IOP Conf. Series: Materials Science and Engineering **732** (2020) 012080 doi:10.1088/1757-899X/732/1/012080

Passenger volume forecasting information system for PT. KAI Daop 2 Bandung using double exponential smoothing method

E L Amalia*, B Harijanto and A Santoso

Informatics Engineering Study Program, Information Technology, Politeknik Negeri Malang

*eka.larasati@polinema.ac.id

Abstract. Daop 2 Bandung is one of the Indonesian railroad operations areas, under the administration of PT Kereta Api Indonesia (Persero). Daop 2 Bandung is currently experiencing a problem in predicting the number of passenger volumes. It is common for railway transportation services to experience passengers flows that increases or decreases in the volume which in turn causes the service of the PT. KAI becomes less optimum. Therefore, a forecasting information system is needed to forecast the volume of train passengers in the upcoming period. This study applied Double Exponential Smoothing method as a forecasting method. The data used is the number of passenger volume data for two periods, i.e. 2017 and 2018 periods. For forecasting accuracy, PE (Percentage Error) and MAPE (Mean Absolute Percentage Error) were used. The passenger volume forecasting results on the Executive Class category shows 946,824 with an error percentage of 11.9962%, the Business Class category shows 221,188 results with an error percentage of 21.6714%, and the Economy Class category shows 5,144,074 with an error percentage of 10.4366%.

1. Introduction

Daop 2 Bandung is one of Indonesia's railroad operations areas, under PT. Kereta Api Indonesia (Persero). Daop 2 Bandung is currently experiencing a problem in predicting the number of passenger volumes. Passenger volume is a condition when passenger capacity exceeds previous capacity. Sometimes rail transportation services experience flows in passenger volume that increasing or decreasing which in turn results in less optimal service. The data obtained during the observations at PT. Bandung Daop 2 KAI are in the form of passenger volume data with the following categories, Executive Class, Business Class, and Economy Class. The railroad category data have a different data structure that has an increasing trend.

Based on the above reason, a forecasting system is needed to forecast the passenger volume in the upcoming period. This in turn is hope to assist in planning the services offered by PT. KAI Daop 2 Bandung. This study uses the Double Exponential Smoothing method, in which the method is classified as the team series method (sequential). The Double Exponential Smoothing method is applied twice for the smoothing process and forecasting data that has an upward trend. To measure the accuracy of forecasting, MAPE (Mean Absolute Percentage Error) calculation is used. It is also used as a search for Alfa (α) forecasting. The Data used in the forecasting process are the data from 2017-2018 periods.

2. Theoretical analysis

2.1. Passenger volume

Volume, also known as capacity, is the calculation to find out the space required to be occupied in an object. The object can be a regular object or an irregular object. Volume is an indication of the extent of usage capacity [1]. Passengers, on the other hand, is "Every person who needs to be transported using transportation services such as an airplane, train, or any other means of transportation, on the basis of the company or organization agreement that manages the means of transportation [2]. Therefore, passenger volume is the space or place required for each person to occupy in the mass transportation services provided by the particular service, which experience either an increase or a decrease to result in exceeding passenger capacity, and is influenced by the transportation service user satisfaction.

2.2. Double exponential smoothing

Double exponential Smoothing method is one of the in-depth exponential smoothing methods. Exponential Smoothing method is a continuous improvement procedure for forecasting the latest observation objects. This method focuses on decreasing the priority exponentially on prior preceding observation objects [3]. In applying the Exponential Smoothing method, there are data patterns that are required in order to determine the Exponential Smoothing method that is suitable for data patterns needed in the Double Exponential Smoothing method using data pattern trend in which the data keeps increasing from each period of time [4].

The stages of the calculation method are as follows.

- To determine the first smoothing:

$$S't = \alpha X_t + (1- \alpha)S't\text{-}1 \quad (1)$$

- To calculate the second smoothing:

$$S''t = \alpha S't + (1 - \alpha) S''t\text{-}1 \quad (2)$$

- To determines the α_t constant value

$$\alpha_t = S't + (S't - S''t) \quad (3)$$

- To determines the slope value / trend b_t

$$b_t = \frac{\alpha}{1-\alpha}(S't - S''t) \quad (4)$$

- to determine the forecasting value

$$F_{t+m} = \alpha_t + b_t\, m \quad (5)$$

Note:

S't	= forecasting value for t period
S"t	= Double Exponential Smoothing t period value
α	= exponential weighting constant
α_t	= constant value
X_t	= t period actual value
Ft+m	= forecasting value
m	= forecasted upcoming period

2.3. Forecast error measurement

Many error calculation methods are available to find out forecasting accuracy, such as MAPE (Mean Absolute Percent Error), to obtain the error percentage.

2.3.1. MAPE: Mean Absolute Percent Error (MAPE). MAPE is the average absolute process between the predicted value and the actual value. It is used to evaluate forecasting accuracy using percentage errors. The following is MAPE calculation formula stages:

- PE Calculation (Percentage Error)

$$\boldsymbol{PE = \left(\frac{Xt - Ft}{Xt} X100\right)} \quad (6)$$

- MAPE Calculation

$$\mathbf{MAPE} = \sum_{t}^{n} \frac{\boldsymbol{PEt}}{\boldsymbol{n}} \quad (7)$$

MAPE value interpretation are as follows:

- <10% = very accurate forecasting.
- 10% -20% = accurate forecasting.
- 20% -50% = fairly accurate forecasting.
- > 50% = inaccurate forecasting.

3. Algorithm analysis

3.1. System work analysis

Block diagram describes the interactions between the user and the system which includes the data input required, a set of process, and also the data output generated from the interactions. The data were retrieved from passenger volume from 2017-2018 periods.

Data input are in the form of train class options used and period (year). System output data is the prediction which is based on input data that has been processed using the forecasting method.

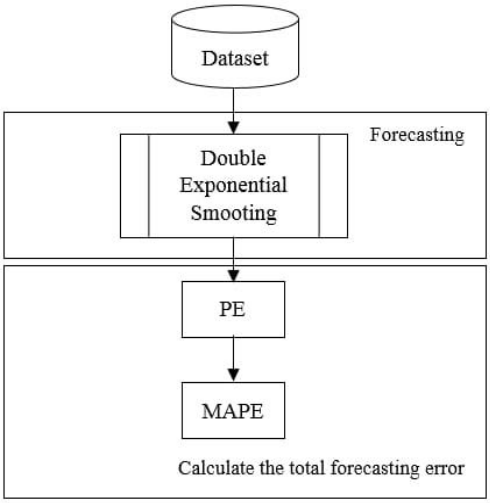

Figure 1. Block diagram.

3.2. The scope of the research

This research was developed an application to calculate passenger volume forecasting trend at PT. KAI Daop 2 Bandung. The focus of this study is to predict passenger volume in the following periods using exponential smoothing and the data used are from 2017 period to 2018 period. Figure 1 shows that the forecasting technique used in this study is double exponential smoothing. PE and MAPE methods are used to calculate error accuracy.

3.3. Dataset

Passenger volume data were retrieved from 2017 period to 2018 period at PT. KAI Daop 2 Bandung. The data on passenger volume are shown in table 1 below.

Table 1. Passenger volume data.

Month	2017/2018		
	Executive Class	Business Class	Economy Class
Jan-17	770526	573890	5441405
Feb-17	625956	268786	4708718
Mar-17	729011	305164	5344856
Apr-17	809453	346084	4932212
May-17	820510	351938	5207331
Jun-17	786731	334120	5127228
Jul-17	978670	435623	5913592
Aug-17	844903	337436	4905755
Sep-17	871157	360784	5128493
Oct-17	847306	323338	5141363
Nov-17	811395	300899	4976950
Dec-17	971181	429208	6340726
Jan-18	806051	363005	5497227
Feb-18	752873	303227	4859475
Mar-18	873965	309208	5468888
Apr-18	908167	309079	5594764
May-18	862440	262802	5361827
Jun-18	1132510	409016	6655129
Jul-18	1120642	395891	6197117
Aug-18	1080212	338010	5674046
Sep-18	1040335	282054	5563542
Oct-18	1055891	264383	5599297
Nov-18	545635	132537	2733045

Based on the data, it can be seen that passenger volume data at PT. KAI Daop 2 Bandung shows an increasing trend and decreasing trend. The following graph shows both trends from 2017/2018 periods.

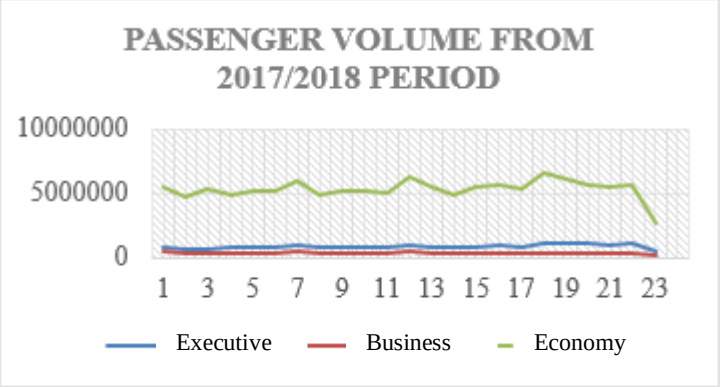

Figure 2. Passenger volume from 2017/2018 period.

4. Results and discussions

4.1. Optimal values evaluation

Double Exponential Smoothing method is used to show trends. Exponential smoothing with the presence of trends such as smoothing on the constants used. Trend is smoothed estimation of the average growth at the end of each period. A smoothing constant parameter (α) must be evaluated in this method.

The α value will be tested from α 0.1 to α 0.9 weight values. The forecasting calculation is done repetitively to obtain the smallest MAPE value.

4.2. Error prediction

The Double Exponential Smoothing method accuracy depends on the selection of smoothing constant values used. In this forecasting, the α value that are tested starts from α = 0.1 to α = 0.9. The Forecasting calculations are executed repetitively to obtain the smallest MAPE value.

In applying MAPE, first PE (Percentage Error) calculations are needed to be done. PE is the stage required to obtain the total PE value, the total PE value that are used to calculate the MAPE value. The total PE calculation is shown in Table 2.

Table 2. PE value (percentage error).

ALPHA	EXECUTIVE CLASS	BUSINESS CLASS	ECONOMY CLASS
0,1	275,9128%	584,1228%	240,0427%
0,2	280,7436%	498,4423%	256,5641%
0,3	305,0762%	520,8305%	269,3060%
0,4	319,0933%	529,8149%	283,2140%
0,5	324,4711%	530,8067%	298,2749%
0,6	331,4166%	553,9764%	321,0236%
0,7	347,3337%	598,7678%	344,8462%
0,8	366,1205%	636,5230%	371,5887%
0,9	397,6077%	681,0404%	401,1319%

PE and MAPE total values can be calculated using different smoothing constants; from the MAPE value, the smallest value will be used as a parameter of the forecasting constant. The results of the MAPE calculation are shown in table 3 below.

Table 3. MAPE results.

ALPHA	EXECUTIVE CLASS	BUSINESS CLASS	ECONOMY CLASS
0,1	**11,9962%**	25,3966%	**10,4366%**
0,2	12,2062%	**21,6714%**	11,1550%
0,3	13,2642%	22,6448%	11,7090%
0,4	13,8736%	23,0354%	12,3137%
0,5	14,1074%	23,0786%	12,9685%
0,6	14,4094%	24,0859%	13,9575%
0,7	15,1015%	26,0334%	14,9933%
0,8	15,9183%	27,6749%	16,1560%
0,9	17,2873%	29,6105%	17,4405%

Table 2 shows that passenger volume forecasting results for the Executive Class category are 946824 using α = 0.1 with MAPE = 11.9962%, the Business Class on the other hand, shows the results of 221188, α = 0.2, MAPE = 21.6714%, and the Economy Class obtained 5144074, α = 0.1, and MAPE = 10.4366%.

The values in the MAPE range can be described as follows. The MAPE range for <10% = forecasting is very accurate, MAPE 10% - 20% = accurate forecasting, MAPE 20% - 50% = forecasting is quite accurate, MAPE> 50% = forecasting is not accurate. The following diagram shows a more detailed information.

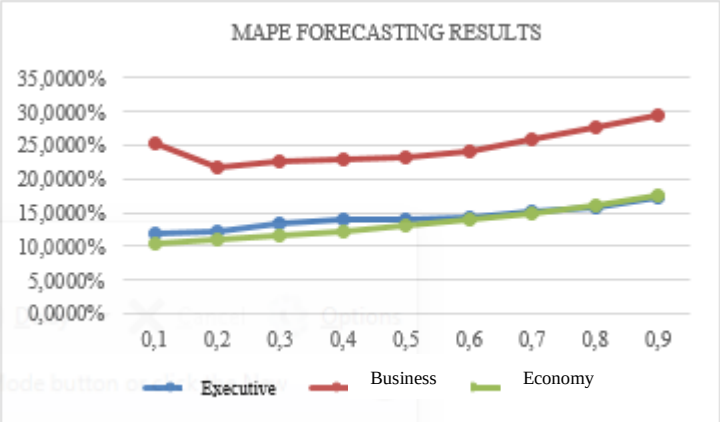

Figure 3. MAPE percentage error testing for KAI 2017/2018 period.

Therefore, the forecasting value for each category is as follows. The Executive Class shows a forecast value of 946824 by using α = 0.1 and obtains MAPE value of 11.9962% which shows accurate forecasting, while the Business Class shows a forecasting value of 221188 using α = 0.2 and obtains a MAPE value of 21.6714% which shows a quite accurate forecasting. Finally, the Economy Class shows a forecast value of 5144074 using α = 0.1 and obtains a MAPE value of 10.4366% which addresses details forecasting results accurate forecasting value. Table 3 below shows a more detailed forecasting results.

Table 4. Forecasting results.

ALPHA	EXECUTIVE CLASS	BUSINESS CLASS	ECONOMY CLASS
0,1	**946824**	248053	**5144074**
0,2	893420	**221188**	4598608
0,3	787445	182777	3924289
0,4	668147	143706	3265137
0,5	551362	110412	2655782
0,6	442300	83687	2089586
0,7	339651	61879	1545022
0,8	239672	42288	1000084
0,9	138905	22400	441284

5. Conclusion

- After testing the calculations with the Double Exponential Smoothing method can be used as information for planning services that will be held by the Operations Manager and Facility Manager.
- The results of forecasting passenger volume in the category of Executive, Business, Economy trains calculated from January 2017 to November 2018, get forecast results of
  - Alpha Executive 0.1, 946824, MAPE 11.9962%, which shows accurate forecasting.
  - Alpha Business 0.2, 221188, MAPE 21.6714%, quite accurate.
  - Alpha Economy 0.1, 5144074, MAPE 10.4366% accurate.

References

[1] Fathony A A and Dewi I S 2018 Pengaruh Dana Pihak Ketiga Dan Return on Asset (Roa) Terhadap Volume Kredit Pada Pt. Bpr Bandung Kidul Periode 2013-2016 *Akurat - J. Ilm. Akunt. - Univ. Bale Bandung* **9** (1) pp 36–56

[2] Sugiharto T, Nugroho F X A P and Poli S 2015 Analisa Kebersihan Fasilitas Kapal Terhadap

Tingkat Kepuasan Penumpang di KM . Binaiya PT . Pelayaran Nasional Indonesia (PELNI) (Determine the effect of cleanliness facilities the ship on the level of passenger satisfaction in Jurusan Ketatalaksanaan) pp 52–62

[3] Mansyur and Rohadi E 2015 Sistem Informasi Peramalan Stok Barang Di Cv. Annora Asia Menggunakan Metode Double Exponential Smoothing *J. Inform. Polinema* **2** pp 45–49

[4] Andini T D and Auristandi P 2016 Peramalan Jumlah Stok Alat Tulis Kantor Di UD Achmad Jaya Menggunakan Metode Double Exponential Smoothing *J. Ilm. Teknol. Inf. STMIK ASIA Malang* **10**(1) pp 1–10