Time series of mathematics education program, FKIP university of jember enthusiast through exponential smoothing method

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Abstract. The purpose of this research was to discuss the implementation of exponential smoothing methods in predicting the number of Mathematics Education Study Program enthusiasts, FKIP University of Jember based on entrance exam. The methodology of the exponential smoothing forecasting method were sketching the time series plot, identifying the model, selecting the best model and forecasting. The accuracy of the estimation results could be seen from the smallest MAPE value. The results of this research showed that the forecasting results were close to the actual data because the MAPE value obtained in this research respectively are close to criteria good or quite good. As a result it can be concluded that forecasting with the exponential smoothing method in predicting the number of Mathematics Education Study Program enthusiasts, FKIP University of Jember had good accuracy since MAPE on ten percent to twenty percent, and had quite good accuracy since MAPE on twenty percent to fifty percent.

1. Introduction

Society's need for education was marked by the increasing quality of education at university. The higher quality of education at a universities, the more prospective students want to enter the universities. One of the universities has increased the number of prospective students this year is University of Jember. The increasing number of prospective students at the University of Jember indirectly affects the increased prospective student enthusiasts in each Study Program in it, one of which is the Mathematics Education Study Program. Based on data from BAAK (Academic and Student Accreditation Bureau) of Jember University, the number of Mathematics Education Study Program enthusiasts in 2018 has increased compared to the previous year.

The number of Mathematics Education Study Program enthusiasts, FKIP University of Jember each year forms a data pattern that will continue in the future. The data could be analyzed using time series analysis. Time series analysis was a tool for analyzing a set of data in a certain time period [1]. The time period referred to in time series could be form of years, quarters, months, weeks and in some cases days or hours [2]. Data obtained from time series analysis form patterns that could be used to forecast decisions in future [3].

Forecasting was the science that predicts events in the future [4]. Forecasting generally used historical data and projected into future with various mathematical models [5]. Forecasting was

divided into two categories namely, qualitative forecasting and quantitative forecasting [6]. Quantitative forecasting could be solved by many methods, one is the exponential smoothing method [7].

The exponential smoothing method was a forecasting method that would be used to predict the Mathematics Education Study Program enthusiasts, FKIP University of Jember. Exponential smoothing method was expected to provide the best result with a high degree of accuracy. The exponential smoothing method was a fairly good method of forecasting long-term or short-term [8]. Other research conducted by [9] that discusses the exponential smoothing method was an exact method for predicting the sales volume of PT Satriamandiri Citramulia based on the value of MSE (Mean Squared Error) and MAPE (Mean Absolute Percentage Error) compared to moving average method and the winters method.

Every prediction result had an error in its formulation. The error level in the result of forecasting the number Mathematics Education Study Program enthusiasts, FKIP University of Jember could be found by looking at the MAPE value [10]. The smaller MAPE value obtained, the better of forecasting result, was 0% to 30% [11].

Based on the description and relevance of the discussion above, the research was to discuss the implementation of exponential smoothing methods in predicting the number of Mathematics Education Study Program enthusiasts, FKIP University of Jember based on entrance exam. The novelty of this research was the exponential smoothing method was applied to predict the number of Mathematics Education Study Program enthusiasts.

2. Major Heading

2.1. Exponential Smoothing Method
Models classification in exponential smoothing method was double exponential smoothing, holt winters additive exponential smoothing and holt winters multiplicative exponential smoothing [12].

2.1.1. Double Exponential Smoothing. The criteria of double exponential smoothing model was based on two smoothing equations [13].

$$S_t = \alpha X_t + (1-\alpha)(S_{t-1} + B_{t-1}) \tag{1}$$

$$B_t = \gamma(S_t - S_{t-1}) + (1-\gamma)B_{t-1} \tag{2}$$

$$F_{t+m} = S_t + B_t m \tag{3}$$

Where:
X_t = actual data period to t
α = total smoothing constant ($0 < \alpha < 1$)
γ = trend smoothing constant ($0 < \gamma < 1$)
S_t = value of smoothing period to t
B_t = value of trend smoothing of the period to t
F_{t+m} = forecast value for m future period from t.

2.1.2. Holt Winters Multiplicative Exponential Smoothing. Different from double exponential smoothing model, holt winters multiplicative exponential smoothing model has criteria based on three smoothing equations [7].

$$S_t = \alpha \frac{X_t}{I_{t-L}} + (1-\alpha)(S_{t-1} + B_{t-1}) \tag{4}$$

$$B_t = \gamma(S_t - S_{t-1}) + (1-\gamma)B_{t-1} \tag{5}$$

$$I_t = \delta \frac{X_t}{S_t} + (1-\delta)I_{t-L} \tag{6}$$

$$F_{t+m} = (S_t + B_t m)I_{t-L+m} \qquad (7)$$

Where:

X_t = actual data period to t

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

γ = trend smoothing constant $(0 < \gamma < 1)$

δ = seasonal smoothing constant $(0 < \delta < 1)$

S_t = value of smoothing period to t

B_t = value of trend smoothing of the period to t

I_t = value of seasonal smoothing of the period to t

L = the length of the seasonal period

F_{t+m} = forecast value for m future period from t.

2.1.3. Holt Winters Additive Exponential Smoothing. Similar to the holt winters multiplicative exponential smoothing, holt winters additive exponential smoothing model has criteria based on three smoothing equations [14].

$$S_t = \alpha(X_t - I_{t-L}) + (1 - \alpha)(S_{t-1} + B_{t-1}) \qquad (8)$$

$$B_t = \gamma(S_t - S_{t-1}) + (1 - \gamma)B_{t-1} \qquad (9)$$

$$I_t = \delta(X_t - S_t) + (1 - \delta)I_{t-L} \qquad (10)$$

$$F_{t+m} = S_t + B_t m + I_{t-L+m} \qquad (11)$$

Where:

X_t = actual data period to t

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

γ = trend smoothing constant $(0 < \gamma < 1)$

δ = seasonal smoothing constant $(0 < \delta < 1)$

S_t = value of smoothing period to t

B_t = value of trend smoothing of the period to t

I_t = value of seasonal smoothing of the period to t

L = the length of the seasonal period

F_{t+m} = forecast value for m future period from t.

2.2. MAPE

MAPE was a measure of accuracy that often used in forecasting. MAPE was calculated from the absolute value of the reduction between actual data and estimated data then divided by the actual data [7].

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{X_i - F_i}{X_i} \times 100\%\right| \quad\text{...............} (12)$$

Where:

n = number of data

X_i = actual data

F_i = estimated data

3. Research Method

The type of research used in this study was applied research with a quantitative approach. The area used in this study was the Mathematics Education Study Program FKIP Jember University with research subjects being the employee of BAAK (Academic and Student Accreditation Bureau) of Jember University. The data used in this study was secondary data, namely the annual data of those Mathematics Education Study Program Enthusiasts, FKIP Jember University from 2009 to 2018.

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The data was obtained based on the results of interviews with research subjects and data documentation while in the field. Data analysis used a quantitative approach with an exponential smoothing method. These are the procedure of data analysis.
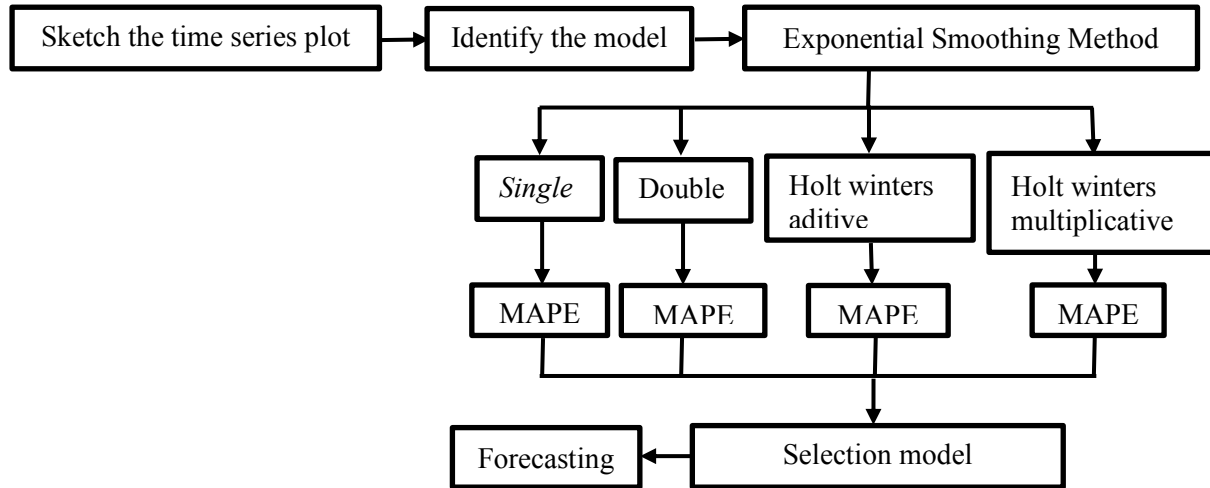

Figure 1. Procedure of Data Analysis

4. Result and Discussion

Based on the purpose of this research, the focus was implementation of exponential smoothing method in predicting the number of Mathematics Education Study Program enthusiasts, FKIP University of Jember. The data of number enthusiast was classified based on the entrance exam. The first process of forecasting exponential smoothing method was sketching the time series plot of each data to saw the patterns from data that had been obtained. Time series plot of enthusiasts based on entrance exam could be seen in Figure 2, Figure 3 and Figure 4.
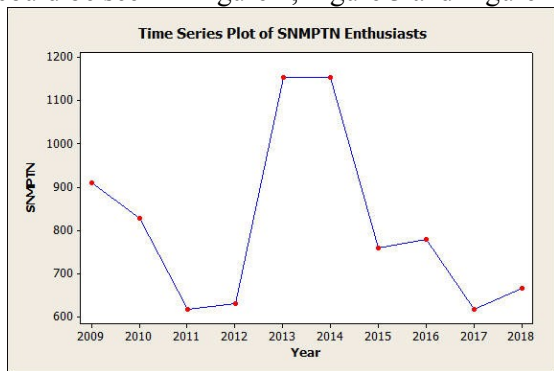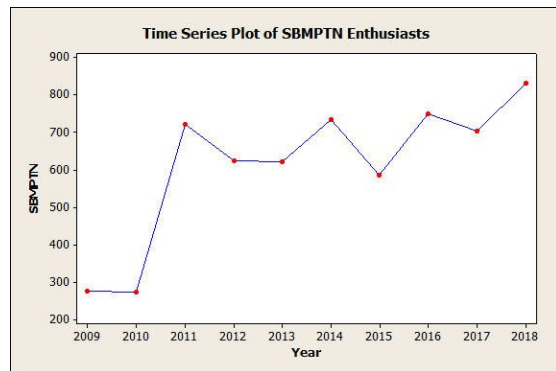

Figure 2. Time Series Plot of SNMPTN Enthusiasts

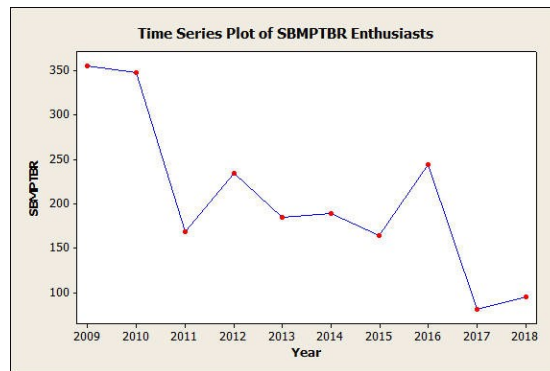**Figure 3.** Time Series Plot of SBMPTN Enthusiasts

Figure 4. Time Series Plot of SBMPTBR Enthusiasts

The second process was identification forecasting model of exponential smoothing method. In this process, each model of exponential smoothing method was implemented to each data enthusiasts. The third process was selecting of the best model of exponential smoothing by looking at the smallest MAPE value. The results of identifying the model can be seen in Table 1.

Table 1. Exponential Smoothing Model of Mathematics Education Study Program Enthusiasts.

Entrance Exam	Model	α	γ	δ	Exponential Smoothing Model
SNMPTN	Holt winters multiplicative exponential smoothing	0.1	0.9	0.1	$S_t = (0.1)\frac{X_t}{I_{t-5}} + (0.9)(S_{t-1} + B_{t-1})$ $B_t = 0.9(S_t - S_{t-1}) + (0.1)B_{t-1}$ $I_t = 0.1\frac{X_t}{S_t} + (0.9)I_{t-5}$
SBMPTN	Holt winters additive exponential smoothing	0.9	0.1	0.1	$S_t = 0.9(X_t - I_{t-5}) + (0.1)(S_{t-1} + B_{t-1})$ $B_t = 0.1(S_t - S_{t-1}) + (0.9)B_{t-1}$ $I_t = 0.1(X_t - S_t) + (0.9)I_{t-5}$
SBMPTBR	Double exponential smoothing	0.1	0.1	-	$S_t = (0.1)X_t + (0.9)(S_{t-1} + B_{t-1})$ $B_t = (0.1)(S_t - S_{t-1}) + (0.9)B_{t-1}$

The final step was forecasting process using the exponential smoothing equation. The forecasting result was obtained by F_{t+m}. The results of forecasting the number Mathematics Education Study Program enthusiasts, FKIP University of Jember based on entrance exam period 2019 until 2021 could be seen in Table 2.

Table 2. Results of Forecasting Mathematics Education Study Program Enthusiasts in 2019-2021.

Entrance exam	2019	2020	2021
SNMPTN	1109	822	699
SBMPTN	875	822	1152
SBMPTBR	72	47	23
Jumlah	2056	1691	1874

After the forecasting results was obtained, the next was to find the forecasting accuracy measured using two measurement methods namely MAE and MAPE. MAE value was used to determine the average deviation of the forecasting results. MAPE value was used to determine the average deviation

percentage of forecasting results. The results of forecasting accuracy calculations could be seen in Table 3.

Table 3. Accuracy of Forecasting Results.

Forecasting Data	MAE	MAPE
SNMPTN	117.623	15.80928
SBMPTN	72.2343	11.33407
SBMPTBR	39.201	21.12543

From Table 3, it is known that MAE values from Mathematics Education Study Program enthusiasts data shows that the forecasting results were close to the actual values. According to [15], MAPE value with a range of $10\% < MAPE \leq 20\%$ had a good level of accuracy while MAPE value with a range of $20\% < MAPE \leq 50\%$ had a quite good level accuracy. Based on Table 3, it could be seen that the MAPE values of the exponential smoothing model in predicting the number of Mathematics Education Study Program enthusiasts had good accuracy and quite good accuracy.

Exponential smoothing method was classified into four models namely single exponential smoothing, double exponential smoothing, holt winters multiplicative exponential smoothing and holt winters additive exponential smoothing. In general, each exponential smoothing model had the same steps in predicting time series data. The first must determine smoothing constant values (α, γ and δ). Where α was total smoothing constant value, γ was trend smoothing constant value and δ was seasonal smoothing constant value. The next step was calculating the total smoothing value (S_t), trend smoothing (B_t), and seasonal smoothing (I_t). In order to found the value of S_t, B_t, and I_t, initial values of S_{t-1}, I_{t-L}, and B_{t-1} must be available when $t = 1$. The final step of the forecasting process used exponential smoothing method, was calculating the forecasting results (F_{t+m}) used the appropriate model. The model used to predict each enthusiast data was determined based on the smallest error value.

After the forecast results was obtained, it was very important to calculated MAPE values to find out how well the forecast model predicts enthusiasts data. MAPE calculations used forecast data for 2009-2018, because in 2019-2021 the actual data of enthusiasts was not available. As a result it has no criteria for calculating the accuracy of forecasting results. Based on MAPE values obtained it could be concluded that exponential smoothing method was a good method in predicting the number of Mathematics Education Study Program enthusiasts.

5. Conclusion
Based on the results of data analysis, the following conclusions can be drawn.
- Forecasting the time series data of the number Mathematics Education Study Program enthusiasts, FKIP Jember University using exponential smoothing models in generally had the same step, which first determining the smoothing constant values (α, γ and δ). The next step was calculated the smoothing value (S_t, B_t and I_t). In order to find the values of S_t, B_t, and I_t, initial values of S_{t-1}, I_{t-L}, and B_{t-1} must be available when $t = 1$. So that the forecast results obtained by F_{t+m}.
- Based on the results of research found that the accuracy of forecasting results was close the actual values. The accuracy of forecasting result could be shown by the MAPE values that had good criteria and quite good criteria, so that the exponential smoothing model could be used to predict the number of Mathematics Education Study Program enthusiasts, FKIP University of Jember.

Based on the results of data analysis, the following suggestion can be drawn.
- Compare several different forecasting methods to get more accurate results.

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