Forecasting the number of Politeknik Negeri Malang new student’s enrolment using single exponential smoothing method

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Abstract. Forecasting the number of new student enrolments at Politeknik Negeri Malang offers the campus a good help to discover new innovations and good marketing strategies. Besides, it can be used as a reference in planning the teaching and learning process. This study used the Single Exponential Smoothing method as a forecasting method. Forecasting accuracy uses Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percentage Error (MAPE). Based on the calculation results, the smoothing constant result is $\alpha = 0.9$ which means it has the smallest error values for the three forecasting accuracy calculation methods.

1. Introduction
Forecasting is the art and a science of estimating future events by involving the taking of historical data and projecting it into the future with a mathematical model [1]. Forecasting is the most important part for every company or business organization in every management decision making. Forecasting itself can be the basis for short, medium and even a long-term planning of a company.

Politeknik Negeri Malang (Polinema) is a vocational education in Malang which has several departments with different levels of interests. The departments are Electrical Engineering, Mechanical Engineering, Information Technology, Civil Engineering, Chemical Engineering, Accounting, and Business Administration. As seen from the number of applicants in Politeknik Negeri Malang, a massive number of applicants comes from both Malang and any other regions each year. This, obviously, requires a prediction or forecasting system to predict the number of applicants for new students which in turn become one of the references in planning the teaching and learning process and exploring good innovation and marketing strategies for the campus.

This study uses single exponential smoothing method. It is done by repeating the continuous calculations using the latest data. The data were taken from new student enrollments total number in 2011-2017 academic year.

2. Theoretical analysis

2.1. New student admission
New student admissions are routine activities carried out by universities every year. The new student admission process is used to screen qualified prospective students according to the criteria determined by the college [2]. By accepting qualified students, it will improve the quality of the University itself.
In general, the process of admitting new students is done through the stages of registration, file selection, and announcement of student admissions.

2.2. Single exponential smoothing
Exponential Smoothing Forecasting method or Exponential Smoothing (multilevel Smoothing) is widely used to predict the purchase of goods (the demand) which changes very quickly [3]. This method is not affected by trends or seasons. The formula is as follows [4]:

\[ S_{t+1} = \alpha X_t + (1 - \alpha) S_t \]  

(1)

Note:
\( S_{t+1} \) : Prediction for \( t+1 \) period
\( X_t \) : Real value of \( t \) period
\( S_t \) : Forecast for \( t \) period
\( \alpha \) : Weight which shows the smoothing constant

2.3. Forecast error measurement

2.3.1. Mean Absolute Deviation (MAD). MAD is a value calculated by taking the absolute total value of each forecasting error divided by the number of periods of data (n).

\[ MAD = \frac{\Sigma(\text{actual} - \text{forecasting})}{n} \]  

(2)

2.3.2. Mean Squared Error (MSE). MSE is the average of squared forecasting error.

\[ MSE = \frac{\Sigma(\text{actual} - \text{forecasting})^2}{n} \]  

(3)

2.3.3. Mean Absolute Percent Error (MAPE). MAPE is calculated as the average of the absolute differentiation between the predicted and actual value, expressed as a percentage of actual value. If we had predicted and actual values for n periods.

\[ MAPE = \frac{\Sigma(\text{absolute error percentage})}{n} \]  

(4)

3. Algorithm analysis

3.1. System performance analysis
Block diagrams explain the interactions that occur between users and systems including entering what data is needed, the processes that occur, and the output data generated from the interactions. The data comes from the number of new student enrollments in 2011-2017 academic year. The input data is in the form of diploma and academic year period options. System output data is a prediction based on input data that has been processed by the forecasting method.
3.2. The scope of research
This research was developed by developing an application that is used for calculating the forecasting number of new student admission in Polinema. The focus of this research is to predict the data in the next academic year using exponential smoothing based on data from 2011 to 2017 academic year. From the diagram as seen in Figure 1, the forecasting technique used in this study uses a single exponential smoothing to calculate error accuracy for forecasting using the MAD, MSE, and MAPE methods.

3.3. Dataset
The data collection is done by collecting the data on new student admissions from 2011 to 2017 academic year in Polinema. The detailed data are shown in Tables 1 and 2.

Table 1. Diploma III student’s data.

|    | Diploma III T. Elektronika | Diploma III T. Listrik | Diploma III T. Telekomunikasi | Diploma III M. Informatika | Diploma III T. Mesin | Diploma III T. Sipil | Diploma III Teknologi Konstruksi Jalan, Jembatan, dan Bangunan Air | Diploma III T. Kimia | Diploma III Akuntansi | Diploma III Administrasi Bisnis | Diploma III Bahasa Inggris |
|----|---------------------------|------------------------|-------------------------------|----------------------------|----------------------|---------------------|-----------------------------------------------------------------|----------------------|----------------------|---------------------------|---------------------|
| D3 | 125                       | 80                     | 130                           | 187                        | 208                  | 139                 | 54                                                             | 164                  | 192                   | 214                       | 87                  |

Table 2. Diploma IV student’s data.

|    | Diploma IV T. Elektronika | Diploma IV Sistem Kelistrikan | Diploma IV Jaringan Telekomunikasi Digital | Diploma IV T. Informatika | Diploma IV T. Otomotif Elektronik | Diploma IV T. Mesin Produksi Dan Perawatan | Diploma IV Manajemen Rekayasa Konstruksi | Diploma IV Teknologi Kimia Industri | Diploma IV Akuntansi Manajemen | Diploma IV Keuangan | Diploma IV Manajemen Pemasaran |
|----|---------------------------|-------------------------------|-------------------------------------------|--------------------------|------------------------------------|-------------------------------------------|-------------------------------------|-------------------------------|-----------------------------|---------------------|-----------------------------|
| D4 | 130                       | 133                           | 132                                        | 218                      | 78                                 | 130                                       | 188                                 | 105                           | 222                         | 91                  | 218                         |

D4 | 1645                       |
4. Results and discussions

4.1. Optimal value selection
In the Single Exponential Smoothing method, the forecasting result accuracy depends on the smoothing constants used [5]. There is one smoothing constant parameter ($\alpha$) that must be evaluated in this method. The optimal $\alpha$ values selection approach is usually done by trial and error. In this forecasting, the value of $\alpha$ that will be used for trial is randomly assigned as the weight value ($\alpha = 0.2$), ($\alpha = 0.5$), ($\alpha = 0.7$) and ($\alpha = 0.9$). Forecasting calculations are performed repeatedly to produce the smallest MAD, MSE, and MAPE values.

4.2. Error prediction model
In evaluating the optimum $\alpha$ smoothing constant determination value, three forecasting error measure comparisons, i.e. Mean Absolute Deviation (MAD), Mean Squared Error (MSE) and Mean Absolute Error (MAPE) were used. From the three forecasting error measures, it will then be compared to find the error prediction method which produces good predictions according to the data used.

From various smoothing constants, the corresponding MAPE, MAD, and MSE values can be calculated for the experimental data. MAD is calculated using equation (2) and the results are given in Table 3.

| Major | 0.2 | 0.5 | 0.7 | 0.9 |
|-------|-----|-----|-----|-----|
| D-III T. Elektronika | 12  | 0   | 3   | 3   |
| D-III T. Listrik | 57  | 68  | 72  | 73  |
| D-III T. Telekomunikasi | 23  | 10  | 4   | 1   |
| D-III M. Informatika | 21  | 10  | 7   | 7   |
| D-III T. Mesin | 18  | 28  | 28  | 28  |
| D-III T. Sipil | 1   | 25  | 27  | 26  |
| D-III Teknologi Konstruksi Jalan, Jembatan, dan Bangunan Air | 46  | 34  | 26  | 18  |
| D-III T. Kimia | 25  | 9   | 8   | 9   |
| D-III Akuntansi | 6   | 7   | 3   | 1   |
| D-III Administrasi Bisnis | 16  | 4   | 4   | 4   |
| D-III Bahasa Inggris | 72  | 49  | 33  | 18  |
| D-IV T. Elektronika | 31  | 5   | 1   | 3   |
| D-IV Sistem Kelistrikan | 30  | 5   | 15  | 18  |
| D-IV Jaringan Telekomunikasi Digital | 28  | 3   | 2   | 4   |
| D-IV T. Informatika | 20  | 32  | 38  | 37  |
| D-IV T. Otomotif Elektronik | 6   | 6   | 9   | 10  |
| D-IV T. Mesin Produksi Dan Perawatan | 69  | 21  | 7   | 2   |
| D-IV Manajemen Rekayasa Konstruksi | 36  | 1   | 9   | 14  |
| D-IV Teknologi Kimia Industri | 65  | 27  | 12  | 4   |
| D-IV Akuntansi Manajemen | 22  | 21  | 26  | 25  |
| D-IV Keuangan | 69  | 46  | 36  | 31  |
| D-IV Manajemen Pemasaran | 50  | 10  | 6   | 7   |
| **MAD** | **33** | **19** | **17** | **16** |

Based on table 3, the values of $\alpha$ which minimize MAD can be determined, which is 0.9. The MAD value generated by $\alpha = 0.9$ is 16. Furthermore, MSE is calculated using equation (3) and the results are given in Table 4.
Table 4. MSE Value for each $\alpha$ experimental smoothing constant.

| Major | 0.2 | 0.5 | 0.7 | 0.9 |
|-------|-----|-----|-----|-----|
| D-III T. Elektronika | 143 | 0 | 10 | 11 |
| D-III T. Listrik | 3246 | 4688 | 5146 | 5379 |
| D-III T. Telekomunikasi | 512 | 92 | 29 | 1 |
| D-III M. Informatika | 460 | 95 | 55 | 48 |
| D-III T. Mesin | 322 | 769 | 765 | 788 |
| D-III T. Sipil | 1 | 609 | 743 | 677 |
| D-III Teknologi Konstruksi Jalan, Jembatan, dan Bangunan Air | 2116 | 1156 | 676 | 324 |
| D-III T. Kimia | 662 | 81 | 67 | 76 |
| D-III Akuntansi | 35 | 45 | 9 | 2 |
| D-III Administrasi Bisnis | 270 | 14 | 13 | 20 |
| D-III Bahasa Inggris | 5127 | 2352 | 1096 | 313 |
| D-IV T. Elektronika | 992 | 25 | 1 | 12 |
| D-IV Sistem Kelistrikan | 923 | 29 | 215 | 322 |
| D-IV Jaringan Telekomunikasi Digital | 806 | 9 | 4 | 12 |
| D-IV T. Informatika | 411 | 993 | 1430 | 1398 |
| D-IV T. Otomotif Elektronik | 34 | 35 | 75 | 106 |
| D-IV T. Mesin Produksi Dan Perawatan | 4776 | 446 | 53 | 3 |
| D-IV Manajemen Rekayasa Konstruksi | 1324 | 2 | 73 | 183 |
| D-IV Teknologi Kimia Industri | 4226 | 702 | 146 | 17 |
| D-IV Akuntansi Manajemen | 495 | 443 | 679 | 649 |
| D-IV Keuangan | 4811 | 2093 | 1290 | 948 |
| D-IV Manajemen Pemasaran | 2524 | 110 | 42 | 54 |
| MSE | 1552 | 672 | 573 | 516 |

Based on table 4 above, the values of $\alpha$ which minimize MSE, which is 0.9, can be determined. The MSE value generated with $\alpha = 0.9$ is 516.

Furthermore, MAPE is calculated using equation (4) and the results are given in table 5.

Table 5. MAPE Value for each $\alpha$ experimental smoothing constant.

| Major | 0.2 | 0.5 | 0.7 | 0.9 |
|-------|-----|-----|-----|-----|
| D-III T. Elektronika | 0.10 | 0.00 | 0.02 | 0.03 |
| D-III T. Listrik | 0.71 | 0.86 | 0.90 | 0.92 |
| D-III T. Telekomunikasi | 0.17 | 0.07 | 0.03 | 0.01 |
| D-III M. Informatika | 0.11 | 0.05 | 0.04 | 0.04 |
| D-III T. Mesin | 0.09 | 0.13 | 0.13 | 0.13 |
| D-III T. Sipil | 0.01 | 0.18 | 0.20 | 0.19 |
| D-III Teknologi Konstruksi Jalan, Jembatan, dan Bangunan Air | 0.85 | 0.63 | 0.48 | 0.33 |
| D-III T. Kimia | 0.15 | 0.05 | 0.05 | 0.05 |
| D-III Akuntansi | 0.03 | 0.03 | 0.02 | 0.01 |
| D-III Administrasi Bisnis | 0.08 | 0.02 | 0.02 | 0.02 |
| D-III Bahasa Inggris | 0.82 | 0.56 | 0.38 | 0.20 |
| D-IV T. Elektronika | 0.24 | 0.04 | 0.01 | 0.03 |
| D-IV Sistem Kelistrikan | 0.23 | 0.04 | 0.11 | 0.13 |
| D-IV Jaringan Telekomunikasi Digital | 0.22 | 0.02 | 0.01 | 0.03 |
| D-IV T. Informatika | 0.09 | 0.14 | 0.17 | 0.01 |
| D-IV T. Otomotif Elektronik | 0.07 | 0.08 | 0.11 | 0.07 |
| D-IV T. Mesin Produksi Dan Perawatan | 0.53 | 0.16 | 0.06 | 0.04 |
| D-IV Manajemen Rekayasa Konstruksi | 0.19 | 0.01 | 0.05 | 0.11 |
| D-IV Teknologi Kimia Industri | 0.62 | 0.25 | 0.11 | 0.34 |
| D-IV Akuntansi Manajemen | 0.10 | 0.09 | 0.12 | 0.11 |
| D-IV Keuangan | 0.76 | 0.50 | 0.39 | 0.34 |
| D-IV Manajemen Pemasaran | 0.23 | 0.05 | 0.03 | 0.03 |
| MSE | 0.29 | 0.18 | 0.16 | 0.14 |
Based on table 5, it can be seen that \( \alpha \) with a value of 0.9 can minimize MAPE. The MAPE value produced with \( \alpha = 0.9 \) is 0.14.

### 4.3. Data analysis

Forecasting is done by predicting the number of new student admissions in each department of Polinema. By developing this application, it is expected that the application can be used as a reference by the academic staffs to prepare an effective and efficient learning process, to be used as one of the references in planning the teaching and learning process by the campus, as well as exploring good innovation and marketing strategies.

In general, the results of data analysis based on experiments that have been carried out using the three criteria of MAD, MSE, and MAPE give the results of smoothing constant values \( \alpha \) which can be said to be the satisfactorily similar for each type of data. From Table 6 below, it can be seen that the best constant value for the three best error calculation methods is \( \alpha = 0.9 \).

#### Table 6. MAPE, MAD, and MSE calculation results.

| Error Accuracy | \(0.20\) | \(0.50\) | \(0.70\) | \(0.90\) |
|----------------|---------|---------|---------|---------|
| MAD            | 33      | 19      | 17      | 16      |
| MSE            | 1.152   | 672     | 573     | 516     |
| MAPE           | 0.29    | 0.18    | 0.16    | 0.14    |

In other words, the three criteria for MAD, MSE, and MAPE can be used interchangeably in forecasting the number of Polinema student’s admissions.

### 5. Conclusion

- Based on the results of the data tested the accuracy calculation or error calculation in 2011 to 2017. The Single Exponential Smoothing method with a value of \( \alpha = 0.2 \) has a smaller average error result.
- Report the number of new students in one period needed to do forecasting the number of new students in the next period. This new student data will later be analyzed with the Single Exponential Smoothing Method for produce forecasting the number of new students in the next period.
- This application can be used to forecast the number of new students as well as for each new school year in accordance with the actual new student data report school so that it can save time in the forecasting process as well the results are quite accurate and can be accounted for.

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