JMSCOWA 2 (2) (2021) Pages:. 125-135

Journal homepage: https://pcijournal.org/index.php/jmscowa

Journal of Mathematics and Scientific Computing with Applications

Published: Pena Cendekia Insani

FORECASTING THE NUMBER OF PASSENGERS FOR THE MEDAN-KUALANAMU TRAIN WITH TIME INVARIANT FUZZY TIME SERIES METHOD

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Article Info

Article history:

Received April 1, 2021
Revised May 2, 2021
Accepted June 13, 2021

Keywords:

Forecasting, Fuzzy Time Series, Number of passangers of the Medan-Kualanamu

ABSTRACT

For forecasting, a forecasting model is needed. Forecasting to find out the increase or even decrease for the departure of Medan - Kualanamu for the next few years. Then the value generated by fuzzy logic is not yes, which has a value of 1, and is not worth 0. Time series is data that is collected from time to time, to describe the development of an activity. From the case of forecasting the number of passengers of the Medan-Kualanamu Train, the author will use the Time Invariant Fuzzy Time Series method. Based on the research, it is obtained that the forecasting of the number of passengers of the Medan-Kualanamu / Kualanamu-Medan train in 2021 is 182,874.9; and 2022 is 266,527,510.6 with AFER is 2,5%.

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1. INTRODUCTION

Forecasting is an activity to predict or predict what will happen in the future with what has happened in the past and present. Another understanding is a calculation analysis technique that will be carried out with a qualitative or quantitative approach to estimate future events by using reference data in the past. Forecasting to find out the increase or even decrease for the departure of Medan - Kualanamu for the next few years. The main purpose of the forecasting process is to reduce uncertainty and make a better estimate of what will happen in the future. One method that has a high level of accuracy based on an error value that is close to 0% is the fuzzy method. (Aladag, 2012).

Fuzzy logic is a method that is based on an artificial intelligence system that can imitate human ability to think into algorithms which are then run by machines. Fuzzy logic interprets vague statements into a logical sense (Aladag, 2012). Fuzzy logic has many values (multivalued value) that can define the values that exist among conventional variables such as yes or no, true or false, and white or black. So the value generated by fuzzy logic is not yes, which is worth 1, and not worth 0. But there is a value between 0 and 1 (Kartikasari, 2019).

Forecasting with fuzzy methods for time series data is known as fuzzy time series. Time series is data collected from time to time, to describe the development of an activity (Admirani, 2018).

In this forecast, the writer chooses to predict the number of passengers on the Medan-Kualanamu Train. Railroad is a form of rail transportation consisting of a series of vehicles towed along a railroad track to transport cargo or passengers. This station has check-in for prospective passengers at Kualanamu International Airport. This service is also the first in Indonesia. On May 8, 2007, this station received the Prima Utama award from the Ministry of Transportation for its service to the public transportation unit.

The Airport Railink Services Kualanamu train (abbreviated ARS Kualanamu) is a train service operated by Railink with the route Medan-Kualanamu International Airport in North Sumatra, Indonesia, (id.m.wikipedia.org)

The factors that cause the rise and fall of the number of train passengers are the convenience of exclusive trains in the form of air-conditioned trains, Reclining Seats, Wi-Fi, audio-visual screens, time, ticket prices, services.

To predict the rise and fall of the number of passengers on the Medan-Kualanamu Train in the future by using the Time Invariant calculation process based on past and present data. Time invariant is time shift (delay, advance, acceleration). Time invariant has a time dependent system function which is not a direct time function. The time-dependent system function is a function of the time-dependent input function.

The time-dependent output function y(t), the input function x(t), the system will be considered time-invariant if there is a time delay at the input $x(t+\delta)$ which immediately equates to the time-delayed output $y(t+\delta)$ function. For example if time t is "elapsed time" then "time-invariant" implies that the relationship between the input function x(t) is constant with respect to time t: $y(t) = f(x(t),t) = f(x(t))$, (Jeng-Ren Hwang, 2000).

From the case of forecasting the number of passengers on the Medan-Kualanamu Train, the author will use the Time Invariant Fuzzy Time Series method. Time Invariant Fuzzy Time Series has the same calculation process as the fuzzy time series method, only the time invariant fuzzy time series method has two special aspects, namely:

1. Variations in historical data are used more than the actual data.
2. To predict future events using a calculation of $R(t, t - 1)$, (Kartika, 2019).

Several studies have applied the Fuzzy Time Series method, including Tuti Hirani (2017) obtained an AFER value of 0.18%, Aria Bayu Elfajar et al (2017) obtained an AFER value of 0.0056% and Dwi Damara Kartikasari et al (2019) obtained an AFER value of 17 ,59%,. Based on the results of several studies above, it can be concluded that Fuzzy method based on time series data has a high level of accuracy and is able to produce good forecasts indicated by a very small AFER (Average Forecasting Error Rate) value.

2. RESEARCH METHODE

A good decision is a decision based on consideration of what will happen at the time of the decision in various company activities. Whether or not the results of a study are determined by the determination of the predictions made. However, keep in mind that forecasts always have an element of error, so that what needs to be considered is an attempt to minimize the errors of the forecast, there are two types of forecasting methods commonly used:

2.1. Time series forecasting method

Time Series data is historical data that is collected, recorded or observed over time in succession. The observation period can be years, months, weeks and in some cases days or hours. In this model, future data values are forecasted based on past data values. The purpose of this method is to find patterns in historical data series and utilize these patterns for future forecasting (Nasution, 2013).The steps of the fuzzy time series method are as follows (Chen, 1996):

1. To determine the set of universes can be searched using the following equation.

[Dmin - D1, Dmax + D2] (2.3)

Information:

a. Dmin is the smallest value of historical data

b. Dmax is the largest value from historical data

c. D1 is any positive number bilangan

d. D2 is any positive number

2. Divide the universal set into intervals with the same number.
3. Define the fuzzy set of the universe set. use $a_1, a_2, a_3, \ldots, A_k$ for fuzzy sets that have linguistic values according to the values in the universal set.

Then the fuzzy set is defined into the following equation:

$$1 = 1_1/u_1 + 1_2/u_2 + \ldots + 1_m/u_m$$
$$2 = 2_1/u_1 + 2_2/u_2 + \ldots + 2_m/u_m \quad (1)$$
$$\ldots = + + +$$
$$k = k_1/u_1 + k_2/u_2 + \ldots + k_m/u_m$$

Where, $a_{ij} \in [0,1]$, $1 \le i \le k$ and $1 \le j \le m$. The variable αij indicates the degree of membership of the interval u_j and fuzzy set A_1.

4. Fuzzification of Historical Data. In this stage, the actual existing data is identified into a fuzzy set. For example, if F(t-1) has a value corresponding to the fuzzy set A_K, then $F(t_i)$ will be fuzzified as A_K.
5. Identifying Fuzzy Logic Relationship (FLR). The way to identify FLR is if F(t-1) is fuzzyified as A_i and F(t) is fuzzyified as AJ, then the Fuzzy Logic Relationship is Ai → AJ. Ai is the left side which is commonly referred to as the current state, and Aj is the right side which is called the next state.
6. Build a Fuzzy Logical Relationship Group (FLRG). To identify the Fuzzy Logic Relationship Group, that is, if there are FLRs that have similarities in the left side is the current state side, then the right side of the FLR will be grouped according to the left side.
7. Defuzzification of predictive value is divided based on:

a. If the results of the fuzzification show that a data is included in the fuzzy set Ai, and only has one Fuzzy Logic Relationship Group ($A_i \rightarrow A_j$), then the defuzzification value for data N+1 is mj.

b. If the results of the fuzzification show that a data entered into the fuzzy set Ai and Ai has more than a Fuzzy Logic Relationship Group ($A_i \rightarrow A_{j1}, A_{j2}, A_{j3}, \ldots, A_{jn}$), then the defuzzification value for data N+1 is $(m_{j1} + m_{j2} + \ldots. + m_{jn})$ /n.

c. If the results of the fuzzification show that a data is included in the fuzzy set Ai, and does not have a single Fuzzy Logic Relationship Group, then the defuzzification value for data N+1 is 0.

2.2. Regression forecasting method

This model is a model that assumes the predicted factor shows a causal relationship in one or more independent variables and uses it to predict the future value of a dependent variable. For an independent variable the regression forecasting model is known as simple regression, and for two or more independent variables the regression forecasting model is multiple regression (Nasution, 2013).

Based on its nature, forecasting techniques are divided into 2 (two) main categories, namely:

1. Qualitative or technological forecasting methods
2. Quantitative forecasting method

2.3. Fuzzy Logic

1. Fuzzy Set

The fuzzy set is a development of the firm set. An unequivocal set is a set whose membership values of its elements only have two possible degrees of membership, namely:

$$\mu_A(x) = \begin{cases} 1; jika\ x \in A \\ 0; jika\ x \notin A \end{cases} \quad (2)$$

Where A is a characteristic function of the set. While in the fuzzy set the degree of membership for each element lies in the interval [0,1].

2.4. Time Invariant Fuzzy Time Series

The Time Invariant Fuzzy Time Series method has the same calculation process as the fuzzy time series method, only the Time Invariant Fuzzy Time Series method has two special aspects, namely:

1. Historical data variations are used more than the actual data
2. To predict future events using a calculation of R(t, t-1), (Jeng-Ren Hwang, 2000).

2.5. Calculating the Error Average Forecasting Error Rate (AFER)

The Average Forecasting Error Rate (AFER) method is used to determine the magnitude of the error that occurs in the forecasting results against the actual data. The following is an equation about how to calculate AFER, (Jilani, 2007).

$$AFER = \left| \frac{\frac{Ai-Fi}{Ai}}{nx100\%} \right| \quad (3)$$

Information:
A_i = The actual value in the i-th data
F_i = The value of the prediction results on the i-th data
N = Number of Data
In the AFER calculation, Ai is the actual data value on the i-th data and Fi is the value of the forecasting results for the i-th data. As for n is the number of numbers 100% is the value to get the percentage result. The AFER value is a value that expresses the percentage difference between the predicted data and the actual data. With a smaller error value, the level of accuracy can be said to be getting better, (Rahmadiani, 2012), (Elfajar, 2017).

3. RESULT AND ANALYSIS

3.1. Presentation of Researched Data Results Data

The results of the research from the data used are the results of the variable number of passengers for the 2016-2000 Medan-Kualanamu/Kualanamu-Medan Railway taken from PT Kereta Api Indonesia (Persero) which can be seen in table 1 below.

The universal set U is expressed from variations in the number of passengers on the Medan-Kualanamu/Kualanamu-Medan Train in previous years using the IBM SPSS Statistic 23 license authorization wizard, which is shown in table 2.

Table 2 Variations in the Number of Passengers for the Medan-Kualanamu/Kualanamu-Medan Train using IBM SPSS Statistic 23 license authorization wizard from 2016-2020.

Descriptive Statistics			
	N	Sum	Variance
2016	12	724233	28633161.295
2017	12	828766	77158223.788
2018	12	748438	124190258.333
2019	12	506138	28438075.606
2020	4	130172	527970490.000
Valid N (listwise)	4		

From table 2 above, it is known that the steps of the forecasting process in the time invariant fuzzy time series method are as follows:

1. Define the universe of discourse (the set of universes U) from the variation of historical data. The historical data variation value is Dmin = 2.843.075,606, and the largest historical data variation value is Dmax = 527.970.490. So that U can be easily partitioned into equal length intervals. So the writer takes D1 and D2 any number, then the writer takes D1 = 506.138 and D2 = 130,172.

From equation 2.3 U = (Dmin-D1,Dmax+D2), then the value of U = (2,336,937,606 ,582,100,662).

To determine the universal set from the historical data set using any positive number determined by the researcher, this research does not use Chen's theory, because there are no definite positive numbers to be used and effective.

2. Partition U into equal length intervals

Range (R) = Max Value - Min Value
= 525,763,724.4
Number of Intervals, K= 1+3.3*Log(N)
K= 3.3067 rounded up to 3
Interval Width i = R/K
i = 158,999,523.51

After the number and width of the interval are obtained, the next step is to divide the data based on the number and width of the interval. It is known that the number of intervals is 3 and the width of the interval is 158,999,523.51 then:

u1 = (2,336,937,606; 161.336,460,12)
u2 = (161.336.460.12; 320.335.982.63)
u3 = (320,335,982,63,; 582,100,662)

To be able to use fuzzy analysis with time series data, the data is arranged in the form of a frequency distribution table, where in fuzzy analysis there is a set of universes. The following is a frequency distribution table based on the fuzzy function method:

Table 3 Fuzzy interval using frequency density

U_i	Interval (I)		Ammount of Data	Number of Sub Interval
U_1	2.336.937,606;	161.336.460,12	4	3
U_2	161.336.460,12;	320.335.982,63	0	1

U_3	320335982,63; 582.100.662	1	2

The frequency distribution table shows that there are 3 intervals and the highest frequency is found in the interval class [2,336,937,606; 161.336.460.12] with 4 data points, while the lowest frequency is in the interval class [161.336.460,12; 320.335.982.63] with 0 data. The number of sub intervals indicates the rank for the interval class where the largest rank starts from the interval that is has the largest amount of data to the smallest amount of data. Based on the frequency table, the first interval has a number of sub intervals of 3, then the interval is ranked 3rd after that for the 3rd rank interval it is divided into 3 sub-intervals of equal size and the 1st rank is divided into 1 subinterval of equal size, thus so on until the 2nd rank interval is divided into 2 equal sub-intervals. So that in the end the sub-intervals formed are 6 sub-intervals which will become the domain for the fuzzy set Ai as shown in the following table:

Table 4 Fuzzy interval using frequency density based on division

Fuzzy set	Interval	Interval width
A1	2336937,606; -50.662.903,56	52999841,17
A2	-50.662.903,56; -103.662.744,73	52999841,17
A3	-103.662.744,73; 161.336.460,12	52999841,17
A4	161.336.460,12; 320.335.982,63	158999523,5
A5	320.335.982,63; 240.836.220,88	79499761,76
A6	240.836.220,88; 582.100.662	79499761,76

Define a fuzzy set Ai. It is assumed that the fuzzy value comes from the linguistic variable of data variation on the number of passengers on the Medan-Kualanamu/Kualanamu-Medan Railway. Lingistic values for A1, A2, and A3 are: A1 (down), A2 (fixed), A3 (up). For the 3 available intervals, each i, I = 1,3 A_j, j = 1,3 is expressed by the real value para range [0,1]:

$A_1 = (\frac{1}{\mu 1}, \frac{0,5}{\mu 2}, \frac{0}{\mu 3})$

$A_2 = (\frac{0,5}{\mu 1}, \frac{1}{\mu 2}, \frac{0,5}{\mu 3})$

$A_3 = (\frac{0}{\mu 1}, \frac{0,5}{\mu 2}, \frac{1}{\mu 3})$

Defuzzification

After getting the interval and fuzzy set, the next step is to find the midpoint value of each interval using Equation $a_i = \frac{batas\ bawah\ interval + bata\ \ atas\ interval}{2}$.

Maka di dapat nilai berikut :

a_1 = -24.162.982,98
a_2 = -77.162.824,15
a_3 = 28.836.857,69
a_4 = 240.836.221,4
a_5 = 280.586.101,8
a_6 = 411.468.441,4

The middle value is the middle value of the distance of each interval. This middle value will be used in the defuzzification stage.

Predicting data percentage changes

Then calculate the midpoint value of each class interval, once obtained, then the midpoint is used to predict the percentage change with the triangular membership function. For example, want to predict
change in percentage of data on Fuzzy Aj = 1; Aj = 2 j n-1 and Aj = n then can be calculated by the following equation:

$$T_j \begin{cases} \dfrac{1{,}5}{\frac{1}{a1}+\frac{0{,}5}{a2}} & \boldsymbol{if\ j=1} \\ \dfrac{2}{\frac{0{,}5}{aj-1}+\frac{1}{aj}+\frac{0{,}5}{aj+1}} & \boldsymbol{if\ 2\ \leq j \leq n-1} \\ \dfrac{1{,}5}{\frac{0{,}5}{an-1}+\frac{1}{an}} & \boldsymbol{if\ j=n} \end{cases}$$

Then the value is:

a. $t_1 = 407.207{,}8$
b. $t_2 = 6.020.905.545$
c. $t_3 = 3{,}46778E-08$
d. $t_4 = 240.836.219{,}4$
e. $t_5 = 0{,}5$
f. $t_6 = 182.874{,}9$

If all the predicted values of the percentage change in data have been obtained, the next step is to predict the value of the i-th forecasting data using the predicted value of the percentage change in data (tj) using the following equation:

$$F_i = \left(\frac{tj}{100} \,.\, xt - 1\right) + x_{t-1} \qquad (2 \leq i\ \leq 6\ and\ 2 \leq t \leq 6)$$

Then the results are known as follows:

$F_2 = 5.245.858.616$
$F_3 = 828.795$
$F_4 = 748.440$
$F_5 = 510.679$
$F_6 = 238.182.087$

3. Fazzing variations from historical forecasting data, if the variation in year t is p and p ui and if the value expressed by the fuzzy set Aj with the maximum membership value falls on ui, then p is declared fuzzified in Aj, the result of variations from the data on the number of passengers on the Medan Railway - Your fuzzified kualana.

To simplify the membership value of the fuzzy set Ai is between 0, 0,5, 1 where 1≤ i n, n is the number of intervals that have been divided previously, here is the matrix form of the formation of the fuzzy set.

Determine R_i, $i = \overline{1,3}$

$$R_1 = A_1^T\ x\ A_1 = \begin{bmatrix} 1 \\ 0{,}5 \\ 0 \end{bmatrix} x \begin{bmatrix} 1 & 0{,}5 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0{,}5 & 0 \\ 0{,}5 & 0{,}5 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$R_1 = A_1^T x A_1 \cup A_1^T x A_3 = \begin{bmatrix} 1 & 0{,}5 & 0 \\ 0{,}5 & 0{,}5 & 0 \\ 0 & 0 & 0 \end{bmatrix} \cup \begin{bmatrix} 0 & 0{,}5 & 1 \\ 0 & 0{,}5 & 0{,}5 \\ 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0{,}5 & 1 \\ 0{,}5 & 0{,}5 & 0{,}5 \\ 0 & 0 & 0 \end{bmatrix}$$

$$R_2 = A_2^T\ x\ A_1 = \begin{bmatrix} 0{,}5 \\ 1 \\ 0{,}5 \end{bmatrix} x \begin{bmatrix} 1 & 0{,}5 & 0 \end{bmatrix} = \begin{bmatrix} 0{,}5 & 0{,}5 & 0 \\ 1 & 0{,}5 & 0 \\ 0{,}5 & 0{,}5 & 0 \end{bmatrix}$$

$$R_2 = A_2^T x A_1 \cup A_2^T\ x A_3 = \begin{bmatrix} 0{,}5 & 0{,}5 & 0 \\ 1 & 0{,}5 & 0 \\ 0{,}5 & 0{,}5 & 0 \end{bmatrix} \cup \begin{bmatrix} 0 & 0{,}5 & 0{,}5 \\ 0 & 0{,}5 & 1 \\ 0 & 0{,}5 & 0, \end{bmatrix} = \begin{bmatrix} 0{,}5 & 0{,}5 & 0{,}5 \\ 1 & 0{,}5 & 1 \\ 0{,}5 & 0{,}5 & 0{,}5 \end{bmatrix}$$

$$R_3 = A_3^T\ A_1 \cup A_3^T\ A_3 = \begin{bmatrix} 0 & 0 & 0 \\ 0{,}5 & 0{,}5 & 0 \\ 1 & 0{,}5 & 0 \end{bmatrix} \cup \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0{,}5 & 0{,}5 \\ 0 & 0{,}5 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0{,}5 & 0{,}5 & 0{,}5 \\ 1 & 0{,}5 & 1 \end{bmatrix}$$

By using the max-min operator.

$$A_1 \circ R_1 = \begin{bmatrix} 1 & 0{,}5 & 0 \end{bmatrix} \circ \begin{bmatrix} 1 & 0{,}5 & 1 \\ 0{,}5 & 0{,}5 & 0{,}5 \\ 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0{,}5 & 1 \end{bmatrix}$$

$$A_2 \circ R_2 = [0{,}5 \quad 1 \quad 0{,}5] \circ \begin{bmatrix} 0{,}5 & 0{,}5 & 0{,}5 \\ 1 & 0{,}5 & 1 \\ 0{,}5 & 0{,}5 & 0{,}5 \end{bmatrix} = [1 \quad 0{,}5 \quad 1]$$

$$A_3 \circ R_3 = [0 \quad 0{,}5 \quad 1] \circ \begin{bmatrix} 0 & 0 & 0 \\ 0{,}5 & 0{,}5 & 0{,}5 \\ 0{,}5 & 1 & 0{,}5 \end{bmatrix} = [0{,}5 \quad 1 \quad 0{,}5]$$

Table 5 Fuzzified Number of Medan-Kualanamu Train Passengers and Variations

Year	Total Passenger	variation	Fazzified Variation
2016	724.233	28.633.161,3	A1
2017	828.766	77.158.223,79	A1
2018	748.438	124.190.258,3	A1
2019	508.138	28.438.075,61	A1
2020	130.132	52.797.0490	A3

4. Stated the fuzzy logic relation Ai → Aj, this can be interpreted that which is located on the left side is called the current estate and Aj which is on the right side of the relationship is called the next state and if there is a reduction in the relationship then it is still counted only 1 time. The information on FRL (Fuzzy Logic Relationship) is as follows:
   1. $A_1 \rightarrow A_1$
   2. $A_1 \rightarrow A_3$

5. Fuzzy Logic Relation Group (FRLG), in Fuzzy Logic Relation there are several relations that are the same on the left side (left side), namely in the current state, then these relations will be collected into the same group, namely:

Table 6 Fuzzy set relations

Year	Total Passsenger	Forecasting The Number Of Passengers	Midpoint	Forecasting the Percentage Change in Data	FRLG
2016	724.233		-24.162.982,98	407.207,8	A1→ A1, A3
2017	828.766	5.245.858.616	-77.162.824,15	6.020.905.545	A1→ A1, A3
2018	748.438	828.795	28.836.857,69	$3{,}46778E-08$	A1→ A1, A3
2019	508.138	748.440	240.836.221,4	240.836.219,4	A1→ A1, A3
2020	130.132	510.679	280.586.101,8	0,5	A3→ A1, A3
2021		182.874,9	411.468.441,4	182.874,9	

Calculate R_i, $i = \overline{1,6}$ as a combination of logical relations so that:

$R_1 = A_1^T x A_1 \cup A_1^T x A_3$

$R_2 = A_2^T x A_1 \cup A_2^T x A_3$

$R_3 = A_3^T A_1 \cup A_3^T A_3$

Where is the union operator.

6. Declare a group of fuzzy logic relations based on known variations from the previous year, namely: If Aj-1 = Aj and Ri = Rj for j = $\overline{1,3}$

so from the definition of composition: Ai = Aj ° Rj

Where Ai is the variation of forecasting in the next 5 years, so that the forecasting output is:
$F(2016) = A_1° R_1$=[1 0,5 1]
$F(2017) = A_1° R_1$=[1 0,5 1]
$F(2018) = A_1° R_1$=[1 0,5 1]
$F(2019) = A_2° R_2$= [1 0,5 1]
$F(2020) = A_3° R_3$=[0,5 1 0,5]
To predict the number of candidates in 2022, it can be expressed by: F(2022) = F(2021) R(2021,2022). On the basis of 2021 we get F(1992) A1.
F(2022) = A1→ A1, A3
Defuzzification(F (2022)) = defuzzification (A1→ A1, A3)
With the equation (f(2022)) = $\frac{U1+U2}{2}$, the value is 266.527.510.6.

7. Forecast its forecast output and defuzzify it. From the results of the fuzzy logic relation group, the defuzzification process is carried out, and it can be concluded that the types of output with z are as follows:

$A_1° R_1$=[1 0,5 1];Z= 6.428.116,8
$A_2° R_2$= [1 0,5 1]; Z = 240.836.219,4
$A_3° R_3$=[0,5 1 0,5];Z = 0,5

8. Calculating the AFER (Aferage Forecasting Error Rate) error to find out forecasting errors.

AFER = $\left|\frac{\frac{Ai-Fi}{Ai}}{nx100\%}\right|$

AFER = 2,5%

3.2. From the forecasting results obtained AFER is 2.5%.

The parameter used to measure the accuracy of the forecast is the Average Forecasting Error Rate (AFER) where if the parameter is in the range of 0%-100%, it can be said that the forecast results are quite good. From the range of 0% - 100% can be grouped into 4 categories, namely from the range of 0% - 10% very good, from the range of 10% - 20% good, from the range of 20% - 50% enough and from the range of 50% - 100% bad.

From the forecasting results obtained in 2017, 2018, 2019, and 2020 of 5,245,858,616, 828,795, 748,440 and 510,679 where from the actual data with the forecast value there is a difference of 2017 = 0.2%, 2018 = 0.2%. 2019 = 0.2%, 2020 = 0.2%, while the results obtained from AFER are 2.5%. So it can be said that the forecast results are said to be very good according to the predetermined categories.

This research uses time invariant fuzzy time series method with 3 fuzzy sets. Based on the research, the forecast for the number of passengers for the Medan-Kualanamu/Kualanamu-Medan Railway in 2021 is 182,874,9; and 2022 is 266,527,510.

3.3` Discussion

The data on the number of passengers on the Medan-Kualanamu/Kualanamu-Medan Train used is sourced from PT Kereta Api Indonesia (Persero). To find the universal set U, it is stated from the variation in the number of passengers of the Medan-Kualanamu/Kualanamu-Medan Train in previous years so that the largest and smallest universe set obtained is Delta Min = 2,843,075, Delta Max = 527,970,490 so that the U value can be obtained. = (2,336,937,606 , 582,100,662). Next, partition U into the same interval length by specifying the range, the length of the number of intervals and the length of the interval. The number of intervals is 3 and the width of the interval is 158,999,523.51. Data on the number of passengers on the Medan-Kualanamu/Kualanamu-Medan Train from 2016 – 2020 is used for the formation of fuzzy sets and to determine the level of accuracy of the methods used for forecasting.

The parameter used to measure the accuracy of the forecast is the Average Forecasting Error Rate (AFER) where if the parameter is in the range of 0%-100%, it can be said that the forecast results are quite good. From the range of 0% - 100% can be grouped into 4 categories, namely from the range of 0% - 10% very good, from the range of 10% - 20% good, from the range of 20% - 50% enough and from the range of 50% - 100% bad.

From the forecasting results obtained in 2017, 2018, 2019, and 2020 of 5,245,858,616, 828,795, 748,440 and 510,679 where from the actual data with the forecast value there is a difference of 2017 = 0.2%, 2018 = 0.2%. 2019 = 0.2%, 2020 = 0.2%, while the results obtained from AFER are 2.5%. So it can be said that the forecast results are said to be very good according to the predetermined categories.

This research uses time invariant fuzzy time series method with 3 fuzzy sets. Based on the research, the forecast for the number of passengers for the Medan-Kualanamu/Kualanamu-Medan Railway in 2021 is 182,874,9; and 2022 is 266,527,510.

3. CONCLUSION

This research uses time invariant fuzzy time series method with 3 fuzzy sets. Based on the research, the forecast for the number of passengers for the Medan-Kualanamu/Kualanamu-Medan Railway in 2021 is 182,874,9; and 2022 is 266,527,510.6 with MSE is 2.60 and AFER is 24,665.12 so it can be said that the forecast results are said to be increasing according to the predetermined category.

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