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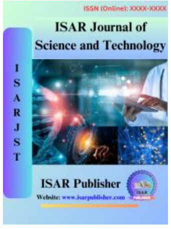

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Modeling of Forecasting the Number of Passenger Departures at I Gusti Ngurah Rai Airport Using the Double Exponential Smoothing and Triple Exponential Smoothing Methods

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Abstract: This study aims to determine the comparison of forecasting methods where the number of passenger departures at I Gusti Ngurah Rai Airport by comparing the Double Exponential Smoothing and Triple Exponential Smoothing methods. The data used is data on the number of passenger departures at the Domestic terminal and International terminal obtained from the Central Bureau of Statistics. The best method obtained is Triple Exponential Smoothing with Additive model for Domestic terminal with constant value α = 0.8182143, β = 0.0001 and γ = 0.0454464. As for the International terminal, the best method obtained is Triple Exponential Smoothing with the Multiplicative model with α = 0.9950000, β = 0.0001, γ = 0.0025000. The accuracy results obtained for the Domestic terminal show a MAPE of 43.68% and MSE of 2437198490.0082073. While the International terminal gets a MAPE of 44.85% and an MSE of 1486733955.6781428.

Keywords: Forecasting, Number of Passengers, Double Exponential Smoothing, Triple Exponential Smoothing, Bali International Airport.

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Introduction

Indonesia has 15 international airports that operate to serve domestic and international flights under PT Pura Angkasa I. Indonesia has 5 airports that have the most traffic in January - August 2023 with an average of 5.1 million domestic passengers and 2.3 million international passengers (BPS, 2023). One of them is I Gusti Ngurah Rai Airport, which is the airport with the highest number of departure passengers after Soekarno-hatta Airport. I Gusti Ngurah Rai Airport is an airport located in the southern part of Bali, this airport serves domestic and international flights as its main flight routes. With very adequate facilities and very professional services make this airport known to the world, where in 2022/2023 I Gusti Ngurah Rai Airport was included in the top 100 ranked 80th in the Skytrax World Airport Awards (Skytrax, 2023).

Based on data from the Central Bureau of Statistics, the normal departure of domestic and international passengers at I Gusti Ngurah Rai Airport can reach 800 thousand to 1 million people per month. In the middle of 2020 to 2022, the number of passengers decreased dramatically with numbers only touching approximately 200 thousand passengers per month. This happens because of external factors such as seasonal factors, weather factors, and special events that affect the ups and downs of the number of domestic and international passengers every month. (BPS, 2023). External factors have a big influence on people's interest in traveling outside the region. The number of passengers will affect the level of service at the airport, so that when there is a surge in passengers, it is necessary to anticipate so that the departure services provided continue to run well and provide comfort for passengers amid the density that occurs at the airport (Banditvilai & Kuharattanachai, 2021; Sai & Sasikala, 2019). With the fluctuating data, the airport is not ready for the unpredictable surge in passengers and must regenerate facilities and services to adjust to existing conditions.

Based on the problems experienced by I Gusti Ngurah Rai Airport, a forecasting model is needed for the number of passenger departures on departure flights to anticipate passenger spikes and special events in the following periods. However, forecasting requires the right method to be able to accurately forecast the number of passengers in the future, so that the airport can readily overcome existing problems. The 2 methods that are suitable for forecasting fluctuating data are Double Exponential Smoothing and Triple Exponential Smoothing.

The first method that will be used for forecasting in the study is Double Exponential Smoothing, which is one of the variations of the Exponential Smoothing method. Double Exponential Smoothing is a method used when data shows a trend (Fitriyani et al., 2022; Suryadana & Sarasvananda, 2024). Double Exponential Smoothing used is a method proposed by Holt's, namely the trend value smoothing method using parameters that are different from

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the parameters used in the original series, where the parameters used in this method are two smoothing parameters, namely alpha and beta (Mirdaolivia & Amelia, 2021; Sudipa et al., 2023). Another method that can be used for forecasting is the Triple Exponential Smoothing method, which is the development of the Double Exponential Smoothing method by adding a third smoothing to stabilize seasonal patterns, so that good forecasting results are obtained, the parameters used are three parameters, namely alpha, beta, gamma parameters (Atmaja et al., 2022; Sarasvananda et al., 2019).

This study aims to compare the two methods to determine which method is more suitable in forecasting the number of departing passengers, so as to obtain a value of forecasting the number of departing passengers that is able to approach the actual value. Comparison of the accuracy of the two methods is carried out based on the error value parameters Mean Absolute Percentage Error (MAPE) and Mean Squared Error (MSE).

Method

Double Exponential Smoothing (DES)

One variant of Double Exponential Smoothing is Double Exponential Smoothing proposed by Holt. Holt's Double Exponential Smoothing (DES) is a trend value smoothing method using different parameters from the parameters used in the original data, where the parameters used in this method are two smoothing parameters, namely alpha (α) and beta (β) with values between 0 and 1 (Adriani et al., n.d.; Wiguna et al., 2023). The formula used in the two-parameter Double Exponential Smoothing (DES) method from Holt (Habsari et al., 2020; Syahrani & Astuti, 2020) :

Initialize the initial value of the smoothing level:

$$S_1 = X_1$$

Initialize the initial value of trend smoothing:

$$b_1 = X_2 - X_1$$

The level smoothing value is determined based on equation :

$$S_t = \alpha X_t + (1 - \alpha)(S_{t-1} + b)_{t-1}$$

The trend smoothing value can be determined based on the equation:

$$b_t = \beta (S_t - S_{t-1}) + (1 - \beta) b_{t-1}$$

The forecast value can be determined based on the equation:

$$F_t = S_t + b_t$$

Description:

S_t = Period t level smoothing value

S_{t-1} = Period t - 1 level smoothing value

α = Level smoothing constant ($0 < \alpha < 1$)

X_t = Actual value of period t

b_t = Trend smoothing in period t

b_{t-1} = Period t - 1 trend smoothing

β = Trend smoothing constant ($0 < \beta < 1$)

F_t = Forecasting value of period t

S_1 = Initialize the initial value of level smoothing

b_1 = Initialize the initial value of trend smoothing

Triple Exponential Smoothing (TES)

Triple Exponential Smoothing is a forecasting algorithm using a seasonal trend data shape, the same as the Double Exponential Smoothing method but there is an additional gamma constant value in order to get a smaller smoothing value and get more accurate forecasting results (Asana et al., 2022; Susila et al., 2022). Triple Exponential Smoothing can also be known as the Holt-Winter method which is a development of the simple exponential smoothing method that uses three smoothing constants, namely constants for overall level smoothing, trend smoothing and seasonal smoothing (Diksa, 2022). This Holt-Winter model uses two approaches, namely Holt-Winter Multiplicative and Holt-Winter Additive (Andriani et al., 2022) :

The Holt-Winter Multiplicative method is used for seasonal variations of time series data that have increased or decreased (fluctuations). With the smoothing value used as follows (Syavasya & Muddana, 2021) :

The initial value of level smoothing is determined by :

$$S_t = \left(\frac{X_1 + X_2 + \cdots + X_n}{n}\right)$$

The initial value of trend smoothing is determined by :

$$b_t = \frac{\left(\frac{X_{t+1} - X_t}{n} + \ldots + \frac{X_{t+1} - X_t}{n}\right)}{n}$$

The initial value of seasonal smoothing is determined by :

$$I_t = \frac{X_t}{S_t}$$

The level smoothing value is determined by :

$$S_t = \alpha \frac{X_t}{I_{t+L}} + (1 - \alpha)(S_{t-1} + b)_{t-1}$$

The trend smoothing value can be determined by :

$$b_t = \beta(S_t - S_{t-1}) + (1 - \beta) b_{t-1}$$

The value of seasonal smoothing can be determined by :

$$I_t = \gamma \left(\frac{X_t}{S_t}\right) + (1 - \gamma)\, I_{t-L}$$

The forecast value can be determined based on the equation:

$$F_t = (S_t + mT_t)\, I_{t-L}$$

The Holt-Winter Additive method is used for seasonal variations of constant time series data. With the smoothing values used as follows:

a. The Initial Value of level smoothing is determined by :

$$S_t = \left(\frac{X_1 + X_2 + \cdots + X_n}{n}\right)$$

The trend smoothing initial value is determined by :

$$b_t = \frac{\left(\frac{X_{t+1} - X_t}{n} + \ldots + \frac{X_{t+1} - X_t}{n}\right)}{n}$$

The initial value of seasonal smoothing is determined by :

$$X_t - I_t$$

The level standard smoothing value is determined based on equation :

$$S_t = \alpha(X_t - I_{t-L}) + (1 - \alpha)(S_{t-1} + b)_{t-1}$$

The trend smoothing value can be determined based on the equation:

$$b_t = \beta(S_t - S_{t-1}) + (1 - \beta)b_{t-1}$$

The seasonal smoothing value can be determined based on equation :

$$I_t = \gamma (X_t - S_t) + (1 - \gamma) I_{t-L}$$

The forecast value can be determined based on the equation:

$$F_t = St + m.b_t + I_{t-L}$$

Description:

S_t = Period t level smoothing

b_t = Period t trend smoothing

S_{-1} = Period t-1 level smoothing

T_{-1} = Period t-1 trend smoothing

I_t = Season adjustment factor

F_t = Forecasting for period t

X_t = Actual data of period t

α= Level smoothing constant

β= Linear trend smoothing constant

γ= Seasonal smoothing constant

L= Number of periods in one season cycle

m= Months to be forecasted in 1 period

Double Exponential Smoothing Modeling

The stages of calculating the number of passenger departures using Double Exponential Smoothing (DES) have several steps, namely Determining the Alpha and Beta parameter values, Initializing the initial level and trend values, Calculating level smoothing, Calculating trend smoothing and Calculating forecasting.

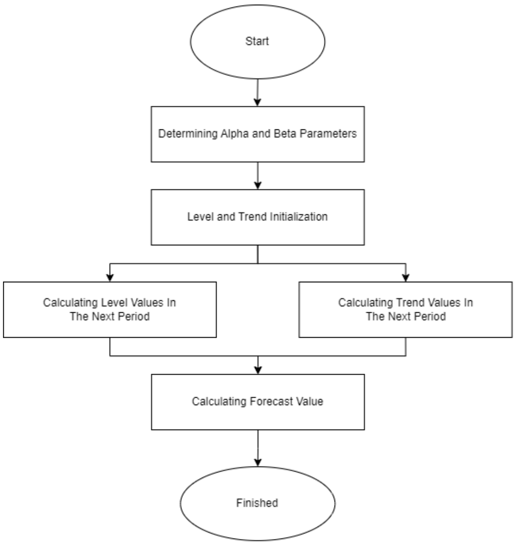

Figure 1. Calculation Flow of Double Exponential Smoothing

Based on figure 1, it can be explained that the initialization process for Holt's Double Exponential Smoothing requires two estimates to understand the trend and initial level of the time series data, namely S_t and b_t . Initialization begins with the level estimate with the formula $S_1 = X_1$ and for the trend estimate obtained from the formula $b_1 = X_2 - X_1$. The smoothing constants α and β in the Double Exponential Smoothing forecasting method act as weighting factors. The values of α and β determine the extent to which recent observations affect the forecast value if α and β are close to one, the latest forecast will include a large adjustment for any errors that occurred in the previous forecast. Conversely, if α and β are close to zero, the latest forecast will be very similar to the old value.

Triple Exponential Smoothing Modeling

The stages of calculating the number of passenger departures using Triple Exponential Smoothing (TES) have several steps, namely Determining the parameter values of Alpha, Beta, and Gamma, Initializing the level, trend and seasonal values in the Multiplicative and Additive models, Performing calculations on the Multiplicative model and Performing calculations on the Additive model.

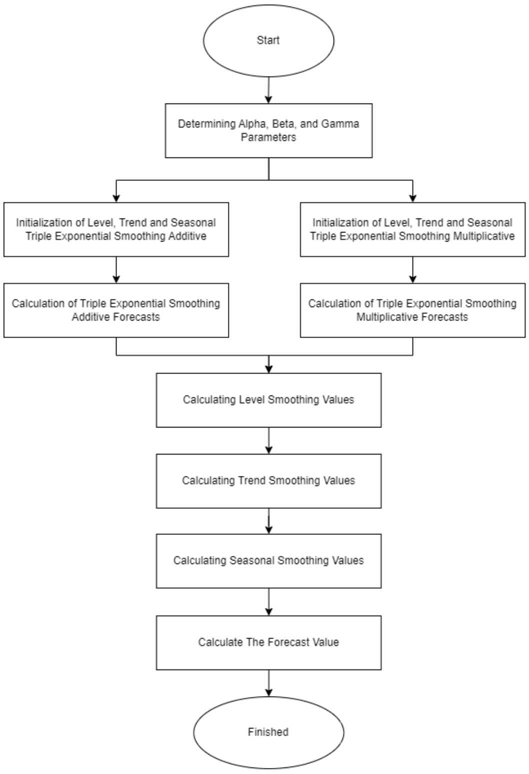

Figure 2. Calculation Flow of Triple Exponential Smoothing

Based on figure 2, it can be explained that the Initialization Process for Triple Exponential Smoothing requires 3 initial estimates, namely level, trend and seasonal values. After getting all the initial values, then proceed to find the Alpha, Beta and Gamma smoothing constants. After getting the constants, the calculation is done with the Multiplicative and Additive models.

The Evaluation process is carried out by comparing the test results to the errors found produced. The forecasting result that produces the smallest error value is the best forecasting to predict the number of passenger departures. Evaluation uses Mean Absolute Percentage Error (MAPE) and Mean Squared Error (MSE).

Data Collection Methods

The data needed for forecasting the number of domestic and international passenger departures in 2010-2023 obtained from the Central Statistics Agency (BPS).

Table 1. Domestic Passenger Departure Data

Period	2010	2011	2012	-	2021	2022	2023
January	207,334	266,295	305,699	-	118,965	317,662	395,523
February	177,417	223,581	232,144	-	71,105	191,034	299,968
March	189,836	229,840	244,916	-	116,888	290,652	329,959
April	203,797	241,933	249,179	-	142,344	224,687	332,397
May	217,123	253,887	248,079	-	121,441	395,423	380,661
June	228,471	279,921	266,074	-	225,671	362,418	423,745
July	264,617	322,512	294,217	-	49,999	408,296	489,801
August	218,281	241,240	308,934	-	47,409	341,349	427,258
September	240,567	307,724	277,000	-	113,912	299,634	389,220
October	249,260	287,098	299,204	-	224,887	341,780	435,859
November	229,486	289,466	260,283	-	274,179	317,266	386,873
December	260,061	299,901	249,064	-	318,264	388,008	429,996

The data in Table 1 displays Domestic passenger departure data from January 2010 to November 2023. This data shows the number of passenger departures in each month, where the highest number in this data is 547,576 and the smallest number is 2,423.

Results and Discussion

Double Exponential Smoothing Method Forecasting

Forecasting using Double Exponential Smoothing requires Alpha and Beta values for the first step to start forecasting. Double Exponential Smoothing method and determine the Alpha and Beta values in order to produce a constant value of the Domestic and International passenger count data in the Double Exponential Smoothing model. The results obtained can be seen in Figure 4.11 for Domestic Data and Figure 4.12 for International Data.

```
                              Holt Model Results
==============================================================================
Dep. Variable:          Data Domestic   No. Observations:                  168
Model:                           Holt   SSE                 550756461032.900
Optimized:                       True   AIC                         3688.980
Trend:                 Multiplicative   BIC                         3701.476
Seasonal:                        None   AICC                        3689.502
Seasonal Periods:                None   Date:                Fri, 24 May 2024
Box-Cox:                        False   Time:                        22:25:09
Box-Cox Coeff.:                  None
==============================================================================
                       coeff                 code              optimized
------------------------------------------------------------------------------
smoothing_level            0.7357143                alpha                 True
smoothing_trend            0.0408730                 beta                 True
initial_level             2.0733e+05                  l.0                False
initial_trend              0.8557063                  b.0                False
------------------------------------------------------------------------------
```

Figure 3. Domestic DES Data Constant Value Output

It can be seen in figure 3 that the output generated for Domestic Data, where the alpha or smoothing level obtained is 0.7357143 and the beta value or smoothing trend with 0.0408730.

```
                              Holt Model Results
==============================================================================
Dep. Variable:     Data International   No. Observations:                  168
Model:                           Holt   SSE                 524957112317.818
Optimized:                       True   AIC                         3680.920
Trend:                 Multiplicative   BIC                         3693.416
Seasonal:                        None   AICC                        3681.442
Seasonal Periods:                None   Date:                Fri, 24 May 2024
Box-Cox:                        False   Time:                        22:38:19
Box-Cox Coeff.:                  None
==============================================================================
                       coeff                 code              optimized
------------------------------------------------------------------------------
smoothing_level            0.9950000                alpha                 True
smoothing_trend               0.0001                 beta                 True
initial_level             2.2487e+05                  l.0                False
initial_trend              0.9304439                  b.0                False
------------------------------------------------------------------------------
```

Figure 4. DES International Constant Value Output

In the International Data shown in Figure 4.12, the resulting output is alpha or smoothing level with a value of 0.9950000 and beta value or smoothing trend with a value of 0.0001.

Plot of Test Data and Train Data DES

After obtaining the results of Train Data and test data, the next step is to form a data plot so that it can easily compare the actual data with the fitted values. The data plot output generated from the above command can be seen in Figure 5 for the Domestic Data plot and Figure 6 for the International Data plot.

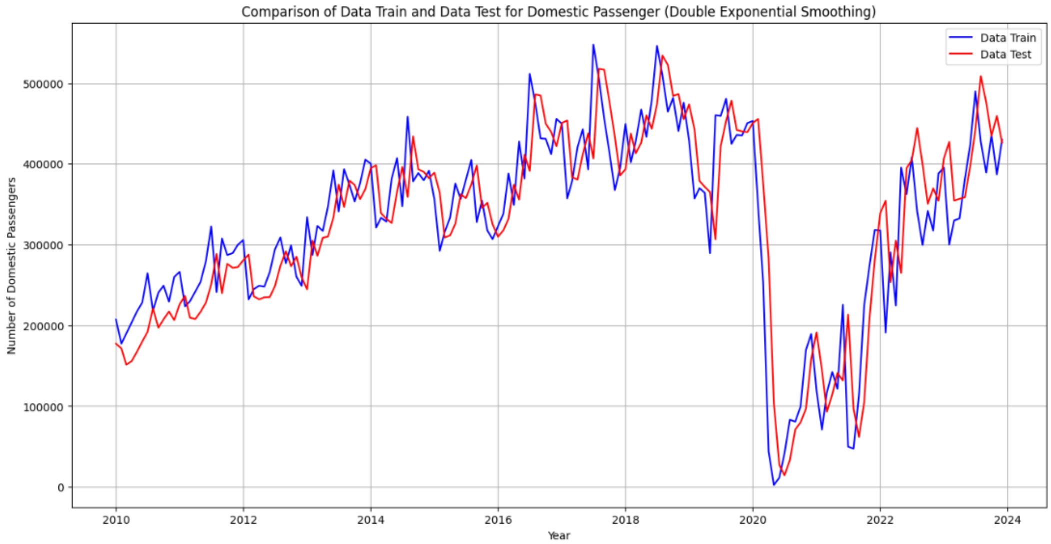

Figure 5. Comparison Data Plot of Domestic DES Data

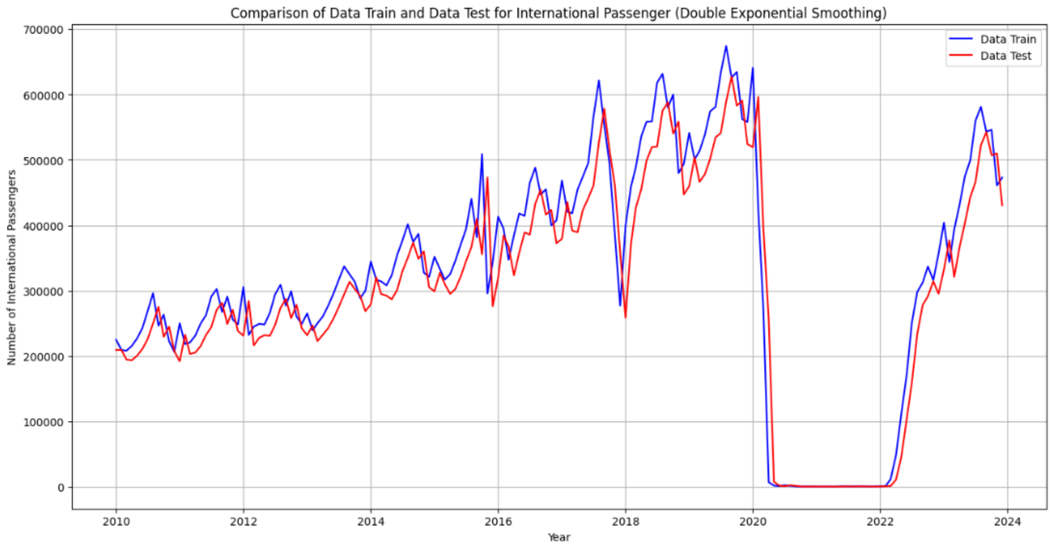

Figure 6. Data Plot of International DES Data Comparison

Double Exponential Smoothing Method Data Testing

After obtaining the data plot, data testing will be carried out using fitted values as test data for the Double Exponential Smoothing method which will later be compared with Triple Exponential Smoothing. Data testing uses MAPE and MSE as an assessment of accuracy. After obtaining the data plot, data testing will be carried out using fitted values as test data for the Double Exponential Smoothing method which will later be compared with Triple Exponential Smoothing. Test results from Domestic passengers get MAPE results of 45.64% and MSE of 3278312268.052977. Test results from International passenger data where MAPE is 44.85% and MSE is 1486733955.6781428.

Table 2. Double Exponential Smoothing Data Test Results

Test data	Domestic Data	Data International
MAPE	45.64%	44.85%
MSE	3278312268.052977	1486733955.6781428

Triple Exponential Smoothing Additive Model

Forecasting with Triple Exponential Smoothing Additive requires Alpha, Beta and Gamma values for the first step to start forecasting. Where Gamma serves to capture existing seasonal patterns. Alpha, Beta and Gamma are determined to find the best constant value to get an accurate comparison using the Triple Exponential Smoothing method. The command to run the Triple Exponential Smoothing Additive model determines the value of Alpha, Beta and Gamma with data on the number of Domestic and International passengers in the Additive model. In applying the Triple Exponential Smoothing Additive method and determining the Alpha, Beta, and Gamma values in order to produce a constant value from the data on the number of Domestic and International passengers in the Triple Exponential Smoothing model. The constant value with Domestic and International passenger count data in the Additive model can be seen in Figure 7 for Domestic Data and Figure 8 for International Data.

```
                       ExponentialSmoothing Model Results
================================================================================
Dep. Variable:                Data Domestic   No. Observations:                  168
Model:                 ExponentialSmoothing   SSE                 409449346321.379
Optimized:                             True   AIC                         3663.171
Trend:                             Additive   BIC                         3713.155
Seasonal:                          Additive   AICC                        3667.762
Seasonal Periods:                        12   Date:                 Fri, 24 May 2024
Box-Cox:                              False   Time:                       22:41:04
Box-Cox Coeff.:                        None
=================================================================================
                          coeff                 code              optimized
---------------------------------------------------------------------------------
smoothing_level               0.8182143                alpha                 True
smoothing_trend                  0.0001                 beta                 True
smoothing_seasonal            0.0454464                gamma                 True
initial_level                2.2275e+05                  l.0                 True
initial_trend                 3706.4970                  b.0                 True
initial_seasons.0             26383.893                  s.0                 True
initial_seasons.1            -37635.523                  s.1                 True
initial_seasons.2            -24780.388                  s.2                 True
initial_seasons.3            -26282.148                  s.3                 True
initial_seasons.4            -5738.8464                  s.4                 True
initial_seasons.5             19915.539                  s.5                 True
initial_seasons.6             23940.435                  s.6                 True
initial_seasons.7             5298.0182                  s.7                 True
initial_seasons.8             11785.456                  s.8                 True
initial_seasons.9             6274.0495                  s.9                 True
initial_seasons.10           -5175.8776                 s.10                 True
initial_seasons.11            6015.3932                 s.11                 True
---------------------------------------------------------------------------------
```

Figure 7. Domestic TES Additive Data Constant Value Output

In Domestic Data with the Additive model, the resulting output is Alpha or smoothing level with a value of 0.8182143, Beta value or smoothing trend with a value of 0.0001 and Gamma value or seasonal smoothing 0.0454464.

```
                       ExponentialSmoothing Model Results
================================================================================
Dep. Variable:           Data International   No. Observations:                  168
Model:                 ExponentialSmoothing   SSE                 294777602741.107
Optimized:                             True   AIC                         3607.968
Trend:                             Additive   BIC                         3657.951
Seasonal:                          Additive   AICC                        3612.558
Seasonal Periods:                        12   Date:                 Fri, 24 May 2024
Box-Cox:                              False   Time:                       22:42:31
Box-Cox Coeff.:                        None
=================================================================================
                          coeff                 code              optimized
---------------------------------------------------------------------------------
smoothing_level               0.9950000                alpha                 True
smoothing_trend                  0.0001                 beta                 True
smoothing_seasonal            0.0050000                gamma                 True
initial_level                2.3508e+05                  l.0                 True
initial_trend                 1455.6028                  b.0                 True
initial_seasons.0             14439.418                  s.0                 True
initial_seasons.1            -27639.582                  s.1                 True
initial_seasons.2            -24174.186                  s.2                 True
initial_seasons.3            -21931.655                  s.3                 True
initial_seasons.4            -12092.477                  s.4                 True
initial_seasons.5             5693.7309                  s.5                 True
initial_seasons.6             28677.981                  s.6                 True
initial_seasons.7             44870.262                  s.7                 True
initial_seasons.8             10418.241                  s.8                 True
initial_seasons.9             21237.148                  s.9                 True
initial_seasons.10           -15709.123                 s.10                 True
initial_seasons.11           -23789.759                 s.11                 True
---------------------------------------------------------------------------------
```

Figure 8. International TES Additive Data Constant Value Output

In International Data with the Additive model, the resulting output is Alpha or smoothing level with a value of 0.9950000, Beta value or smoothing trend with a value of 0.3908929 and Gamma value or seasonal smoothing 0.0050000.

Plot of Test Data and Train Data TES Additive

After obtaining the forecasting results, the data plot is then formed so that it can easily compare the prediction results with the actual data. The data plot output generated from the above command can be seen in Figure 9 for the Domestic Data plot and Figure 10 for the International Data plot.

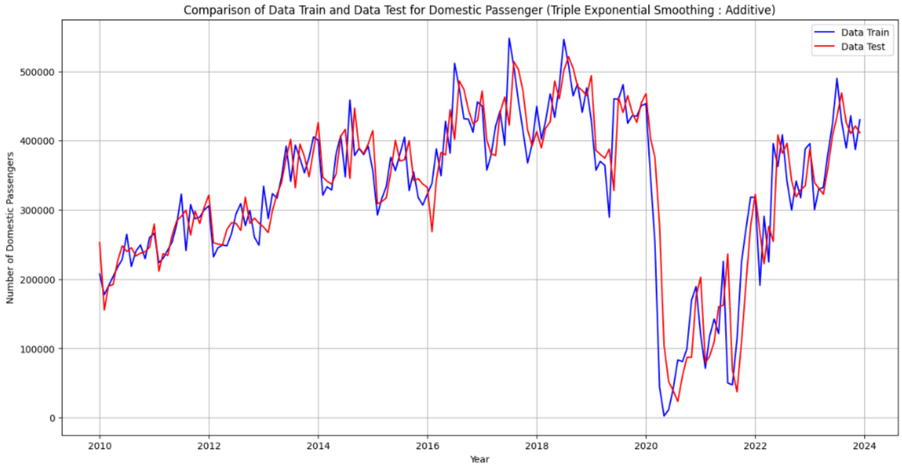

Figure 9. Comparison Data Plot of Domestic TES Additive Data

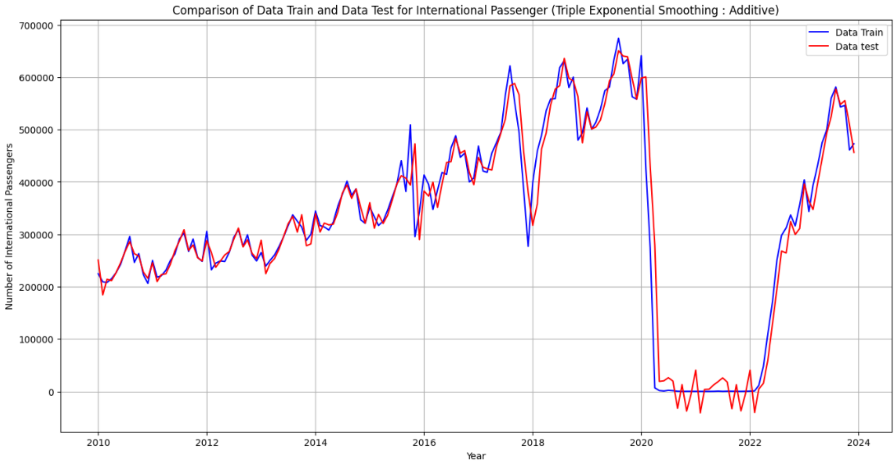

Figure 10. Data Plot of International TES Additive Comparison Data

Triple Exponential Smoothing Data Test Additive Model

After getting the same data plot as before, data testing will be carried out using fitted values as test data for the Triple Exponential Smoothing Additive method which will later be compared with Triple Exponential Smoothing Multiplicative and Double Exponential Smoothing. Domestic passenger data gets MAPE results of 43.68% and MSE of 2437198490.0082073. Domestic passenger data gets MAPE results of 1297.85% and MSE of 1754628587.7446864.

Triple Exponential Smoothing Modeling Multiplicative Modeling

Similar to the Additive model, forecasting with Triple Exponential Smoothing Multiplicative also requires Alpha, Beta and Gamma values for the first step to start forecasting. In applying the Multiplicative Triple Exponential Smoothing method and determining the Alpha, Beta, and Gamma values in order to produce a constant value from the data on the number of Domestic and International passengers in the Multiplicative Triple Exponential Smoothing model. The constant value with the number of Domestic and International passengers in the Multiplicative model can be seen in Figure 11 for Domestic Data and Figure 12 for International Data.

```
                       ExponentialSmoothing Model Results
================================================================================
Dep. Variable:              Data Domestic   No. Observations:                168
Model:               ExponentialSmoothing   SSE                 420511078064.327
Optimized:                           True   AIC                         3667.650
Trend:                     Multiplicative   BIC                         3717.633
Seasonal:                  Multiplicative   AICC                        3672.240
Seasonal Periods:                      12   Date:                Fri, 24 May 2024
Box-Cox:                            False   Time:                       22:52:38
Box-Cox Coeff.:                      None
=================================================================================
                          coeff                 code              optimized
---------------------------------------------------------------------------------
smoothing_level               0.7475000                alpha                True
smoothing_trend                  0.0001                 beta                True
smoothing_seasonal            0.0180357                gamma                True
initial_level                2.2275e+05                  l.0                True
initial_trend                 1.0166397                  b.0                True
initial_seasons.0             1.0872714                  s.0                True
initial_seasons.1             0.8755259                  s.1                True
initial_seasons.2             0.9176963                  s.2                True
initial_seasons.3             0.9164603                  s.3                True
initial_seasons.4             0.9753848                  s.4                True
initial_seasons.5             1.0561283                  s.5                True
initial_seasons.6             1.0979932                  s.6                True
initial_seasons.7             1.0095228                  s.7                True
initial_seasons.8             1.0407451                  s.8                True
initial_seasons.9             1.0257221                  s.9                True
initial_seasons.10            0.9786745                 s.10                True
initial_seasons.11            1.0188752                 s.11                True
---------------------------------------------------------------------------------
```

Figure 11. Output of Constant Value of Multiplicative Domestic TES Data

In Domestic Data with the Multiplicative model, the resulting output is Alpha or smoothing level with a value of 0.7475000, Beta value or smoothing trend with a value of 0.0001 and Gamma value or smoothing seasonal 0.0180357.

```
                       ExponentialSmoothing Model Results
================================================================================
Dep. Variable:        Data International   No. Observations:                 168
Model:              ExponentialSmoothing   SSE                  249771304553.928
Optimized:                          True   AIC                          3580.134
Trend:                    Multiplicative   BIC                          3630.118
Seasonal:                 Multiplicative   AICC                         3584.725
Seasonal Periods:                     12   Date:                Fri, 24 May 2024
Box-Cox:                           False   Time:                        22:55:10
Box-Cox Coeff.:                     None
=================================================================================
                          coeff                 code              optimized
---------------------------------------------------------------------------------
smoothing_level           0.9950000                alpha                True
smoothing_trend              0.0001                 beta                True
smoothing_seasonal        0.0025000                gamma                True
initial_level            2.3508e+05                  l.0                True
initial_trend             1.0061921                  b.0                True
initial_seasons.0         1.0497783                  s.0                True
initial_seasons.1         0.8960786                  s.1                True
initial_seasons.2         0.9108842                  s.2                True
initial_seasons.3         0.9223231                  s.3                True
initial_seasons.4         0.9576379                  s.4                True
initial_seasons.5         1.0177435                  s.5                True
initial_seasons.6         1.1086142                  s.6                True
initial_seasons.7         1.1700775                  s.7                True
initial_seasons.8         1.0361255                  s.8                True
initial_seasons.9         1.0800349                  s.9                True
initial_seasons.10        0.9414616                 s.10                True
initial_seasons.11        0.9092407                 s.11                True
---------------------------------------------------------------------------------
```

Figure 12. International TES Multiplicative Data Constant Value Output

In Data International with the Multiplicative model, the resulting output is Alpha or smoothing level with a value of 0.9950000, Beta value or smoothing trend with a value of 0.0001 and Gamma value or seasonal smoothing 0.0025000.

Plot of Test Data and Train Data TES Multiplicative

After obtaining the forecasting results, the data plot is then formed so that it can easily compare the prediction results with the actual data. The data plot output generated from the above command can be seen in Figure 13 for the Domestic Data plot and Figure 14 for the International Data plot.

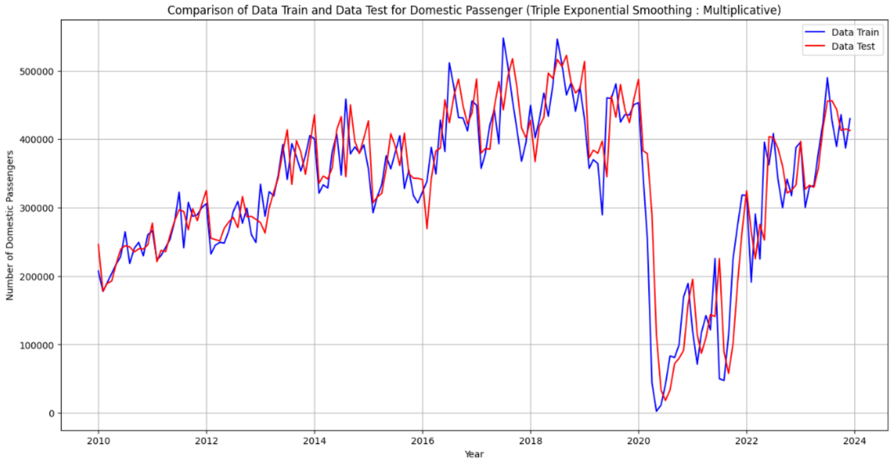

Figure 13. Comparative Data Plot of Multiplicative Domestic TES Data

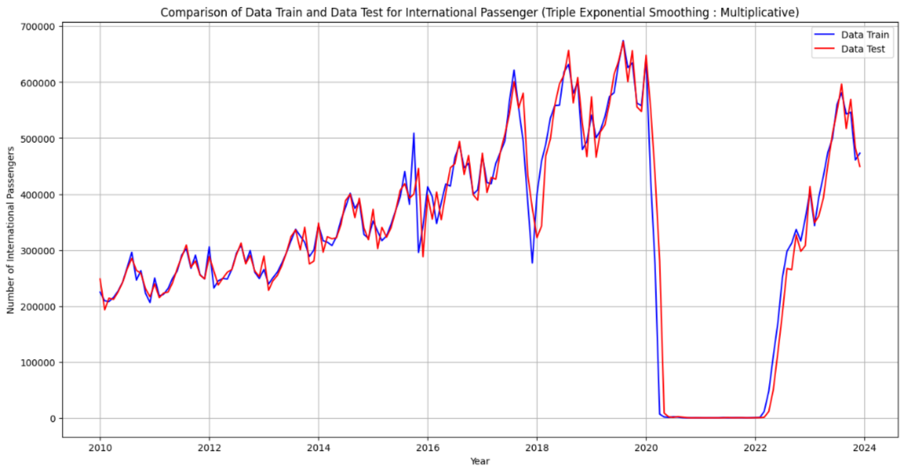

Figure 14. Data Plot of International TES Multiplicative Comparison Data

Data Test of Triple Exponential Smoothing Multiplicative Model

Domestic passenger data gets MAPE results of 45.62% and MSE of 2503042131.3352785. International passenger data gets MAPE results of 46.89% and MSE of 3124744716.177487.

Method Value Comparison

After obtaining all the test data values for each method, they will then be compared to determine the best accuracy value at each terminal. The comparison table can be seen in Table 2 and Table 3.

Table 2. Comparison of Test Data Error on Domestic Data

Method	MAPE	MSE
DES	45.64%	3278312268.052977
TES Additive	43.68%	2437198490.0082073
Multiplicative TES	45.62%	2503042131.3352785

Table 2 above shows that the MAPE and MSE values of all methods have MAPE with sufficient values because they are within the range of 20%>50%. The smallest MAPE and MSE fall to the Triple Exponential Smoothing Additive model with a MAPE value of 43.68% and an MSE value of 2437198490.0082073. Comparison for data on the number of domestic passengers can be concluded that the Triple Exponential Smoothing method with the Additive model is more suitable for forecasting the number of domestic passenger departures at I Gusti Ngurah Rai Airport in the future.

Table 3. Comparison of Test Data Error on International Data

Methods	MAPE	MSE
DES	46.89%	3124744716.177487
TES Additive	1297.85%	1754628587.7446864
Multiplicative TES	44.85%	1486733955.6781428

In Table 3. it can be seen that the MAPE and MSE values, 2 of them have sufficient MAPE, but 1 method has a very large value with a value of 1297.85% which indicates that the method is not very suitable for use in data on the number of international passengers. The smallest MAPE and MSE fall to Multiplicative Triple Exponential Smoothing with a MAPE value of 44.85% and an MSE value of 1486733955.6781428. It can be concluded that the Triple Exponential Smoothing method with the Multiplicative model is more suitable for forecasting the number of international passenger departures at I Gusti Ngurah Rai Airport in the future.

Domestic Passenger Departure Forecasting

After finding the best method from the three methods that have been compared, then forecasting the number of passengers from the Domestic and International terminals, there is a Triple Exponential Smoothing Additive model which is the best method. There are forecasting results in the form of numbers and data plots from January 2024 to December 2024.

Table 4. Additive Triple Exponential Smoothing Forecasting Results

Period	**Forecast**
2024-01-01	434062
2024-02-01	377207
2024-03-01	402870
2024-04-01	395681
2024-05-01	425341
2024-06-01	455082
2024-07-01	470909
2024-08-01	455408
2024-09-01	446680
2024-10-01	463665
2024-11-01	450829
2024-12-01	470556

The data plot to clarify the forecasting results can be seen in Figure 15.

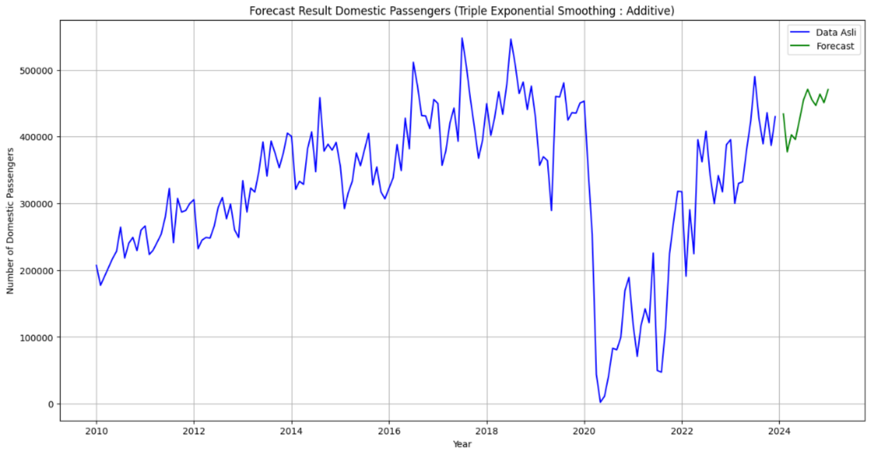

Figure 15. Data Plot of Forecasting Results for Domestic Passenger Data

International Passenger Departure Forecasting

With the Triple Exponential Smoothing Multiplicative model being the best method. there are forecasting results in the form of numbers and data plots from January 2024 to December 2024.

Table 5. Multiplicative Triple Exponential Smoothing Forecasting Results

Period	Forecast
2024-01-01	549070
2024-02-01	473719
2024-03-01	497443
2024-04-01	496551
2024-05-01	519796
2024-06-01	556411
2024-07-01	610133
2024-08-01	650003
2024-09-01	578252
2024-10-01	606272
2024-11-01	535854
2024-12-01	522282

The data plot to clarify the forecasting results can be seen in Figure 16.

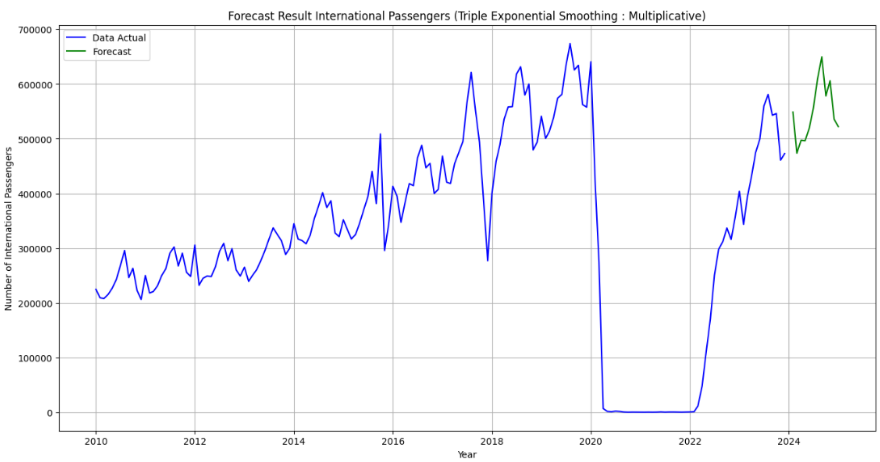

Figure 16. Data Plot of International Passenger Data Forecasting Results

Conclusion and Suggestions

The conclusion of this study shows that the Triple Exponential Smoothing (TES) method has the best performance in forecasting the number of passenger departures at I Gusti Ngurah Rai Airport compared to the Double Exponential Smoothing (DES) method. For data on the number of domestic passenger departures, the TES Additive model produces a Mean Absolute Percentage Error (MAPE) value of 43.68% and a Mean Squared Error (MSE) of 2,437,198,490, which indicates that this model has a fairly good level of accuracy and the smallest error among other methods. The forecasting results for the next 12 months show an increasing trend in the number of domestic passengers. Meanwhile, for data on the number of international passenger departures, the Multiplicative TES model provides the best results with a MAPE value of 44.85% and MSE of 1,486,733,955. Although both TES methods (Additive and Multiplicative) show good results, the Multiplicative TES is superior for international data, considering that the Additive TES method shows very high MAPE results and is not suitable for use. Forecasting for the next 12 months also shows an increasing trend in the number of international passengers. Overall, this study identified TES as the most effective forecasting method for passenger departure data at the airport, with the Additive model suitable for domestic data and the Multiplicative model for international data, each showing an increasing trend in future passenger numbers. The research suggestion is that based on the results of data analysis and conclusions made, the suggestion from the author is that further research is needed by comparing other time series forecasting methods to obtain more accurate forecasting results which are useful as a consideration for I Gusti Ngurah Rai Airport flights to determine policies in terms of forecasting the number of passengers.

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