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Forecasting The Number of Passengers Arrival on Domestic Flights at Yogyakarta International Airport in 2024-2025 Using Holt-Winter's Exponential Smoothing and ARIMA

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Abstract: The purpose of this research is to get forecasting results with the best model of the Holt-Winter's Exponential Smoothing and ARIMA forecasting methods by looking at the smallest error value, where both of them can handle time data sets. A comparison of forecasting methods was carried out to obtain a high level of model accuracy using actual data for the period of January 2021 to December 2022 to obtain forecasting results for the number of passengers for 2024-2025. Forecasting with the Holt-Winter's Exponential Smoothing method produces a MAPE value of 42.39968. The best method was obtained for predicting the number of domestic arrival passengers at Yogyakarta International Airport in 2024-2025 when viewed based on the smallest MAPE value, namely, the ARIMA method with model (4,1,0) for the January 2024 period is 279,956 passengers with the obtained MAPE value that is equal to 32.66308.

Keywords. *Airport, Forecasting, Passengers Forecast, Holt-Winter's Exponential Smoothing, ARIMA*

1. Introduction

Yogyakarta, the largest tourist city in Indonesia after Bali, has enough infrastructure and culture to attract both local and foreign tourists. From an economic perspective, airports as a place of entry and exit of money, which can potentially boost the country's economy due to the large number of tourists who use it. Yogyakarta International Airport itself already has world-class facilities. With this complete transportation infrastructure, tourist destinations can be promoted and Kulon Progo's economy can develop.

The number of local and foreign tourists who come to this city, thus making the airport which was once the only one in Yogyakarta, namely Adisutjipto Airport, is overcapacity for passengers and accompanied by development and additional capacity. Therefore, an airport is needed that can accommodate a larger number of passengers and that can accommodate aircraft that have a wide body.

In March 2020, Yogyakarta International Airport officially fully operated to transport passengers to and from Yogyakarta. An area of 583 ha houses Yogyakarta International Airport in Temon Regency, Kulon Progo. Yogyakarta International Airport has one runway along 3,250m x 45m with a shoulder runway length of 30m on each side. With this runway, aircraft with wide bodies such as Boeing 777-300 and Airbus 380 can arrive at this airport. The airport has a terminal area of 219,000 square meters and can accommodate 20 million passengers annually.

It is very important for airports and airlines to estimate the number of passengers who will come to Yogyakarta International Airport because an increase in the number of passengers can cause traffic congestion on flights, which can slow down flights, and affect the performance of facilities and services at the airport. However, as with the airline industry, there is sometimes an increase or decrease in passengers. Forecasting the number of domestic arrival passengers at Yogyakarta International Airport is necessary due to the increasing number of domestic arrival passengers. The number of passengers will have an impact on the level of service at the airport, so when there is a surge in passengers, anticipation is needed so that the service continues to run well and provide comfort to passengers. The

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purpose of this study is to obtain forecasting of the number of aircraft passengers by comparing 2 forecasting methods, namely, Holt-Winter's Exponential Smoothing and ARIMA by looking at the smallest error value size of the two methods.

2. Literature Review

A. Airport

Airport is an area related to air transportation services where in that area there is intra/intermodal movement and aircraft movement equipped with basic facilities and supporting facilities and other safety facilities to ensure the availability of facilities for air transportation for regional communities.

B. Passenger

A passenger is someone who uses transportation services to make a certain trip by paying a certain amount of money to the carrier. Which means, passengers are people who buy tickets and travel using transportation facilities provided by transportation or commercial companies.

C. Forecasting

According to Jay Heizer and Barry Render (2009:162) Forecasting, or prediction, is a technique and discipline for predicting what will happen in the future. Forecasting can be done by involving past data and projecting future data with mathematical models. According to (Sudjana, 1989) Forecasting is the process of estimating (measuring) the magnitude or amount of something at a time to be determined based on past data that has been analyzed scientifically, especially using statistical methods.

Forecasting can be distinguished from several types depending on how it is approached. According to Herjanto, (2008). Based on the time horizon, forecasting can be of three types, namely:

1. Long-Term Forecasting, which covers more than 18 months. For example, forecasting is intended for equity participation, facility planning, and *planning Research and Development activities.*
2. Medium-Term Forecasting, a period of time that covers between 3 months to 18 months.
3. Short Term Forecasting, which covers a period of less than 3 months. For example, forecasting in conjunction with planning material purchases, work scheduling, and employee assignments.

In general, quantitative forecasting methods can be divided into two parts, namely, (Santoso, 2009):

1. Causal method (regression)

   The causal method is to enter and test variables that are thought to affect the *dependent* variable. Forecasting is based on causal relationships, thus the model will be more than one variable.
2. Time series method

   The time series method attempts to forecast the future using historical data, in other words the time series method tries to see what happened at a certain period of time and uses past time series data to forecast. This method is based on data input in the form of data with a time base (daily, weekly, monthly, and others).

The forecasting process consists of the following steps:

1. Goal setting

   Before doing a forecast, you should first know the purpose of the forecasting and the usefulness of the forecasting results, then the forecasting results are estimated to the short or long term.
2. Model development

   Once the goal is achieved, the next step is to develop a model that is a simpler presentation of the system being studied. In forecasting, a model is an analytical framework that, when input data is included, will produce an estimate of the number of passengers arriving in the future.
3. Model testing

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Before deployment, models are typically tested to determine the expected level of accuracy, validation, and reliability. This includes applying it to historical data and preparing estimates for the current year with available data.

4. Model deployment

   Before testing, historical data is fed into the model to generate a forecast.

5. Revision and Evaluation

   Forecasts that have been made should always be corrected and revisited. While evaluation is a comparison of forecasts with real results to assess the accuracy of using a method or forecasting technique.

D. Time Series Methods

The data obtained for the time series is data collected based on a certain time span. To analyze a series of data from a *time series function* using periodic series analysis methods with the assumption that combinations of patterns always repeat in the future, and the basic pattern can be identified based on historical data from the series.

E. Smoothing Method

Smoothing method or *Smoothing* method, included in the periodic series forecasting method. This smoothing method has a basic method, namely simple weighting or smoothing past observations in a periodic series source to obtain future forecasts.

F. Autoregressive Integrated Moving Average (ARIMA)

Autoregressive Integrated Moving Average (ARIMA) is a forecasting method obtained through a combination of *autoregressive* (AR) and *moving average* *(*MA), (William W.S Wei, 2006). The ARIMA model was developed by George Box and Gwilyn Jenkins in 1976, so the ari-ma method is often referred to as ARIMA Box-Jenkins. The ARIMA model uses past and present data to produce accurate short-term forecasts. Therefore, this forecasting model is very good accuracy if used for short-term theft.

In general, non-seasonal ARIMA models consist of *autoregressive* (AR) models, *moving average* (MA) models, ARMA models and ARIMA models. In general, the Box-Jenkins model is formulated with ARIMA notation (*p,q,d*). In this case it means:

p = Order or degree of AR (*Autoregressive*)

d = Order or degree of distinction (*Differencing*)

q = Order or degree MA (*Moving Average*)

G. Holt-Winter's Exponential Smoothing

The exponential smoothing method has three types of exponential smoothing methods, namely, Brown's One-Parameter Double Exponential Smoothing, Holt's Two-Parameter Double Smoothing method, and Winter's Triple Exponential Smoothing method. The *exponential smoothing* method is one method that is often used in forecasting *time series* data to plot *trend* and *seasonal* data, Software used as a tool in statistical analysis confidently using *R* Studio software. As the name implies, in predicting values using this method, two smoothing constants are used, namely α dan γ with values of 0 and 1 selected by *trial and error* to produce the smallest *Mean Square Error* (MSE).

$$S_t = (aX_t) + (1-\alpha)(S_{t-1})$$
$$B_t = \gamma(S_t - S_{t-1}) + (1+\gamma)B_{t-1}$$

$$F_{t+m} = (S_t + B_t m$$

$$Error = F_t - X_t$$

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H. Forecasting Error Measures

1. *Mean Absolute Error* (MAE)

MAE is used to measure the error of the model's alleged value expressed in the form of an *absolute average* of errors. The formula for determining the value of MAE is expressed by the equation: $\text{MAE} = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n}$

y_i = Predictions
x_i = actual data
n = amount of data

2. Mean Absolute Percentage Error (MAPE)

Mean Absolute Percentage Error (MAPE) It is calculated using the absolute error of each period divided by the actual observed value for that period. MAPE is an error measurement that calculates the percentage size of deviation between actual data and forecasting data. The MAPE value can be calculated using the following equation :

$$\text{MAPE} = \left(\frac{100\%}{n}\right)\sum_{t=1}^{n} \frac{|Xt - Ft|}{Xt}$$

Xt = Actual data in period t
Ft = forecasting value in period t
N = Amount of data

Table 2.2 Criteria for Forecasting Results Based on MAPE Values

MAPE	Forecasting Results
$\leq 10\%$	Tall
$10\% < MAPE \leq 20\%$	Good
$20\% < MAPE \leq 50\%$	*Reasonable*
$> 50\%$	Low

I. Software R Studio

Software R Studio is a system for analysis, statistical data manipulation (statistical modeling), and graphing which was first created by Ross Ihaka and Robert Gentleman from the Department of Statistics, University of Auckland, New Zealand in 1992. This R abbreviation comes from both creators' names. R provides a wide range of statistical *tools* from linear to non-linear, *time series analysis*, *clustering*, and others. R also provides graphic engineering tools that aim to display data that has been processed visually in the form of graphs. The advantage *of R software* is that it is very versatile because it is one of the programming languages that has a lot of *packages* in it, is very interactive, S-based, and also popular because R is a language that is widely used by researchers in the field of statistics (Masudin, I, Ibrahim, M.F, 2018).

3. Research Method

A. Place and Time of Research

The research site is at Yogayakarta International Airport, Jl. Wates – Purworejo KM 42, Palihan, Temon District, Kulon Progo Regency, Yogyakarta Special Region. The study was conducted in February 2023.

B. Data Sources

The data used in this study is secondary data obtained from PT Angkasa Pura I (Persero) at the YIA *Apron Movement Control* (AMC) Unit which includes Air Transport Traffic time series data collected from January 2021 to December 2022.

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C. Data Analysis Techniques

After the required data has been met, the next step is to process the data. In the data analysis stage, starting from data stationary tests, identifying models to determine the best model, after finding the best model, the next stage is to forecast the number of domestic arrival passengers at Yogyakarta International Airport for the next 24 months (next 2 years).

D. Metode Holt-Winter's Exponential Smoothing

Here are the steps in forecasting *Holt-Winter's Exponential Smoothing* according to (Makridakis, Spyros & Wheelwright, S. & Hyndman, 1984):

1. Data input to R Studio software program
2. Convert data into *time series* data with basic *R* Studio functions
3. Plot time *series data*.
4. Calculate the smoothing of the model with the equation:
   1. $S_t = aX_t + (1-\alpha)(S_{t-1} + b_{t-1})$
   2. $b_t = \gamma(S_t + S_{t-1}) + (1-\gamma)b_{t-1}$
   3. $F_{t+m} = S_t + b_t m$

   With
   S_t : Smoothing Value at time *t*
   x_t : Data on time period *t*
   b_t : Trend in the t-th period
   α : First parameter of leveling between zero and one
   γ : The second parameter, for trend smoothing
   F_{t+m}: The result of the forecasting of the ($t + m$)
   m : The number of advance periods to be foreseen

5. Determine how to compare the smallest MSE and MAPE error calculations.
6. Make predictions for 24 periods after the data *comes out of the sample*
7. Create a predictive autoplot with 2 Holt parameters

E. Metode Autoregressive Integrated Moving Average

The research steps carried out using the ARIMA method are as follows:

1. Create a *time series plot on in-sample data to identify* time series *patterns of domestic arrival aircraft passenger data.*
2. Perform data stationary identification.
3. Create ACF and PACF plots.
4. Identification and underfitting *of ARIMA models based on ACF and PACF plots.*
5. Perform a diagnostic check if none of the models meet the underfitting
6. Parameter estimation, significant testing of parameters and assumptions in the models formed.
7. Calculates the RMSE value from the out-sample. To select the best model, a comparison of RMSE values for out-sample data in each model is performed.
8. Forecast for the next 36 months with the best model.
9. Provide conclusions and suggestions from research results.

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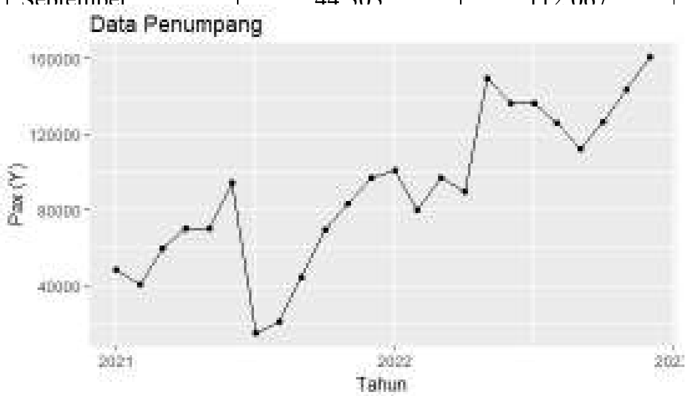
4. Result and Discussion

Identification of data on the arrival of domestic arrival aircraft passengers at Yogyakarta International Airport in January 2021 – December 2022 can be seen in table 4.1

Table 4.1 Actual Data on Domestic Arrival Passengers for 2021-2022

Month	Year	
	2021	**2022**
January	48.769	101.087
February	40.788	79.742
March	59.749	96.821
April	70.231	90.194
May	70.105	149.487
June	94.693	136.318
July	15.191	136.537
August	20.712	126.112
September	44.303	112.067



(Source : Yogyakarta International Airport Air Transport Traffic Data)

Figure 4. 1 Plot of Actual Data on the Number of Domestic Arrival Passengers of Yogyakarta International Airport in 2021-

It is seen that there was a decrease in July of 79,502 passengers due to the Emergency PPKM which aims to reduce the growth rate of Covid-19 since the end of June where it began to experience a surge in cases, which resulted in changes in airport operational schedules, where the operational time of Yogyakarta International Airport started from 07:00 – 20:00 WIB, but during the emergency PPKM the operational time changed to 07:00 – 16:00 WIB (9 hours) and an increase in the number of passengers starting to be seen from August 2021 – present.

A. Passenger Forecasting model with Holt-winter's exponential smoothing method

In determining the value of the *Holt-Winter's Exponential Smoothing* parameter will look for the weighting value or parameter α dan γ. Since the data does not contain seasonal patterns, only these two parameters will help calculate the predicted value of *Holt-Winter's Exponential Smoothing*. In determining these two parameters, it is done repeatedly. The two selected parameters must be in the interval (0,1) and with the least error value. α dan γ

Using *R studio software*, values from two parameters α were γ obtained and for *Holt-Winter's Exponential Smoothing method*. That is, obtained with the value of $\alpha = 0{,}8492244 \approx 0{,}8$ and $\gamma = 0{,}09409181 \approx 0{,}1$.

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The data obtained is data that has been calculated using *R Studio software*, which has gone through a data stationary test by getting a *P-Value* value of 0.0104 which means the data is stationary. After getting the value of the parameter to be used, a forecasting model is carried out for 24 periods. The results of forecasting 24 periods using *Holt-Winter's Exponential Smoothing* method with and values $\alpha = 0{,}8492244 \approx 0{,}8$ $\gamma = 0{,}09409181 \approx 0{,}1$, from R Studio *software* can be seen in table 4.2 as follows :

Table 4.2 Results of Forecasting the Number of Domestic Arrival Passengers for 2024-2025

Month	**Year**	
	2024	**2025**
January	218.536	274.269
February	223.180	278.914
March	232.469	283.558
April	237.114	288.203
May	237.114	292.847
June	241.758	297.492
July	246.403	302.136
August	251.047	306.780
September	255.691	311.425
Oktober	260.336	316.069
November	264.980	320.714
Desember	269.625	325.358
TOTAL	**2.938.253**	**3.597.765**

The accuracy and error values obtained in forecasting passenger data through *Holt-Winter's Exponential Smoothing* method are as in the following table.

Table 4.3 Error accuracy

Accuracy components	**Training Set**
ME	7182,073
RMSE	26822,19
MAE	20900,83
MPE	-8,497221
MAPE	42,39968
MASE	0,3366816
ACF1	-0,04691332

In table 4.3 it can be seen that for the error size obtained using Holt-Winter's Exponential Smoothing method, namely, for RMSE 26822.19, and MAPE obtained by 42.39968.

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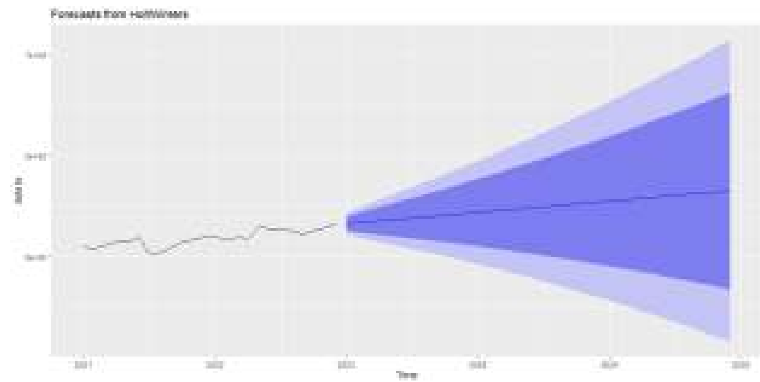

Figure 4. 2 Plot of Forecasting Results of Passenger Numbers for 2024-20025

B.Passenger Forecasting Model with Auto Regressive Integrated Moving Average Method

Stage 1. Time-Series Plot Checking and Data Stasionecity

The initial step taken in determining the time series model at the stage of model formation is to check the stationary data through a time series diagram. In addition to the time series plot, stationary values can be seen through the ADF (*Augmented Dickey-Fuller*) test. The results of the ADF test through RStudio can be seen in the Table 4.1

Tabel 4.4 Uji ADF (Augmented Dickey-Fuller)

Dickey Fuller	*p-value*	*Alternative Hypothesis*
-3,2363	0,1014	stationary

After the process of checking stationary data on the mean using the R software application, by taking the initial hypothesis, namely the data is not stationary against the mean while the alternative hypothesis, namely stationary data on the mean and the α significance level is 5% (0.05), so that the P-Value value is obtained amounted to 0.1014. The area of criticism used is that the initial hypothesis is rejected if the p-value is smaller than α, therefore because the p-value (0.1014) is greater than α (0.05) causing H0 to be accepted, that is, stationary data is not against the mean.

Stage 2. Data Transformation

Based on the first *differential* value obtained by 1, it will be used in the data transformation process. The transformation method used will be determined based on the largest value of the *Dickey-Fuller* absolute, this is done to check the level of stationary that is better between ddif (differencing*) and dtrans (*differencing with Log-Trans). The test results are shown in the following table.

Table 4.5 Test Results Differencing

Metode	*Dickey Fuller*	*p-value*	*Alternative Hypothesis*
Ddif1	-3,4009	0,07766	stationary
dtrans1	-3,3574	0,08369	stationary

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It can be seen that the value |Dickey-Fuller| ddif1 of 3.4009 is greater than |Dickey-Fuller| dtrans1 which is 3.3574. So for the transformation that will be used in this forecasting data is ddif1 with *differencing* 1.

Stage 3. Model Identification

Based on the results *of the first differentiation*, stationary has been fulfilled, the next step is to determine the estimated value of ACF and PACF. The estimated value used is the result of the transformation of ddif1 through a process that has been done before, and is produced as shown below.

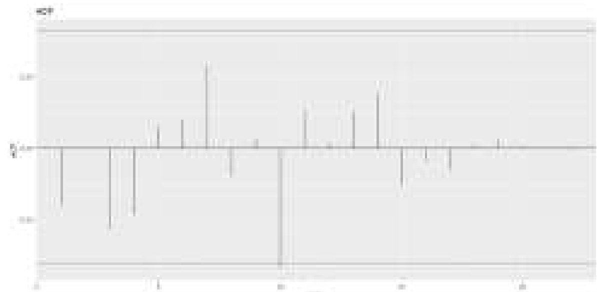

Figure 4.3 ACF plot

Based on the ACF plot image above, it can be seen that there is no line out of the blue line which is the lower *confidence limit* or lower significant limit in the first four lags. That is, on the plot the first *differencing* result is significant at lag 0. It can be concluded that there is no *moving average* (MA) pattern and forms the MA model (0).

Gambar 4.4 Plot PACF

Based on the PACF plot image above, it can be seen that there is a line coming out of the blue line which is *the lower confidence limit* or lower significant limit in the first four lags, namely lag 4. This means that on the plot the first *differencing* result is significant at lag 4. It can be concluded that there is an *autoregressive* (AR) pattern and forms an AR model (4).

Stage 4. Corresponding ARIMA Model Estimation (p,d,q)

Based on the results of ACF plot analysis, PACF, and significant *differencing* results, it can be concluded that the data is stationary and a temporary model can be determined, namely ARIMA (4,1,0).

Stage 5. Data Forecasting Using the Best Model

By using *R Studio software*, the value obtained from the results of forecasting passenger data for 2024 to 2025 which is listed in table 4.6 below.

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Table 4.6 Forecasting Results Using ARIMA Model Method (4,1,0)

Month	Year	
	2024	**2025**
January	279.956	493.241
February	292.724	517.094
March	306.485	542.150
April	321.594	568.485
May	337.659	596.118
June	354.272	625.064
July	371.338	655.380
August	389.091	687.157
September	407.850	720.492
Oktober	427.719	755.464
November	448.620	792.138
Desember	470.458	830.582
TOTAL	**4.407.766**	**7.783.365**

The accuracy and error values obtained in forecasting passenger data through the ARIMA method are as follows.

Table 4.7 Error Size Accuracy

Accuracy components	Training Set
ME	2759,387
RMSE	22236,49
MAE	15393,26
MPE	-13,09136
MAPE	32,66308
MASE	0,2479628
ACF1	-0,1866638

In table 4.7, it is found that the size of the upset in the ARIMA method (4,1,0) has an RMSE value of 2223.69 and a MAPE value of 32.66308.

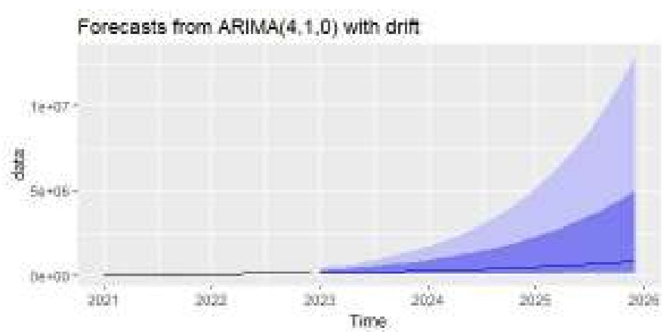

Figure 4.5 Plots of Passenger Number Forecasting Results for 2024-2025

Figure 4.7 shows that a demonstration using the ARIMA model (4,1,0) produces a very high value or increase each year.

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C. Best Method Based on Smallest MAPE Value

From the results of the analysis and discussion that has been explained in the previous sub-chapter, the smallest error value has been obtained from both methods, namely *the Holt-Winter's Exponential Smoothing* method and the ARIMA Box-Jenkins model method (4,1,0) with :

Table 4.8 Comparison Table of Two Error Accuracy Values of Two Methods

Error Accuracy / **Method**	***Holt-Winter's Exponential Smoothing***	**ARIMA Box-Jenkins (4,1,0)**
RMSE	26822,19	22236,49
MAE	20900,83	15393,26
MAPE	**42,39968**	**32,66308**

When viewed from table 4.8 it can be seen that from the two error accuracy values of the two methods above, the forecasting method with the best model with the smallest MAPE value can be chosen, namely the ARIMA Box-Jenkins model method (4,1,0).

The forecasting results that have been calculated and obtained from both forecasting methods, are still not 100% accurate because judging from peak and weak season factors which will affect ticket prices, it can affect the number of passengers coming and going at a time. Also seen from the connectedness of routes and schedules and flight frequencies at the airport.

5. Conclusion

1. Obtained values from *Holt-Winter's Exponential Smoothing* method with and $\alpha = 0{,}8492244 \approx 0{,}8\, \gamma = 0{,}09409181 \approx 0{,}1$ obtained RMSE values = 26822.19, MAE = 20900.83, and MAPE of 42.39968. With a total number of domestic arrival passengers in 2024 of 2,938,253 and in 2025 as many as 3,597,765 passengers came.
2. The best model obtained from the ARIMA method is the ARIMA model (4,1,0) with RMSE value = 22236.49, MAE = 15393.26 and MAPE value of 32.66308. With a total number of domestic arrival passengers in 2024 of 4,407,766 and a total number of passengers in 2025 of 7,783,365 arriving passengers.
3. The best method in forecasting the number of domestic arrival passengers at Yogyakarta International Airport in 2024-2025 when viewed based on the smallest MAPE value, namely, the ARIMA method with a model (4,1,0) for the January 2024 period is 279,956 passengers with a MAPE value obtained of 32.66308.

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