# COMPARISON OF FORECASTING ACCURACY RATE OF EXPONENTIAL SMOOTHING METHOD ON ADMISSION OF NEW STUDENTS

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**Abstract**
Forecasting is a tool or technique used to predict or predict a value in the future by paying attention to relevant data or information, both past data or information as well as current data or information. There are several forecasting methods, one of which is the exponential smoothing method. In this study a comparison of forecasting accuracy to new student admission data in a study program at a university using the single exponential smoothing, double exponential smoothing and triple exponential smoothing methods. The best forecasting using the single exponential smoothing method is obtained when the parameter value $\alpha = 0.9$ with the mean percentage error (MPE) = 0.0239, while the best forecasting using the double exponential smoothing method is obtained when the parameter value $\alpha = 0.8$ and $\beta = 1$, with an MPE value of 0.1172. The best forecasting using the triple exponential smoothing method is obtained when the values of $\alpha = 0.6$ and $\beta = 0.9$, with an MPE value of 0.0161. Based on the forecasting results of the three methods, it was concluded that the best forecasting obtained in this study was to use the triple exponential smoothing method with an MPE value of 0.0161.

**Keywords:** Exponential Smoothing, Single Exponential Smoothing, Double Exponential Smoothing, Triple Exponential Smoothing, Mean Percentage Error (MPE)

## INTRODUCTION

At a university, an increase in the admission of new students can be used as an indicator of the success of the education system at the university [1]. Various methods are carried out as an effort to increase the number of new student admissions. Starting from promotional activities to improving infrastructure and curriculum that can be accepted in the labor market.

In several universities, a promotion team was formed to help introduce the university to the public. Not only for marketing, but the promotion team is also expected to be able to make predictions related to the number of new student admissions [2]. Predicting the admission of new students will certainly affect the target area of the promotion and the budget that will be used.

Prediction or forecasting is a tool or technique used to estimate a value in the future by taking into account relevant data or information, both past data or information or current data or information [3]. There are 2 general methods in the equation that are qualitative and quantitative. The qualitative method is intuitive and is usually done when there is no past data or history, which results in the inability of mathematical calculations. While quantitative methods can be done based on previous data so that calculations can be done mathematically [4].

In forecasting, several methods are applied together, to find the best method in the selection of criteria used by reference to determine the best model [5]. In the forecasting process, whether or not the model used is very influential in the decisions made. By looking at the smallest error rate from the model that can be chosen in making predictions in the future.

Exponential smoothing is one of the methods in the forecasting process. The exponential smoothing method performs a continuous calculation process that uses the latest data [6]. Exponential smoothing has 3 variants of methods including single exponential smoothing, double exponential smoothing and triple exponential smoothing [7]. Based on the discussion, in this study forecasting using single exponential smoothing, double exponential smoothing and triple exponential methods to find the best accuracy of the three methods.

## MATERIALS AND METHOD

Forecasting is a tool or technique used to predict or predict a value in the future by paying attention to relevant data or information, both past data or information or current data or information [3]. In forecasting, there are 2 general methods, namely qualitative and quantitative. The qualitative method is intuitive and is usually done when there is no past data / history, which results in the inability of mathematical calculations. While quantitative methods can be done based on previous data/history so that calculations can be done mathematically [4].

Exponential smoothing is one of the methods in the forecasting process. The exponential smoothing method performs a continuous calculation process that uses the latest data [6]. Each data is given a weight, where the weight used is symbolized by alpha. Alpha symbols can be freely determined, which reduces forecast errors. The smoothing constant value, $\alpha$, can be chosen between values 0 and 1, because it applies: $0 < \alpha < 1$ [8]. Exponential smoothing has 3 variants of methods including single exponential smoothing, double exponential smoothing and triple exponential smoothing [7].

A single exponential smoothing method or known as simple exponential smoothing is a short-term forecasting model. This model assumes that the data fluctuates around a fixed mean value, without consistent growth trends or patterns [9]. This method is formulated according to the following equation:

$$F_{t+1} = \alpha * X_t + (1-\alpha) * F_t \qquad (1)$$

Where :
$F_{t+1}$ : Forecasting at time - (t + 1)
$F_t$ : Forecasting at time - t
$X_t + (1-\alpha)$ : Actual time series value
$\alpha$ : Constants between 0 to 1

The double exponential smoothing method is used when there is trend data. Basically this method is the same as the single exponential smoothing method, but there are additional weights used to detect trends from the data [10]. The double exponential smoothing method is formulated according to the following equation:

$$L_t = \propto Y_t + (1-\propto)(L_{t-1} + b_{t-1}) \qquad (2)$$
$$b_t = \gamma(L_t - L_{t-1}) + (1 - \gamma)b_{t-1} \qquad (3)$$
$$F_{t+m} = L_t + b_t m \qquad (4)$$

Weights α and γ are between 0 and 1. Lt represents the estimated amount (level) stating the forecast value at time t, and bt represents the value of the slope at time t.

The triple exponential smoothing method is used when the data shows seasonal trends and behavior [11]. Triple exponential smoothing method is done by using the equation:

$$S_t = \propto \frac{Y_t}{L_{t-L}} + (1-\propto)(S_{t-1} + b_{t-1}) \qquad (5)$$
$$b_t = \gamma(S_t - S_{t-1}) + (1 - \gamma)b_{t-1} \qquad (6)$$
$$L_t = \beta \frac{Y_t}{S_t} + (1 - \beta)L_{t-L} \qquad (7)$$
$$F_{t+m} = (S_t + mb_t)L_{t-L+m} \qquad (8)$$

Where :

| | | |
|---|---|---|
| Y | : | Observation data |
| S | : | Observation data of smoothing results |
| b | : | Trend Factor |
| I | : | Index |
| F | : | Forecast in period m |
| m | : | Period |
| t | : | Time Index |
| α, β, γ | : | Constant value to smooth the MSE value, where this value is in the range of 0.1 to 1.0 |

In forecasting, several methods are applied together, to find the best method in the selection of criteria used by reference to determine the best model [5]. In the forecasting process,

whether or not the model used is very influential in the decisions made. By looking at the smallest error rate from the model that can be chosen in making predictions in the future [12]. The magnitude of the error can be calculated by measuring the error rate, among others [13]:

- MAPE (Mean Absolute Percentage Error), which is the presentation of errors by seeing how much the value of forecasting compared to the actual value. MAPE is formulated according to the following equation:

$$MAPE = \sum \frac{\left|\frac{Yt-Ft}{Yt}\right|}{nYt} x100 \quad (9)$$

- MAD (Mean Absolute Deviation), which measures error by averaging the absolute error of forecasting. The error measured in this measurement will be the same as the original data and is used to compare different forecasting methods. MAD is formulated according to the following equation:

$$MAD = \frac{\sum|Ft|}{m} \quad (10)$$

- MPE (Mean Percentage Error) is the average calculated from the percentage error where the estimated model differs from the actual value of the estimated quantity. MPE is calculated according to the following equation:

$$MPE = \frac{100\%}{n} \sum \frac{(Ft-Yt)}{m} \quad (11)$$

Based on sample data that has been carried out in the research on the implementation of the double exponential smoothing method [14] in table 1, the next forecasting process will be described using the three variants of exponential smoothing.

**Table 1. Data Sample Forecasting New Student Admissions**

| Periode (m) | Data Aktual (Yt) | Forecasting(Ft) |
|---|---|---|
| 3 | 80 | 80 |
| 4 | 59 | 146 |
| 5 | 62 | 161 |
| 6 | 30 | ? |

In accordance with equation 1, forecasting is done using an α value of 0.5. Forecasting results using the single exponential smoothing method based on the first data obtained:

$$F_{t+1} = \propto * X_t + (1-\propto) * F_t$$
$$F_{t6} = 0.5 * 62 + (1-0.5) * 161$$
$$F_{t6} = 111,5 = 112$$

If forecasting is done using the double exponential smoothing method where parameter α is 0.5, while parameter β is 0.4., According to equations 2, 3 and 4, we get:

$$L_t = \propto Y_t + (1-\propto)(L_{t-1} + b_{t-1})$$
$$b_t = \gamma(L_t - L_{t-1}) + (1 - \gamma)b_{t-1}$$
$$F_{t+m} = L_t + b_t m$$

$$L_{t5} = 0.5 \times 62 + (1-0.5) \times 161.1$$
$$= 111.55$$
$$b_{t5} = 0.4 \times (111.55-102.5)+(1-0.4) \times 58.6$$
$$= 38.78$$
$$F_{t6} = 111.55+38.78$$
$$= 150.33 = 150$$

While the triple exponential smoothing method using the α parameter value of 0.5 produces the forecasting process as follows:

$$S't = 0.5*62 + (1- 0.5)59$$
$$= 60.5$$
$$S''t = 0.5*60.5 + (1-0.5)*59$$
$$= 59.8$$
$$S'''t = 0.5*59.8 + (1-0.5)*59$$
$$= 59.4$$

$$at = 3*60.5 – 3*59.8+59.4$$
$$= 61.5$$

$$bt = (0.5/(2(1-0.5)^2)[(6-5*0.5)*60.5-(10-8*0.5)*59.8+(4-3*0.5)*59.4]$$
$$= 1*1.5$$
$$= 1.5$$

$$ct = ((0.5^2)/(1-0.5)^2)[60.5-2*59.8+59.4]$$
$$= 1*0.3$$
$$= 0.3$$

So the forecast value in the 6th period is equal to:
$$Ft + m = 61.5 +1.5+0.5*0.3^2$$
$$= 65,6$$

**RESULT**

Comparison of the accuracy of forecasting methods using single exponential smoothing, double exponential smoothing, and triple exponential smoothing methods is done on the data of new student admissions in a study program at a university for the past 10 years [14].

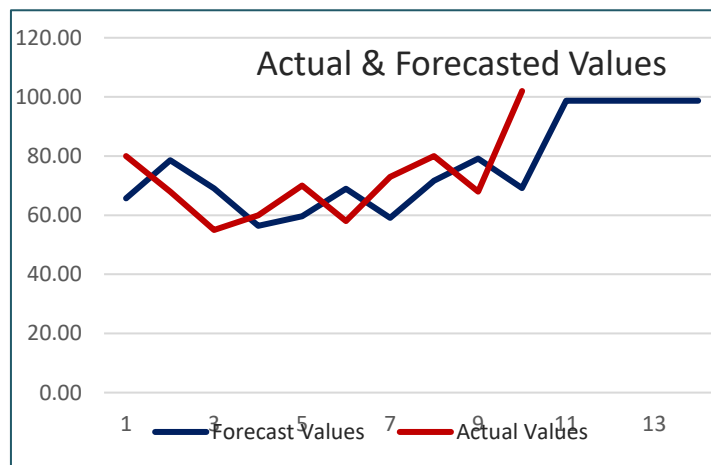**Table 2. Testing Data for New Student Admissions**

| Periode (m) | Data Aktual (Yt) |
|---|---|
| 1 | 80 |
| 2 | 68 |
| 3 | 55 |
| 4 | 60 |
| 5 | 70 |
| 6 | 58 |
| 7 | 73 |
| 8 | 80 |
| 9 | 68 |
| 10 | 102 |

The application of the single exponential smoothing method is done by using the parameter value $0 < \alpha < 1$. The results of forecasting calculations using the single exponential smoothing method by using the parameter value $\alpha = 0.9$ are presented in Table 3.

**Table 3. Forecasting Single Exponential Smoothing with Parameter Value $\alpha = 0.9$**

| Number | Data Value | Forecast Value |
|---|---|---|
| 1 | 80 | 79 |
| 2 | 68 | 69 |
| 3 | 55 | 56 |
| 4 | 60 | 60 |
| 5 | 70 | 69 |
| 6 | 58 | 59 |
| 7 | 73 | 72 |
| 8 | 80 | 79 |
| 9 | 68 | 69 |
| 10 | 102 | 99 |
| MAD | | 13,0139 |
| MAPE | | 0,1768 |
| MPE | | 0,0239 |



**Figure 1. Comparison of Actual Value and Single Exponential Smoothing Forecasting Parameters with Parameter Value $\alpha = 0.9$**

Changes in MPE values based on changing parameter values $0 < \alpha < 1$ forecasting using single exponential smoothing are presented in Table 4.

**Table 4. Changes in MPE Value Based on Changes in the Parameter Value α in Single Exponential Smoothing**

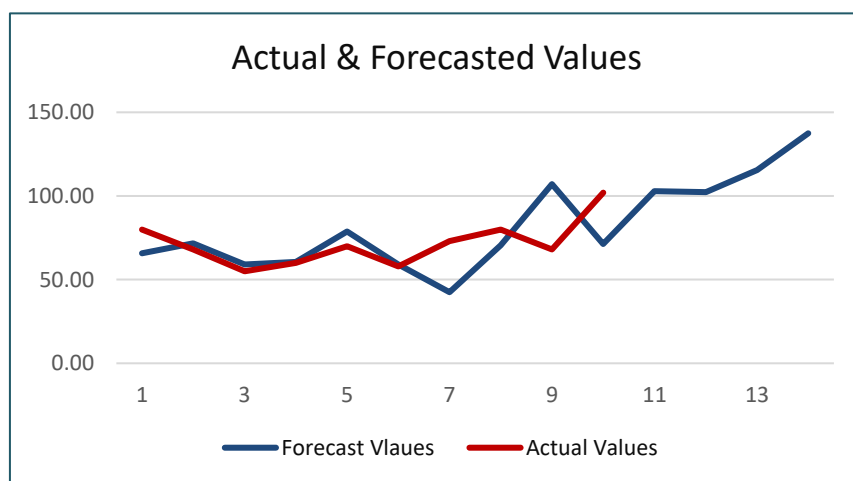| Number | α | MPE |
|--------|-----|--------|
| 1 | 0.1 | 0,0431 |
| 2 | 0.2 | 0,0385 |
| 3 | 0.3 | 0,0354 |
| 4 | 0.4 | 0,0327 |
| 5 | 0.5 | 0,0303 |
| 6 | 0.6 | 0,0281 |
| 7 | 0.7 | 0,0263 |
| 8 | 0.8 | 0,0249 |
| 9 | 0.9 | 0,0239 |

Forecasting using the Triple Exponential Smoothing method is carried out with variations in the parameter value $0 < \alpha < 1$ and the parameter value $0 < \beta < 1$. As a sample of the results of the Triple Exponential Smoothing forecasting using the parameter value $\alpha = 0.6$ and the parameter $\beta = 0.9$ are presented in Table 5.

**Table 5. Forecasting Triple Exponential Smoothing with Parameter Value α = 0.6 and Parameter Value β = 0.9**

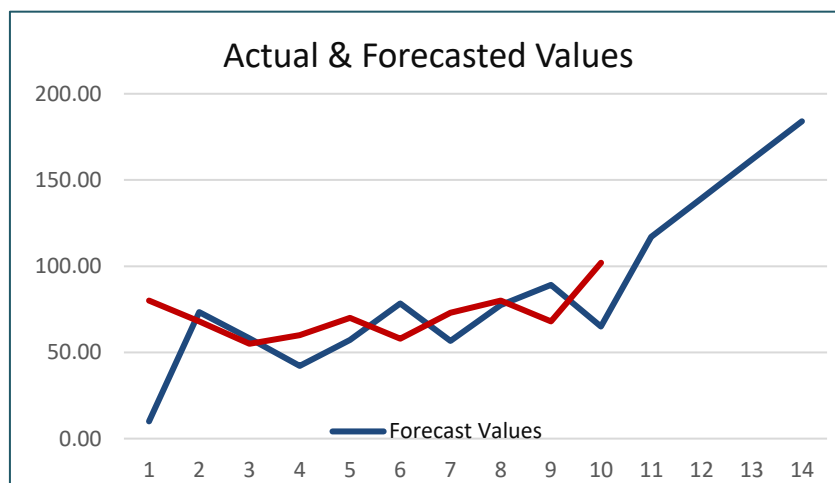| Number | Data Value | Forecast Value |
|--------|------------|----------------|
| 1 | 80 | 72 |
| 2 | 68 | 59 |
| 3 | 55 | 61 |
| 4 | 60 | 79 |
| 5 | 70 | 59 |
| 6 | 58 | 42 |
| 7 | 73 | 72 |
| 8 | 80 | 111 |
| 9 | 68 | 68 |
| 10 | 102 | 103 |
| MAD | | 14,2125 |
| MAPE | | 0,1871 |
| MPE | | 0,0161 |



**Figure 2. Comparison of Actual Value and Triple Exponential Smoothing Forecasting with Parameter Parameters α = 0.6 and β = 0.9**

Based on the results of research conducted on new student admission data using the double exponential smoothing method, it was found that the best forecast was found when the parameter values α = 0.8 and β = 1 [14], as in Table 6.

**Table 6. Double Exponential Smoothing Forecasting Results with parameter values α = 0.8 and β = 1**

| Number | Actual Value | Forecast Value |
|---|---|---|
| 1 | 80 | 73 |
| 2 | 68 | 58 |
| 3 | 55 | 42 |
| 4 | 60 | 57 |
| 5 | 70 | 78 |
| 6 | 58 | 57 |
| 7 | 73 | 77 |
| 8 | 80 | 89 |
| 9 | 68 | 65 |
| 10 | 102 | 117 |
| MAD | | 20.65656 |
| MAPE | | 0.27722 |
| MPE | | 0.11719 |



**Figure 3. Comparison Chart of Actual Values and Double Exponential Smoothing Forecasting Values with Parameter Parameters α = 0.8 and β = 1**

Comparison of forecast values using the single exponential smoothing, double exponential smoothing and triple exponential smoothing methods based on admission data for new students for the last 10 years in a study program at a university is presented in Table 7.

**Table 7. Comparison of Forecasting Value in Exponential Smoothing Method**

| Number | Data Value | Forecast Value | | |
|---|---|---|---|---|
| | | Single Eksponential Smoothing | Double Eksponential Smoothing | Triple Eksponential Smoothing |
| 1 | 80 | 79 | 73 | 72 |
| 2 | 68 | 69 | 58 | 59 |
| 3 | 55 | 56 | 42 | 61 |
| 4 | 60 | 60 | 57 | 79 |

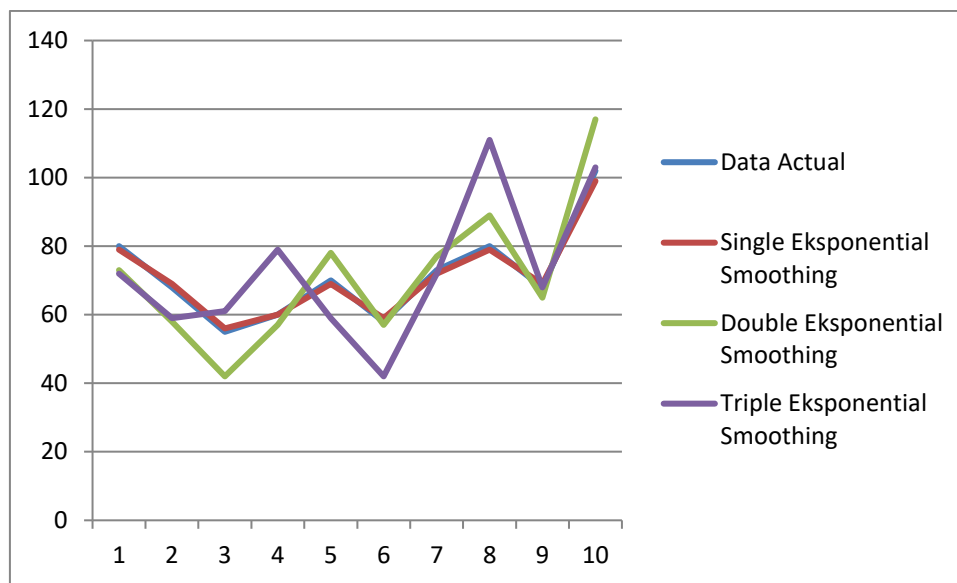| | | | | |
|---|---|---|---|---|
| 5 | 70 | 69 | 78 | 59 |
| 6 | 58 | 59 | 57 | 42 |
| 7 | 73 | 72 | 77 | 72 |
| 8 | 80 | 79 | 89 | 111 |
| 9 | 68 | 69 | 65 | 68 |
| 10 | 102 | 99 | 117 | 103 |
| MAD | | 13,0139 | 2.065.656 | 14,2125 |
| MAPE | | 0,1768 | 0.27722 | 0,1871 |
| MPE | | 0,0239 | 0.11719 | 0,0161 |



**Figure 4. Exponential Smoothing Forecasting Comparison Graph**

## CONCLUSION

Based on the results obtained in this study, the conclusions obtained include:

- The best forecasting using the single exponential smoothing method is obtained when the parameter value α = 0.9 with the mean percentage error (MPE) value = 0.0239.
- The best forecasting using the double exponential smoothing method is obtained when the parameter values α = 0.8 and β = 1, with an MPE value of 0.1172.
- The best forecasting using the triple exponential smoothing method is obtained when the values of α = 0.6 and β = 0.9, with an MPE value of 0.0161.

The triple exponential smoothing method performs the best forecasting with an MPE value of 0.0161.

## ACKNOWLEDGMENTS

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