Model	Variables	Prob.	Description
ARIMA (3,1,3)	AR (3)	0,4422	Proper to use
	MA (3)	0,9180	Not worth using
ARIMA (3,1,9)	AR (3)	0,0000	Proper to use
	MA (9)	0,0286	Proper to use
ARIMA (5,1,3)	AR (5)	0,0310	Proper to use
	MA (3)	0,0000	Proper to use

Based on Table 3, it can be seen that the ARIMA model that is feasible to use is ARIMA (3,1,9) and ARIMA (5,1,3) because it has a prob* value of less than 0.05.

In choosing the best model, it is done by looking at the smallest value of Akaike's Information Criterion (AIC), Schwartz Criterion (SC), and Hannan-Quinn Criterion (HQC). The following table shows the values of AIC, SC and HQC in the following Table 4.

Table 4. Comparison table of AIC, SC and HQC values

ARIMA models (p,d,q)	AIC value	SC value	HQC value
ARIMA (3,1,9)	11,53735	11,58414	11,55603
ARIMA (5,1,3)	11,53911	11,58597	11,55786

Based on table 5, it can be seen that among the 2 ARIMA models obtained, the smallest AIC, SC and HQC values are in the ARIMA model (3,1,9).

The diagnostic checking process is the process of checking the assumption of residual white noise to find out whether the variance value is constant or not by using the Ljung-Box test statistic as Figure 3.

Date: 10/22/21 Time: 16:51
Sample (adjusted): 2 324
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.090	0.090	2.6389	
		2	-0.102	-0.111	6.0125	
		3	-0.005	0.016	6.0195	0.014
		4	-0.003	-0.016	6.0226	0.049
		5	0.093	0.098	8.9067	0.031
		6	0.035	0.014	9.3107	0.054
		7	0.005	0.021	9.3176	0.097
		8	0.064	0.067	10.696	0.098
		9	-0.010	-0.020	10.732	0.151
		10	-0.007	0.003	10.747	0.216
		11	0.001	-0.008	10.747	0.293
		12	-0.010	-0.011	10.783	0.375
		13	-0.096	-0.112	13.900	0.239
		14	-0.053	-0.037	14.840	0.250
		15	0.091	0.081	17.642	0.172
		16	0.114	0.091	22.073	0.077
		17	0.033	0.038	22.451	0.097
		18	0.094	0.135	25.482	0.062
		19	-0.052	-0.053	26.416	0.067
		20	-0.050	-0.029	27.278	0.074
		21	0.057	0.042	28.422	0.076
		22	0.049	0.025	29.261	0.083
		23	0.026	-0.012	29.505	0.102
		24	-0.037	-0.049	29.984	0.119
		25	0.003	0.022	29.988	0.150
		26	0.068	0.031	31.646	0.136
		27	-0.003	-0.012	31.648	0.168
		28	-0.019	0.014	31.783	0.200
		29	0.033	0.067	32.167	0.226
		30	0.007	0.002	32.184	0.267
		31	-0.037	-0.035	32.670	0.291
		32	-0.036	-0.042	33.132	0.317
		33	-0.000	-0.041	33.132	0.364
		34	0.093	0.067	36.261	0.277
		35	0.053	0.062	37.287	0.278
		36	0.058	0.079	38.536	0.272

Figure 3. ACF and PACF Ljung-Box Data Patterns

Based on Figure 3, it can be seen that the bar graphs on ACF and PACF do not cross the Bartlett line, so it can be concluded that the model meets the qualifications for forecasting. Furthermore, to see if the model contains white noise, it is done by looking at the AR Roots and MA Roots points and the obtained modulus value.

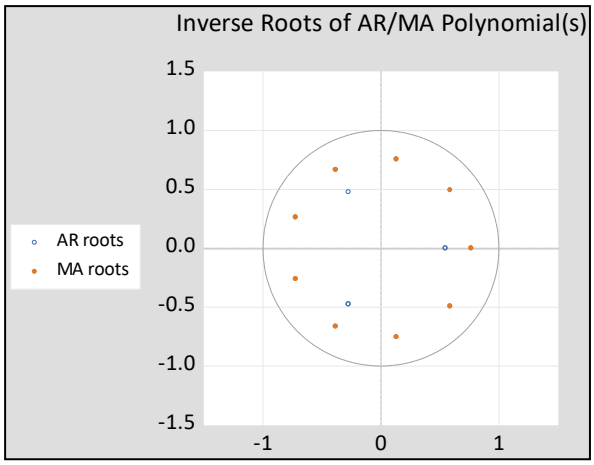

Figure 4. Point Polynomial AR/MA Roots

Based on Figure 4, it can be seen that the AR Roots and MA Roots points are all in a circle (unit circle), which means that the data does not have white noise.

Table 5. AR/MA Roots Modulus Values

Root(s)	Modulus
AR Root(s)	0,549089
MA Root(s)	0,767386

Based on Table 5, it can be seen that AR Roots and MA Roots have a modulus value < 1, meaning that the ARIMA (3,1,9) model is stationary and the model fits the data and meets the requirements of a good forecasting model..

Forecasting the JKSE value for the next 30 periods is presented in the following graph:

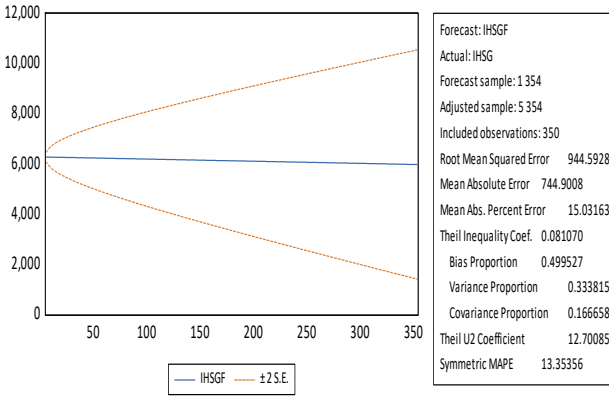

Figure 5. JKSE Forecasting Results with ARIMA Model (3,1,9)

Based on Figure 5, it can be seen that the results of forecasting the JKSE value using ARIMA (3,1,9) obtained the RMSE value of 944,5928, the MAE value of 744,9008 and the MAPE value of 15,03163. Of these three criteria, the chosen one is MAPE because it has the smallest criterion value. Henceforth, the actual value will be compared with the forecast value as shown in the following Figure 6.

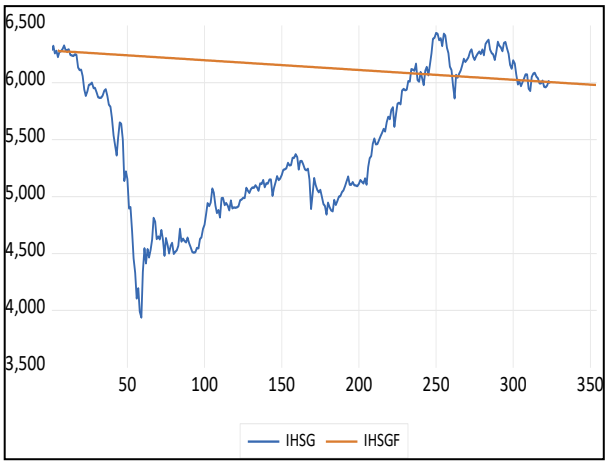

Figure 6. Results of Comparison of Actual Value and Forecasting Value of JKSE

Based on Figure 4, it can be seen that the estimation results of the JKSE forecast for the next 30 periods tend to decrease.

To determine the accuracy of the ARIMA method in predicting the JKSE, it can be seen using the Mean Absolute Percentage Error (MAPE) by comparing the actual value and the forecast value. To compare it can use Microsoft Excel. The results of the comparison between the actual value and the JKSE forecast value for 30 periods can be seen in the following Table 6.

Table 6. *Mean Absolut Percentage Error* (MAPE)

Date	Aktual	Forecast	MAPE
03/05/2021	5.952,60	6.003,94	0,862
04/05/2021	5.963,82	6.003,08	0,658
05/05/2021	5.975,91	6.002,22	0,440
06/05/2021	5.970,24	6.001,36	0,521
07/05/2021	5.928,31	6.000,51	1,218
10/05/2021	5.975,79	5.999,65	0,399
11/05/2021	5.938,35	5.998,79	1,018
17/05/2021	5.833,86	5.997,93	2,812
18/05/2021	5.834,39	5.997,07	2,788
19/05/2021	5.760,58	5.996,22	4,091
20/05/2021	5.797,60	5.995,36	3,411
21/05/2021	5.773,12	5.994,50	3,835
24/05/2021	5.763,63	5.993,64	3,991
25/05/2021	5.815,84	5.992,79	3,042
27/05/2021	5.841,83	5.991,93	2,569
28/05/2021	5.848,62	5.991,07	2,436
31/05/2021	5.947,46	5.990,21	0,719
02/06/2021	6.031,58	5.989,36	0,700
03/06/2021	6.091,51	5.988,50	1,691
04/06/2021	6.065,17	5.987,64	1,278
07/06/2021	6.069,94	5.986,78	1,370
08/06/2021	5.999,37	5.985,93	0,224
09/06/2021	6.047,48	5.985,07	1,032
10/06/2021	6.107,54	5.984,21	2,019
11/06/2021	6.095,50	5.983,35	1,840
14/06/2021	6.080,38	5.982,50	1,610
15/06/2021	6.089,04	5.981,64	1,764
16/06/2021	6.078,57	5.980,78	1,609
17/06/2021	6.068,45	5.979,92	1,459
18/06/2021	6.007,12	5.979,06	0,467
MAPE			1,729

Based on Table 6, it can be seen that the percentage value of the JKSE forecasting error using the ARIMA method using MAPE is 1.73%. This means that the

ARIMA model (3,1,9) has a very good forecasting model ability because it has a MAPE < 10% result that is 1,73% which indicates that the forecasting accuracy is 98,27%.

3.2. Discussion

Based on the results of data processing that has been carried out using the ARIMA method to predict the Jakarta Composite Index (JKSE), it is known that the ARIMA model (3,1,9) is the best model that can predict the JKSE for the next 30 periods. ARIMA (3,1,9) is able to predict JKSE accurately because it has a MAPE result of 1,73%. This proves that the JKSE forecasting using daily data with the ARIMA method is very appropriate to do. However, JKSE forecasting cannot be carried out in the long term, because the more forecasting periods in the future, the higher the standard error value. This shows that the more periods you want to forecast, the accuracy of the JKSE forecasting will decrease.

The results of this study are in line with research (10) which states that ARIMA (2,1,2) can predict the JKSE with an accuracy rate of 83.33%. However, this research is not in line with research (15) which concludes that the Double Exponential Smoothing method is better at predicting the stock prices of the three companies incorporated in LQ45 based on the highest EPS value because they have a smaller MAPE value. (10) (15).

Throughout the research period, the JKSE value fluctuated greatly due to the Covid-19 pandemic, so it was very difficult for investors to predict, but this study shows that ARIMA can predict the JKSE very well, as evidenced by the results of research showing forecasting accuracy of 98.27%. The value of the JKSE which had dropped drastically in March 2020 was due to the Covid-19 pandemic which caused negative sentiment towards the stock market. Investors choose to sell their shares and switch to safer investment instruments. However, the JKSE value slowly rose again because the market had adjusted to the issues and policies imposed due to the Covid-19 pandemic. Negative sentiment due to Covid-19 is no longer a new sentiment that will make investors panic selling. The JKSE value has increased because the Covid-19 vaccine has been found, thus creating positive sentiment for the JKSE movement. In addition, the JKSE value has increased because during the pandemic there were additional domestic retail investors entering the stock market, which is dominated by the millennial generation..

The use of ARIMA as a forecasting method has been proven to be a good and appropriate choice for forecasting in the short term, so that the use of the ARIMA method can be said to be included in investment analysis, namely technical analysis. Technical analysis is an investment analysis that is widely used by investors who invest in the short term because it is practical to predict stock movements only based on historical charts of stock movements. As for investing in the long term, it would be more appropriate to use fundamental analysis which analyzes a lot of financial data so that a more comprehensive analysis will be obtained. Therefore, this research will be useful for investors and the public who want to invest in the capital market because it can assist in making investment decisions.

4. Conclusion

The results showed that the best ARIMA model to predict the value of the Jakarta Composite Index is ARIMA (3,1,9). ARIMA (3,1,9) can predict the JKSE value very well because the value of the forecasting result is not much different from the actual value. This is also evidenced by the results of the accuracy test using MAPE which has a result of 1.729, which means the accuracy of forecasting is 98.27%. These results can be a reference for investors in the stock market in predicting stock prices, especially using a technical analysis approach.

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