The Comparison of Double Moving Average and Double Exponential Smoothing Methods in Forecasting the Number of Foreign Tourists Coming to North Sumatera

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Abstract. In Mathematics, Forecasting is scientific. Forecasting uses statistical techniques to describe the future using previous data. Based on North Sumatra BPS data, the number of foreign tourists coming to North Sumatra fluctuates. Therefore, forecasting the number of foreign tourism needs to be done so that tourism actors can prepare themselves. The purpose of this study is to compare time series forecasting methods, namely Double Moving Average (DMA) and Double Exponential Smoothing (DES). Then the number of tourists is predicted using the best method, the method with the smallest MAPE. The research data in the form of secondary data obtained from BPS as many as 108 data, from January 2010 to December 2018. The calculation process uses Ms. Excel. The results showed that the 12th time order on DMA had the smallest MAPE value, which was 14.12%. Whereas the DES Brown method with and DES Holt yielding MAPE values respectively 12.71% and 12.21%. Forecasting the number of foreign tourists coming to North Sumatra in 2019 using the DES Holt method.

1. INTRODUCTION

Tourism as one of the economic sectors plays an important role in driving economic growth and social welfare. The development of the tourism sector has a positive impact on people's welfare. Pye and Lin say that the tourism industry has contributed a lot to the speed, acceleration, and direction of development in developing countries so that it can be considered as an "entry point" for people's welfare [7]. Therefore, attention to the tourism sector is needed. The performance of the tourism sector is determined by the ability to bring in as many tourists as possible.

North Sumatra as one of the largest provinces in Indonesia has huge tourism potential, both natural, cultural and culinary tourism potential. All the potential possessed has attracted the interest of tourists, especially foreign tourists to come to North Sumatra. The number of foreign tourists coming to North Sumatra fluctuates, this can be seen from BPS data. The number of tourists that fluctuates has an
impact on tourism actors. Therefore, forecasting the number of foreign tourists coming to North Sumatra is needed. From the results of these forecasts, tourism actors can develop various strategies and actions in dealing with the possibilities that can occur in the future.

Buffa say that forecasting is the use of statistical techniques in the form of a future picture based on the processing of historical figures [3]. With the use of relevant data in the past, it is expected to provide greater objectivity. Furthermore, the use of these techniques is expected to provide a greater level of confidence because they can be tested for irregularities that occur scientifically.

Research on forecasting, especially about time series (time series) that is data obtained from time to time has been done. Some of these studies are Chu applied three univariate-based ARMA models and found that the ARMA-based model is very good, the average percentage of errors is less than two percent [5]. Chen shows that the combined use of linear and nonlinear methods can improve the accuracy of forecasting results in the Inbound Outbound Tourism data series in Taiwan [4]. Furthermore, Erie Sadewo in his writing compared several time series methods in forecasting the number of tourist arrivals in the Karimun Regency, Riau Islands Province [8]. In this paper, he compared five methods, namely Naïve Method, Double Moving Average (DMA), Double Exponential Smoothing (DES), Linear Regression Against Time and Jenkins ARIMA Box. The results of this study, the DMA method is the best method to describe data patterns and predict. Azizah and Hudiyanti shows the comparison of Double Moving Average and Brown’s Double Exponential Smoothing. Azizah forecasted the number of migrations entering the city of Surabaya in 2015 [2]. Hudiyanti forecasted the number of foreign tourist arrivals at Ngurah Rai Airport [6]. Ariyanto uses the Double Exponential Smoothing Holt Method in the forecasting of food crop production [1].

In this study, forecasting the number of foreign tourists coming to North Sumatra using the Double Moving Average (DMA) and Double Exponential Smoothing (DES) methods. The use of both methods is to accommodate the trend patterns that occur in research data. Researchers tested several parameters to get the best parameter values for each method. Next, the researchers made an accuracy comparison through MAPE for the two methods. Forecasting the number of tourists in 2019 using the method that has the smallest MAPE.

2. RESEARCH METHOD

In conducting this research, researchers conducted systematic stages to get good research results. The stages begin with the study of literature, the formulation of problems, solving problems and ending with concluding. At the literature study stage, researchers read books and journals to obtain the information needed, namely the models and methods used. Next, the researcher formulated the problem to be solved, namely (1) looking for a time order that produced the smallest MAPE value in the Double Moving Average (DMA) method (2) looking for an alpha value (\( \alpha \)) that had the smallest MAPE value in the Double Exponential Smoothing Brown (DES Brown method) ) (3) find the alpha (\( \alpha \)) and Beta (\( \beta \)) values that produce the smallest MAPE value in the Double Exponential Smoothing Holt (DES Holt) method.

In the problem-solving stage, researchers conducted data collection and processing. The data used are secondary data sourced from The Central Agency on Statistics (BPS) of North Sumatra totaling 108 data. For data processing, researchers use the Smoothing method, which is a forecasting method that performs refinement of past data by taking an average of values over several periods to estimate the value of a period. The Smoothing methods used are the DMA, DES Brown and DES Holt methods. In data processing, to make calculations easier, researchers use Ms. Excel. In the final stage, researchers compared the MAPE values of the three methods used. The best method in this study is the method.
that has the smallest MAPE. Furthermore, using the best method for forecasting the number of foreign tourists coming to North Sumatra in the future.

2.1. Double Moving Average (DMA) Method

Moving Average method is a predicting method that is done by taking a group of observations, looking for the average value as a forecast for the next period. In the DMA method, the moving average process occurs twice. The steps in forecasting using the DMA method are as follows

a. Calculates Single Moving Average ($S'_i$)

$$S'_i = \frac{X_i + X_{i-1} + X_{i-2} + \Lambda + X_{i-n-1}}{n}$$

(1)

b. Calculate Double Moving Average ($S''_i$)

$$S''_i = \frac{S'_i+S'_{i-1}+S'_{i-2}+\Lambda + S'_{i-n-1}}{n}$$

(2)

c. Determine the amount of constant value

$$a_i = 2S'_i - S''_i$$

(3)

d. Determine the amount of trend

$$b_i = \frac{2}{n-1}(S'_i - S''_i)$$

(4)

e. Determine the forecast value

$$F_{t+p} = a_i + b_i m$$

(5)

2.2. Double Exponential Smoothing (DES) Method

Exponential Smoothing method is a method that makes continuous improvements to forecasting the latest observation objects. In other words, the latest observation will be given a higher priority for forecasting than the longer observation. The DES method is used when data shows a trend. A trend is a smoothed estimate of the average growth at the end of each period. There are two methods in DES, namely the DES Brown Method and DES Holt.

2.2.1. Brown's Double Exponential Smoothing (DES) Method

The method developed by Brown can overcome the differences that arise between the actual data and forecast values due to trends in the plot. This method uses a smoothing parameter, namely alpha with magnitude $0 < \alpha < 1$. Following are the steps in using the DES Brown method

a. Calculate Single Exponential Smoothing ($S'$)

$$S'_i = \alpha X_i + (1-\alpha)S'_{i-1}$$

(6)

b. Calculate Double Moving Average ($S''$)

$$S''_i = \alpha S'_i + (1-\alpha)S''_{i-1}$$

(7)

c. Determine the amount of constant value

$$a_i = 2S'_i - S''_i$$

(8)
d. Determine the amount of trend

\[ b_t = \frac{\alpha}{1 - \alpha} (S'_t - S''_t) \]  \hspace{1cm} (9)

e. Determine the forecast value

\[ F_{t+m} = a_t + b_tm \]  \hspace{1cm} (10)

At the period \( t = 1 \), value \( S'_{t-1} \) and \( S''_{t-1} \) set equal to \( X_1 \).

### 2.2.2. Double Exponential Smoothing (DES) Holt Method

In this method, the trend value is not smoothed by double smoothing directly, but the trend smoothing process is carried out with parameters different from the parameters in the actual data smoothing. The steps for using the Holt DES method are as follows

a. The Total smoothing

\[ S_t = \alpha X_t + (1 - \alpha) (S'_{t-1} + T_{t-1}) ; \hspace{0.5cm} 0 < \alpha < 1 \]  \hspace{1cm} (11)

b. The trend smoothing

\[ T_t = \beta (S_t - S_{t-1}) S'_t + (1 - \beta) T_{t-1} ; \hspace{0.5cm} 0 < \beta < 1 \]  \hspace{1cm} (12)

c. Determine the forecast value

\[ F_{t+m} = S_t + T_tm \]  \hspace{1cm} (13)

At the period \( t = 1 \), value \( S'_{t-1} = X_1 \) and \( T_{t-1} = \frac{X_3 - X_2 + X_5 + X_4}{2} \) \hspace{1cm} (14)

### 2.3. Mean Absolute Percentage Error (MAPE)

To calculate the accuracy of forecasting results, researchers use MAPE. MAPE measures the average absolute error as a percentage of the average value of the absolute error rate of the actual data period. The following equation is used:

\[ MAPE = \frac{1}{n} \sum_{t=1}^{n} \frac{|Y(t) - Y'(t)|}{Y(t)} \times 100\% \]  \hspace{1cm} (15)

Where \( Y(t) \) is the actual data, \( Y'(t) \) is the forecast value and \( n \) is the amount of data used.

MAPE accuracy criteria can be seen in the following Table 1.

| Criteria | The limit of MAPE Percentage |
|----------|-------------------------------|
| Very good| < 10%                         |
| Good     | 10% - 20%                     |
| Enough   | 20% - 50%                     |
| Not Accurate | >50%                    |

### 3. RESULTS AND DISCUSSION
3.1. Research data

The research data is secondary data in the form of data on the number of foreign tourists coming to North Sumatra from January 2010 to December 2018 with a total of 108 data. Data were taken directly from BPS North Sumatra. The graph of the data can be seen in Figure 1 below:

![The Total Forecasting Of Foreign Tourists Coming To North Sumatra](image)

Figure 1. The number of Foreign Tourists Visiting North Sumatra

From Figure 1, it can be seen that the amount of tourist data coming to Sumatra fluctuates. The data shows a trend that is increasing from October to December each year and then has decreased in January and February. The minimum data is 13103 in January 2016 and the maximum data is 33017 in December 2014. The average value of the data is 19968.15 and the standard deviation value is 3629.003.

3.2. Forecasting with DMA.

In the process of forecasting with DMA, the most important thing to do is to determine the value of the time orde. The choice of time orde value is done by trial and error. Testing with the help of Ms. Excel to determine the best time orde value that provides accurate forecasting results, the smallest MAPE value. The results of several time orde values and the resulting MAPE can be seen in the following table:

| Order Time | MAPE | Order Time | MAPE | Order Time | MAPE | Order Time | MAPE |
|------------|------|------------|------|------------|------|------------|------|
| 2          | 20.62| 7          | 15.60| 12         | 14.12| 17         | 15.66|
| 3          | 17.95| 8          | 15.90| 13         | 14.16| 18         | 16.12|
| 4          | 16.54| 9          | 15.75| 14         | 14.54| 19         | 16.15|
| 5          | 15.75| 10         | 16.02| 15         | 14.96| 20         | 16.49|
| 6          | 15.47| 11         | 15.38| 16         | 15.38|--          |     |
From Table 2. It can be seen that MAPE from time order does not have a large difference. The time order that gives the smallest MAPE value of 14.12% with GOOD criteria is the order of time 12. The graph of forecasting results from several time orders can be seen in Figure 2 below.

![Graph Effect of Some Time Order on Forecasting Results](image_url)

Figure 2. The influence graph of several time orders on the results of forecasting

3.3. Forecasting with DES Brown

Testing the effect of the value of alpha parameters is done to find the alpha value that has the best accuracy in forecasting. The alpha parameter selection is done by trial and error until finding the alpha value that produces the smallest MAPE. Testing is done with the help of Ms. Excel. MAPE from testing some Alpha values can be seen in the following table.

| ALPHA (α) | MAPE  | ALPHA (α) | MAPE  | ALPHA (α) | MAPE  | ALPHA (α) | MAPE  |
|-----------|-------|-----------|-------|-----------|-------|-----------|-------|
| 0.1       | 12.77 | 0.6       | 15.91 | 0.01      | 12.71 | 0.06      | 12.78 |
| 0.2       | 13.21 | 0.7       | 17.35 | 0.02      | 12.75 | 0.07      | 12.77 |
| 0.3       | 13.76 | 0.8       | 19.21 | 0.03      | 12.75 | 0.08      | 12.74 |
| 0.4       | 14.39 | 0.9       | 21.32 | 0.04      | 12.76 | 0.09      | 12.73 |
| 0.5       | 14.92 | 0.5       | 12.78 |           |       |           |       |

In Table 3 it can be seen that the MAPE values obtained for any alpha value chosen are between 12% to 22%. The alpha value that provides the most accurate forecasting results is 0.01 with a MAPE value of 12.71% and is in the GOOD criteria. The graph in Figure 3 shows the results of forecasting some alpha values.
3.4. Forecasting with DES Holt.

In forecasting using the Holt DES method, testing is carried out using two-parameter values at once, namely alpha and beta. The test is done to get the most accurate alpha and beta parameter pairs, which have the smallest MAPE values. The selection of alpha and beta is done by trial and error, while testing uses Ms. Excel. The following table shows pairs of alpha and beta values and the resulting MAPE values.

| ALPHA (α) | BETA (β) | MAPE | ALPHA (α) | BETA (β) | MAPE | ALPHA (α) | BETA (β) | MAPE |
|-----------|----------|------|-----------|----------|------|-----------|----------|------|
| 0.1       | 0.1      | 13.73| 0.3       | 0.1      | 12.67| 0.7       | 0.1      | 13.14|
| 0.1       | 0.2      | 13.82| 0.3       | 0.01     | 12.42| 0.7       | 0.01     | 13.35|
| 0.1       | 0.01     | 12.84| 0.4       | 0.1      | 13.34| 0.8       | 0.1      | 13.23|
| 0.1       | 0.02     | 13.04| 0.4       | 0.01     | 12.65| 0.8       | 0.01     | 13.49|
| 0.2       | 0.1      | 12.79| 0.5       | 0.1      | 12.84| 0.9       | 0.1      | 13.36|
| 0.2       | 0.2      | 13.04| 0.5       | 0.01     | 12.93| 0.9       | 0.2      | 13.07|
| 0.2       | 0.01     | 12.21| 0.6       | 0.1      | 13.01| 0.9       | 0.01     | 13.76|
| 0.2       | 0.02     | 12.39| 0.6       | 0.01     | 13.16| 0.9       | 0.02     | 13.72|

Based on Table 4 it can be seen that for any Alpha and Beta values have a MAPE value between 12% to 14%. When the alpha value of 0.2 and the beta value of 0.01 obtained MAPE value of 12.21%, it means that the forecasting results are good. In Figure 4 below, we can see the graph of the influence of several pairs of Alpha and Beta values on the forecast value.
3.5 The comparison of Forecasting Results

Forecasting methods are said to be accurate based on the resulting MAPE values. A method is said to be accurate if the method produces the smallest MAPE value. Table 5 below shows the comparison of MAPE values obtained from each method.

Table 5. The comparison of Forecasting Accuracy Models

| Method                                | MAPE   |
|---------------------------------------|--------|
| Double Moving Average (DMA) Order Time = 12 | 14.12% |
| Double Exponential Smoothing Brown (DES Brown) $\alpha = 0.01$ | 12.71% |
| Double Exponential Smoothing Holt (DES Holt) $\alpha = 0.2, \beta = 0.01$ | 12.21% |

From Table 5 it can be seen that the forecasting accuracy of the three methods is in the good criteria. The method that produces the smallest MAPE value is the DES Holt method for Alpha 0.2 and Beta 0.01 values. Furthermore, the DES Holt method will be used in forecasting the number of foreign tourists coming to North Sumatra in 2019.

3.6. Forecasting the Number of Foreign Tourists Visiting North Sumatra

The final stage in this study is forecasting the number of foreign tourists coming to North Sumatra using the Holt DES method. Table 6 below shows the calculations on the DES Holt method in determining the value and what is used in forecasting 2019.
Tabl(e 6. The calculations DES Holt Model

|         | S'(t) | T(t)  |
|---------|-------|-------|
| Jan '10 | 14067 | 14067 |
| Feb     | 15765 | 14307 |
| Mar     | 17038 | 14756.52 |
| Apr     | 15091 | 14731.29 |
| ...     | ...   | ...   |
| ...     | ...   | ...   |
| Sep '18 | 20015 | 20785.09 |
| Oct     | 16130 | 19842.2 |
| Nov     | 22737 | 20401.87 |
| Dec     | 21787 | 20664.27 |

Furthermore, in Table 7, forecasting values in 2019 are seen using the DES Holt model with Alpha = 0.2 and Beta = 0.01.

Table 7. Forecasting the Number of Foreign Tourists Coming to North Sumatra

| Month    | The amount of Forecasting | Month   | The amount of Forecasting |
|----------|----------------------------|---------|---------------------------|
| January  | 20648.80135                | July    | 20555.97007               |
| February | 20633.32947                | August  | 20540.49819               |
| March    | 20617.85759                | September | 20525.02631          |
| April    | 20602.38571                | October | 20509.55443               |
| May      | 20586.91383                | November | 20494.08255            |
| June     | 20571.44195                | December | 20478.61067            |

4. CONCLUSION

The Double Moving Average (DMA) method and the Double Exponential Smoothing (DES) method can be used in forecasting the number of foreign tourists coming to North Sumatra. In the DMA method, the MAPE value was 14.12% in the 12th time order. In the DES Brown method, the MAPE value was obtained 12.71% in taking the Alpha value of 0.01. Whereas in the DES holt method, the pair of Alpha values = 0.2 and Beta = 0.01 yields a MAPE value of 12.21%. Of the three methods used, the Holt DES method is the most accurate.

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References

[1] Ariyanto R, Puspitasari D and Ericawati F 2017 Penerapan metode double exponential smoothing pada peramalan produksi tanaman padi J. Informatika Polinema 4(1) 57-62

[2] Azizah A F N 2015 Peramalan migrasi masuk kota surabaya tahun 2015 dengan metode double moving average dan double exponential smoothing brown J. Biometrika dan Kependudukan 4(2) 172-80.

[3] Buffa E S and Sarin R K 1996 Modern Production and Operation Management ed.8 (London : Jhon Willey and Sons Inc)

[4] Chen K 2011 Combining linier and nonlinier model in forecasting tourism demand Expert Systems With Applications 38(8) 10368-76

[5] Chu F 2009 Analyzing anf forecasting tourism demand with ARAR algorithm Tourism Management 29(6) 1185-96

[6] Hudiyanti C V, Bachtiar F A and Setiawan B D 2019 Perbandingan double moving average dan double exponential smoothing untuk peramalan jumlah kedatangan wisatawan mancanegara di bandara ngurah rai, J. Pengembangan Teknologi Informasi dan Ilmu Komputer 3(3) 2667-72

[7] Pye E A and Lin T B 1983 Tourism in Asia, The Economic Impact (Singapura: Siangapore University Press)

[8] Sadewo E 2013 Perbandingan beberapa metode time series pada peramalan jumlah kunjungan wisatawan mancanegara : studi kasus di kabupaten Karimun, Provinsi Kepulaun Riau https://www.researchgate.net/publication/311558057