



Forecasting Jakarta Islamic Index Stock Prices: A Comparative Study of ARIMA and Holt’s Double Exponential Smoothing

Yuliana Dwi Nur'aini¹, Sugito^{2*}, Moch. Abdul Mukid³, Hasbi Yasin⁴

^{1,2,3,4}Department of Statistics, Universitas Diponegoro, Semarang, Indonesia

ARTICLE INFO	ABSTRACT
Published Online: 24 September 2025	The capital market is one of the most popular investment options today. In the capital market, stock price prediction is an important issue for investors so that a good forecasting method is needed as a basis for decision making in transactions. One of the commonly used forecasting methods is ARIMA. However, in ARIMA modelling, several assumptions must be met such as the assumption of stationarity, parameter significance, and white noise assumptions. The Double Exponential Smoothing Holt method is one of the forecasting methods where the only assumption that must be met is the assumption of stationarity. The purpose of this study is to obtain the best model using a time series analysis approach, namely the ARIMA method and Double Exponential Smoothing Holt to forecast the Jakarta Islamic Index stock price for 10 periods in the future. Based on the analysis that has been done, the Jakarta Islamic Index stock price forecast should be done using the ARIMA method with the ARIMA (1,1,0) model because it has the smallest MAPE value, which is 1.5292%.
Corresponding Author: Sugito	
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I. INTRODUCTION

Investments have grown and continue to grow very rapidly, not only in terms of the number of investors and the amount of capital invested, but also in terms of the different types of securities products that can be considered as investment alternatives (Tandelin, 2010). Investing often involves a variety of activities, such as investing money in various assets. The field of investment includes tangible assets such as land, gold, real estate, or financial investments such as stocks, bonds, and investment funds. Shares are proof of ownership of the assets of a particular company that issues shares. The market where securities such as stocks and bonds are traded is called the capital market. In Indonesia, capital market instruments have been developed through conventional capital markets and Islamic capital markets. The sharia capital market can be interpreted as a capital market that applies Sharia principles based on Islamic teachings in conducting economic transactions.

Forecasting is the act of anticipating future events, while forecasting is the act of predicting future circumstances. Forecasting can be done qualitatively and quantitatively. Qualitative forecasting is very objective because it requires the opinions of experts. Meanwhile, forecasting quantitatively uses historical data as a reference for forecasting calculations.

In general, quantitative forecasting is divided into two methods, namely regression forecasting and time series forecasting. The time series method is a forecasting method that is based on the analysis of patterns in the relationship between the variables to be estimated and the time variables. Forecasting a time series data needs to pay attention to the type or pattern of data (Hanke and Wichren, 2005).

One of the most used methods in forecasting is ARIMA modelling introduced by Box-Jenkins (1976)(Lusiani and Habinudin, 2011). The other method is the exponential smoothing method. The exponential smoothing method is generally classified into single exponential smoothing, double exponential smoothing, and triple exponential smoothing (Makridakis, Wheelwright, & Hyndman, 1998; Hyndman & Athanasopoulos, 2018). Furthermore, double exponential smoothing can be divided into two approaches, namely Brown’s Double Exponential Smoothing and Holt’s Double Exponential Smoothing. Brown’s method applies linear exponential smoothing in a manner like a linear moving average, while Holt’s method follows the same principle but does not directly employ double smoothing. Instead, it introduces an additional parameter to smooth the trend component (Chatfield, 2000; Wei, 2006).

The remainder of this article is organised as follows. Section 2 explains the ARIMA and Double Exponential Smoothing (DES) models, complete with parameter estimation methods and hypothesis testing. In Section 3, we present the research methodology we used. Section 4 presents the results of data processing and analysis related to JII stock data forecasting. Section 5 presents the findings.

II. METHOD DETAILS

An investment is a commitment to a certain amount of money or other resources at this time in the hope of making a profit in the future. As time goes by, investment seems to have become an inseparable part. Because it's natural to want to put yourself in a safe position for the future. The capital market is a meeting place for parties who have excess funds (investors) and parties who need funds through securities transactions. Stocks are now the investment vehicle of choice for many investors because they can produce quite high returns. Stocks are securities that can prove that someone owns a company.

Forecasting is the activity of predicting what will happen in the future (Makridakis et al., 1999). The purpose of forecasting is to minimize uncertainty and obtain an estimate that is close to the actual situation. The forecasting method makes it possible to predict what will happen in the future based on past data. The forecasting method is divided into two categories, namely qualitative and quantitative methods. Qualitative methods can be used when available data do not allow long-term predictions about the future (long-term forecasting) and mathematical modelling is not available. On the other hand, quantitative methods are based on raw data and use mathematical rules to predict the future. The quantitative method consists of the time series analysis method and causal analysis.

Periodic series analysis, or time series analysis, is one of the data analysis methods that aims to estimate and forecast the future (Makridakis et al., 1999). Periodic series analysis makes it possible to find out the development of events as well as their correlation or impact on other events. The selection of techniques in forecasting methods other than the type of data also depends on the data pattern of a certain period. There are patterns of data types that include horizontal patterns, seasonal patterns, cyclical patterns, and trend patterns. Various patterns must be solved by different methods according to the specifications of each method. Data can be analysed by periodic series analysis if it meets the assumption of stationariness both in mean and variance.

ARIMA is one of the forecasting methods whose model formation is influenced by time by using data in the past and present as related variables. The ARIMA model is usually written as ARIMA (p, d, q), where p is the order of the *Autoregressive* (AR) process, q is the order of the *Moving Average* (MA) process, and d is the *order of Differencing*. The arima method can be identified by looking at the ACF plot and the PACF plot. According to Wei (2006), after the model is

identified, then estimate the parameters in the model. There are many types of methods for estimating model parameters, but the Ordinary Least Square (OLS) method is commonly used. OLS estimation is an estimation method that minimizes the square difference between the original parameter value and the estimated parameter value. Look at a simple regression model below.

$$Z_t = \phi Z_{t-1} + a_t, t = 1, 2, \dots, n, \tag{1}$$

Next is the diagnostic examination According to Rosadi (2012), to conduct a diagnostic examination is to conduct a Q-Ljung-Box test to analyze whether there is a serial relationship in the residual resulting from comparing the results of the model estimate with the observed data.

$$Q = n(n+2) \sum_{k=1}^K (n-k)^{-1} \hat{\rho}_k^2, \tag{2}$$

Statistics Q are distributed χ^2 with a $(K-m)$ degree of freedom where K is the maximum lag and m is the number of parameters in the model or $m = p + q$, $\hat{\rho}_k^2$ is a residual autocorrelation to lag k .

According to Wei (2006), an information criterion namely AIC (Akaike's Information Criterion) is defined as follows:

$$AIC(M) = n \ln(\hat{\sigma}_n^2) + 2M, \tag{3}$$

If the value of Akaike's Information Criterion (AIC) obtained is smaller, it means that the model used is better.

The Double Exponential Smoothing of Holt is often also called the two-parameter double exponential smoothing method. The method proposed by Holt does not use double refining directly but uses other parameters as trend refiners, namely β parameters. α parameters are still used as refiners of the original data as in the previous method. The Double Exponential Smoothing Holt method has 3 equations, namely:

$$S_t = \alpha Z_t + (1-\alpha)(S_{t-1} + b_{t-1}), \tag{4}$$

$$b_t = \beta(Z_t - S_{t-1}) + (1-\beta)b_{t-1}, \tag{5}$$

$$F_{t+m} = S_t + b_t m, \tag{6}$$

Mean Absolute Error (MAE) is the average absolute difference between the actual value and the predicted value. In general, the MAE value is used as an error prediction in time series analysis. The MAE formula can be seen as follows (Makridakis et al., 1999):

$$MAE = \frac{1}{n-i+1} \sum_{t=i}^n |Z_t - F_t|, \tag{7}$$

MAPE (*Mean Absolute Percentage Error*) is a continuation of the calculation of MAE by ordering the results of MAE calculations.

$$MAPE = \frac{1}{n-i+1} \sum_{t=i}^n \left| \frac{Z_t - F_t}{Z_t} \right| \times 100\% , \quad (8)$$

III. RESEARCH METHODS

The type of data used in this study is quantitative data. The data used falls under the category of ratio data, which is data that has all the characteristics of the interval and has an absolute zero point where mathematical calculations can be performed. The data source for this study is secondary data. The data for this study is historical data for *the Jakarta Islamic Index* which has been published on *the investing.com* website.

The variable in this study is the daily closing price data of the Jakarta Islamic Index for the period December 1, 2023, to June 27, 2024. The number of time series data for analysis is 130 data. Stock price data from December 1, 2023, to June 11, 2024, is for training data or calculation of forecasting models, while stock price data from June 12, 2024, to June 27, 2024, is used for data testing or comparing forecast results with actual data. The data can be analyzed by:

1. Identify training data patterns
2. Perform forecasting analysis using ARIMA
3. Perform forecasting analysis using the DES Holt method
4. Determining the best model and calculating forecasting values
5. Interpreting and drawing conclusions

IV. RESULTS AND DISCUSSION

Forecast analysis, the first step is to make a visualization of the closing price of Jakarta Islamic Index shares from training data with a time series plot. The plot time series of the training data, namely the closing price data of Jakarta Islamic Index shares (December 1 – June 11, 2024) can be seen in Figure 1.

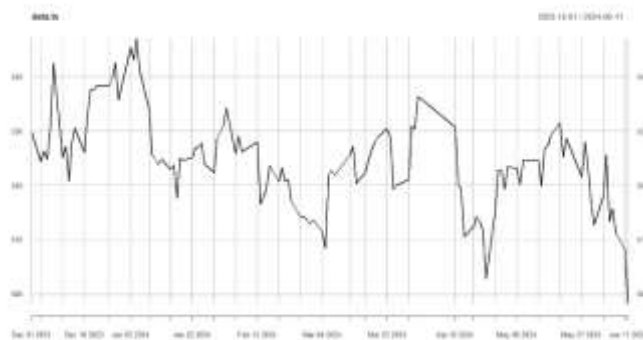


Figure 1. Plot Time Series Jakarta Islamic Index Stock Closing Price

Based on Figure 1, the JII closing price data pattern fluctuates quite extremely, so that the data has a non-stationary

pattern. However, visually, it tends to be subjective, so a formal test needs to be carried out.

The data stated to be stationary in the variant can be seen using the Box-Cox method. The rounded value of λ is 1.99, so it can be concluded that the price data of the JII stock index has not met the stationary assumptions in the variant, so the Box-Cox transformation is carried out to get a stationary value, namely $\lambda = 1$. After the transformation is obtained, the rounded value = 0.99 ~ 1 data is already stationary in the variant.

Data with stationarity in means can be known using the Augmented Dickey-Fuller Test (ADF).

Hypothesis:

$H_0: \delta = 0$ (has unit root or non-stationary data)

$H_1: \delta < 0$ (no root unit or stationary data)

Significance Level: $\alpha = 5\%$

Test Statistics:

$$t_{stat} = \frac{\hat{\delta}}{SE(\hat{\delta})} = -2.9902 , \text{ and } p_value = 0.1653$$

Conclusion:

At the level of significance, it can be concluded that the closing price data of the Jakarta Islamic Index is not stationary in the mean.

Since the results of the ADF test show that the data is not stationary in the mean, it is necessary to do the first differentiation. Then an ADF test was carried out for differencing results, which are as follows:

Test Statistics:

$$t_{stat} = \frac{\hat{\delta}}{SE(\hat{\delta})} = -5.3619 , \text{ and } p_value = 0.01$$

Conclusion:

At the level of significance, it can be concluded that the closing price data of the Jakarta Islamic Index is stationary in the mean.

After the assumption of stationarity in the mean and variant is met, the next stage is to make a provisional ARIMA model estimate. A possible model can be known by looking at the ACF and PACF plot graphs of the data that has been transformed and the one-time differentiation. The alleged AR order is determined by looking at the PACF plot which shows that the data pattern is broken after the 1st lag. Meanwhile, the MA order suspect is determined by looking at the ACF plot which shows that the data pattern is broken after the 1st lag. So, the possible ARIMA models are ARIMA(1,1,0), ARIMA(1,1,1), ARIMA(0,1,1), ARIMA(2,1,1), ARIMA(2,1,0), ARIMA(1,1,2), and ARIMA(0,1,2).

After obtaining a provisional model, the next stage is to estimate the model parameters. The similarities of the model used are as follows:

$$\phi_p(B)(1-B)^d Z_t = \theta_q(B)a_t , \quad (9)$$

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Parameter estimation is carried out using R studio, and the results presented in Table 1.

Table 1. Estimated ARIMA Model Parameters

Type	Parameters	Parameter Estimation	Standard Error
ARIMA(1,1,0)	ϕ_1	-0.1970	0.0307
ARIMA(1,1,1)	ϕ_1	-0.3233	0.6833
	θ_1	0.1331	0.8747
ARIMA(0,1,1)	θ_1	-0.2017	0.0319
ARIMA(2,1,1)	ϕ_1	0.7139	4.3805
	ϕ_2	0.1155	0.2310
	θ_1	-0.9644	9.4220
ARIMA(2,1,0)	ϕ_1	-0.1967	0.0347
	ϕ_2	0.0018	0.9843
ARIMA(1,1,2)	ϕ_1	-0.5572	0.3325
	θ_1	0.3552	0.5377
	θ_2	-0.0703	0.6697
ARIMA(0,1,2)	θ_1	-0.2018	0.0317
	θ_2	-0.0021	0.9830

Next, testing is carried out to see if the ARIMA parameters are significant or not. For example, δ is the ARIMA model parameters (including ϕ and θ), the ARIMA model parameter test is carried out using the following hypothesis:

Hypothesis:

$H_0: \delta = 0$ (parameters have no effect on the model)

$H_1: \delta \neq 0$ (parameters affect the model)

Significance Level: $\alpha = 5\%$

Test Statistics:

$$Z_{stat} = \frac{\hat{\delta}}{SE(\hat{\delta})}$$

Test criteria:

Reject H_0 if $|Z_{stat}| \geq Z_{\alpha/2}$ or $p_value \leq \alpha$.

Conclusion:

Based on Table 1, it can be concluded that the ARIMA (1,1,0) and ARIMA (0,1,1) models have significant parameters at a significant level of 5% due to the P-value < 0.05. Meanwhile, the ARIMA (1,1,1), ARIMA (2,1,1), ARIMA (2,1,0), ARIMA (1,1,2), and ARIMA (0,1,2) models have insignificant parameters at the significance level of 5% due to the P-value > 0.05.

After obtaining significant ARIMA model parameter estimates, residual diagnostics were performed. This step was carried out to test the residual assumptions of the model, namely the white noise residual test. The white noise residual test was performed to determine whether there was correlation between residuals or not. The test performed in the white noise

residual test was the Ljung-Box test using R studio. The results of the Ljung-Box test are presented in Table 2.

Table 2. Residual White Noise Assumption Test ARIMA (1,1,0)

Lag	Q	P-value	Decision
12	5,7633	0,8887	H_0 Accepted
24	12,0473	0,9697	H_0 Accepted
36	20,8874	0,9717	H_0 Accepted
48	31,8580	0,9554	H_0 Accepted

ARIMA (0,1,1)			
Lag to-	Q	P-value	Decision
12	5,8710	0,8818	H_0 Accepted
24	12,2779	0,9660	H_0 Accepted
36	21,1956	0,9681	H_0 Accepted
48	32,2439	0,9503	H_0 Accepted

Based on Table 2, it can be concluded that the ARIMA (1,1,0) and ARIMA (0,1,1) models have residual *white noise* at a significance level of 5% due to the P-value at all lags greater than 0.05.

The further stage is to test the homoscedasticity of the ARIMA model residuals using the following hypothesis:

Hypothesis:

$H_0: \beta_1 = \beta_2 = \dots = \beta_p = 0$ (no ARCH/GARCH effect)

$H_1: \text{there is at least one value } \beta_k = 0; k = 1, 2, \dots, p \text{ (there is an ARCH/GARCH effect)}$

Significance level: $\alpha = 5\%$

Test statistics:

$$LM = \frac{(SSR_0 - SSR_1)/p}{SSR_1/(n - 2p - 1)}$$

Rejection Criteria:

Reject H_0 if $LM > \chi^2_{(0.05;p)}$ or p-value < 0.05, it means that there is no case of heteroscedasticity in the residual model.

Decision:

According to the data analysis results, the p-value for the ARIMA (1,1,0) model is 0.5411 and the p-value for the ARIMA (0,1,1) model is 0.5308, therefore H_0 is accepted. It can be concluded that there is no ARCH/GARCH effect on the ARIMA (1,1,0) and ARIMA (0,1,1) models.

The following assumption test is the residual normality test conducted using the Kolmogorov-Smirnov test. The Kolmogorov-Smirnov residual normality test can be conducted using the following steps:

Hypothesis:

$H_0: \text{Residual data is normally distributed}$

$H_1: \text{Residual data is not normally distributed}$

Significance level: $\alpha = 5\%$

Test statistics:

$$D = \max |S_n(a_i) - F_0(a_i)|$$

Rejection Criteria:

Reject H_0 if $D > D_{(1-0.05)/(2,120)}$ or p-value < 0.05.

Decision:

The data analysis results show that the p-value for the ARIMA (1,1,0) model is 0.5073 and the p-value for the ARIMA (0,1,1) model is 0.487, so H_0 is accepted. Thus, it can be concluded that the ARIMA (1,1,0) and ARIMA (0,1,1) models satisfy the assumption of residual normality.

After conducting residual diagnostics, the next phase is to select the best ARIMA model. The best ARIMA model is one in which all parameters are significant, satisfy the white noise assumption, and have the smallest AIC score. Table 3 presented the comparison of some of the models that have been identified before:

Table 3. ARIMA Best Model Selection

Type	Parameter Significance	White Noise	AIC
ARIMA(1,1,0)	Yes	Yes	2385.5725
ARIMA(0,1,1)	Yes	Yes	2385.5782

Based on Table 3, the best model that was chosen was the ARIMA model (1,1,0) because it had a smaller AIC value than the other models, which was 2385.5725 and met all assumptions. Next, the model was formed by looking at the estimated value of the ARIMA model parameter (1,1,0) as shown in Table 1. So that the model obtained for the transformation data can be described as:

$$Z_t^* = Z_{t-1}^* - 0.1970Z_{t-1}^* + 0.1970Z_{t-2}^* + a_t$$

where $Z_t^* = (Z_t)^2$, then to return to the initial data form $Z_t = \sqrt{Z_t^*}$, where Z_t^* is the Jakarta Islamic Index stock price after transformation and Z_t is the Jakarta Islamic Index stock price data.

In the Double Exponential Smoothing Holt method, the α parameter is used as a parameter for smoothing the original data or smoothing the level component (average level) of the time series. Meanwhile, the β parameter is used as a parameter for smoothing the trend data or smoothing the rate of change of the time series data. The values of parameters α and β are obtained through trial and error, namely the values of α and β that produce the smallest sum of squares. Based on the output of the R software and manual calculations in Excel, the value of α is 0.8576316 and the value of β is 0.1031015. Based on these results, the values of α and β obtained are the optimum values.

The calculation of the smoothing value S_t and trend b_t begins in the second period ($t=2$), so the forecasting results automatically begin in the third period ($t=3$). When analysing the first line, the level and trend values do not exist because they do not have the previous accessory data values, what can be filled in is the second line or the second period. In the second period, the level value is automatically equal to the original data value of the second period, and the trend value

is obtained from the reduction of the level value and the previous day's data value.

$$S_2 = x_2 = 524.46$$

The trend smoothing value on December 4, 2023 can be calculated by subtracting the current period data with the previous period data due to the absence of information about the trend smoothing value of the previous data, so that the current trend smoothing value at $t = 2$ is obtained as follows:

$$b_2 = x_2 - x_1 = 524.46 - 529.76 = -5.3$$

The calculation of exponential smoothing values and smoothing of subsequent periods can be done using equations (4) and (5), yielding the following results:

Period 5 December 2023 ($t = 3$)

$$S_3 = 0.857632(526.27) + (1 - 0.857632)(524.46 - 5.3) = 525.2578$$

$$b_3 = 0.1031015(525.2578 - 524.46) + (1 - 0.1031015)(-5.3) = -4.6713$$

Period 6 December 2023 ($t = 4$)

$$S_3 = 0.857632(524.8) + (1 - 0.857632)(525.2578 - 4.6713) = 524.2001$$

$$b_4 = 0.1031015(524.2001 - 525.2578) + (1 - 0.1031015)(-4.6713) = -4.2987$$

The calculations will continue until June 11, 2024 ($t = 120$).

After calculating the exponential smoothing value and the trend smoothing value, then the forecasting value can be found with equation (6) which is by adding the exponential smoothing value with the trend smoothing value of the previous period ($t - 1$). The forecast calculation value starts from the third period ($t = 1$) because the level smoothing and trend smoothing values start in the second period ($t = 2$). The results of forecasting using the DES-Holt method are presented in Table 4.

Table 4. Forecasting of Double Exponential Smoothing-Holt Method

Period (t)	Stock Data (X_t)	Forecast Value (F_{t+m})	Galat (e_t)
4/12/2023	524.46		
5/12/2023	526.27	519.1600	7.1100
6/12/2023	524.80	520.5865	4.2135
7/12/2023	530.65	519.9014	10.7486
8/12/2023	542.49	525.7714	16.7185
⋮	⋮	⋮	⋮
11/06/2024	498.26	507.3915	-9.1314

Based on Table 4, a comparison of the actual value and forecast value of the closing price data of JII shares using Double Exponential Smoothing-Holt can be seen in Figure 2.



Figure 2. Forecasting Results of the DES Holt Method

Based on Figure 2, the value of the forecast results shown with the orange line looks not very different and tends to be close to the actual data shown by the blue line. So visually the *Double Exponential Smoothing Holt* method can predict JII stock price data well. However, other calculations are still needed to assess how much of the forecasting error occurred in the forecasting of the *Holt Double Exponential Smoothing* method.

After obtaining the forecast value from the Autoregressive Integrated Moving Average (ARIMA) and Double Exponential Smoothing Holt methods in forecasting the closing price of Jakarta Islamic Index shares. The forecasting value of each method is then obtained an error or error, based on the error value, the best model can be found among the Autoregressive Integrated Moving Average (ARIMA) and Double Exponential Smoothing Holt methods by calculating MAE and MAPE. The MAE and MAPE values can be found in the following Table 5

Table 5. Comparison of MAE and MAPE Values of ARIMA and DES Holt Methods

Method	MAE	MAPE
ARIMA (1,1,0)	3.8503	0.7353
DES Holt	4.1192	0.7856

Based on Table 5, the MAE and MAPE values of the ARIMA method (1,1,0) are less than the Double Exponential Smoothing Holt method, so it is concluded that the ARIMA method is considered better in forecasting than the Double Exponential Smoothing Holt method.

The calculation of forecasting testing data for the period of June 12, 2024, to June 27, 2024, was carried out using the best model, namely ARIMA (1,1,0). The results of this forecasting data will later be compared with actual data for the period June 12, 2024, to June 27, 2024, to obtain model accuracy.

The results of the calculation of the forecast of the closing price of Jakarta Islamic Index shares for the next 10 periods are presented in Table 6.

Table 6. Best Method Prediction Results

Period	Forecasting
12/06/2024	500,2326
13/06/2024	499,8445
14/06/2024	499,9210
19/06/2024	499,9060
20/06/2024	499,9089
21/06/2024	499,9083
24/06/2024	499,9085
25/06/2024	499,9084
26/06/2024	499,9084
27/06/2024	499,9084

Based on calculations, the resulting model has a MAPE value of 1.5292%, indicating that the average forecasting error with the best model is 1.5292% of the actual value. This value indicates an excellent level of accuracy, considering that the MAPE value is less than 10%.

V. CONCLUSION

The procedure for forming a forecasting model using the ARIMA method was influenced by the autocorrelation function (ACF) and the partial autocorrelation function (PACF) while the procedure for forming a forecasting model using the Double Exponential Smoothing Holt method was influenced by the magnitude of the most optimal α and β values for the data, namely $\alpha=0.8576316$ and $\beta=0.1031015$. The Jakarta Islamic Index stock closing price forecast using ARIMA(1,1,0) gives an MAE value of 3.8503 while the Double Exponential Smoothing Holt method gives an MAE of 4.1191. The MAPE value of the ARIMA method (1,1,0) worth 0.7353 in the training data is also less than the Double Exponential Smoothing Holt method worth 0.7856. So, the ARIMA(1,1,0) method provides a smaller average value of absolute forecasting error than the Double Exponential Smoothing Holt method. The MAE and MAPE values of the ARIMA(1,1,0) are smaller than the Double Exponential Smoothing Holt method, so the ARIMA(1,1,0) is a better model in predicting the closing price of the Jakarta Islamic Index compared to the Double Exponential Smoothing Holt method. The ARIMA(1,1,0) gives a MAPE value of 1.5292% on the testing data so that the ARIMA(1,1,0) has excellent forecasting accuracy.

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