Application of Weighted Fuzzy Time Series Model to Forecast Trans Jogja's Passengers

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Abstract: Trans Jogja is a public transportation in Yogyakarta which is operated by Dishubkominfo DIY. It is one of the ways to overcome transportation problems especially traffic jams. The total number of the buses until now reaches to 54. In fact, it does not significantly overcome the traffic jam problem yet. Dishubkominfo DIY always makes some efforts to improve the Trans Jogja management. One of them is by giving good services to the passengers. So, it is important to predict the amount of the passengers of Trans Jogja. This forecast uses the data from July 1st 2014 – September 29th 2014. This forecast is based on Weighted Fuzzy Time Series (WFTS). To forecast using WFTS, there are some important steps. There are defining the universe of discourse U, defining the fuzzy sets, establishing fuzzy logical relationship, grouping, forecasting, defuzzification, assigning weights and the last is calculating the final forecast values. The data of passengers is not stationer. It must be stationered first by differencing the data. From the forecasting result, MAPE and MSE of testing data are larger than MAPE and MSE of training data. So, WFTS can be used to predict Trans Jogja passenger in the following time.

Key words: Forecasting, trans Jogja's passengers, weighted fuzzy time series.

1. Introduction

Yogyakarta is one of the populous cities in Indonesia [1]. Traffic jam happens especially at the rush hours. Operating Trans Jogja bus is one of strategies that have been made [2] to solve traffic jams. Trans Jogja bus is operated since 2008 and it has been alternative solution to provide public transport-based on "buy the service". The number of the buses is 54 buses with 112 shelters. A good management of buses of Trans Jogja makes them interesting. To improve the management, it is needed to know the number of passengers. Thus, a research to predict the number of Trans Jogja passengers is significant to be conducted.

Some researchers have conducted researches which predict the buses passengers. One of them is Hidayat [3] with his research about the method of Adaptive Neuro Fuzzy Inference System and When-xia [4] using regression analysis method.

The fuzzy time series method is a dynamic process that uses linguistic values as observations. The research on fuzzy system that uses time series data was first conducted by Song [5]-[7] to predict the number of enrollments in a university. Other research conducted by Nurhayadi [8] is to predict the register at the Albama University. Then, Shah [9] applied fuzzy time series to predict the gross domestic capital in

India. One more researcher, Abadi [10], constructed fuzzy time series that combines the lookup tables and value decomposition method for predicting inflation rate.

Chen [11], in the year 1996 developed Song method which is further developed by Yu [12] in 2005. Again, Song method is developed by Lee [13] talking about the seasonal data and by Suhartono [14], [15] about forecasting seasonal and trend data. Finally, the study by Suhartono is applied to forecast tourist arrivals.

In fact, Lee's research [16] weighted fuzzy time series method has better accuracy than Chen's [11], Yu's [12], and Cheng's [17] method. Thus, in this paper, the writer used the Lee's method to predict the passengers of Trans Jogja bus. Since Lee [16] has many orders, the writer merely use the first one which is about weighted fuzzy time series model with data time variant. The data obtained are in the form of daily data of Trans Jogja's passengers. Differencing data to get stationary data is important since the data are not stationer. After acquiring the results of forecasting, the writer calculated the value of MAPE (Mean Absolute Percentage Error) and MSE (Mean Square Error) of fuzzy time series method and weighted fuzzy time series method [16].

2. Forecasting with Fuzzy Time Series

Fuzzy time series (FTS) is the development of a fuzzy system using time series data. Linguistic variables that used in this research are the data in the previous period which is mapped in to the data in the next period.

Definition 2.1. [11] Let U be universe of discourse, $U=\{u_1,u_2,\ldots,u_{n1}\}$. A fuzzy set A of U is defined by

$$A=\left\{\frac{f_A(u_1)}{u_1}+\frac{f_A(u_2)}{u_2}+\ldots+\frac{f_A(u_n)}{u_n}\right\} \tag{1}$$

where f_A is the membership function of A, $f_A:U\to[0,1]$, and $f_A(u_1)$ indicates the grade of membership of u_1 in A, where $f_A(u_1)\in[0,1]$ and $1\le i\le n$.

Definition 2.2. [5] Let $Y(t)\,(t=\ldots,\ 0,\ 1,\ 2,\ldots)$, a subset of R, be the universe of discourse on which fuzzy set $f_i(t)\,(i=1,\ 2,\ldots)$ are defined and $F(t)$ be a collection of $f_i(t)\,(i=1,\ 2,\ \ldots)$. Then, $F(t)$ is called a fuzzy time series on $Y(t)\,(t=\ldots,0,\ 1,\ 2,\ldots)$.

Definition 2.3. [11] If there exists a fuzzy relationship $R(t-1,\,t)$, such that $F(t)=F(t-1)\circ R(t-1,t)$, where $\circ$ is an arithmetic operator, then $F(t)$ is said to be caused by $F(t-1)$. The relationship between $F(t)$ and $F(t-1)$ can be denoted by $F(t-1)\to F(t)$.

Definition 2.4. [11] Let $F(t)$ be a fuzzy time series. If for any time, $F(t)=F(t-1)$ and $F(t)$ only has finite elements, then $F(t)$ is called a time-invariant fuzzy time series. Otherwise, it is called a time-variant fuzzy time series.

Based on Definition 2.4., in this forecasting, the data must be stationary data.

Definition 2.5. [11] Suppose $F(t-1)=A_i$ and $F(t)=A_j$, a fuzzy logical relationship can be defined as

$$A_i\to A_j \tag{2}$$

where A_i and A_j are called the left-hand side (LHS) and right-hand side (RHS) the fuzzy logical relationship, respectively.

The steps to forecast with fuzzy time series [11] are given as follows:

Step 1. Define the universe of discourse U.

Step 2. Divide the universal of discourse U with the same interval.

Step 3. Define fuzzy set on a universal discourse called U.

Step 4. Determine the fuzzy logical relationship.

Step 5. Establish group the fuzzy logical relationship.

Step 6. Forecast. Let $F(t-1) = A_i$,

Case 1: If the fuzzy logical relationship of A_i is empty; $A_i \to \varnothing$, then $F(t)$, forecast value, is equal to A_i.

Case 2: There is only one fuzzy logical relationship in the fuzzy logical relationship sequence. If $A_i \to A_j$, then $F(t)$, forecast value, is equal to A_j.

Case 3: If $A_i \to A_{j_1}, A_{j_2}, \ldots, A_{j_k}$, then $F(t)$, forecast value, is equal to $A_{j_1}, A_{j_2}, \ldots, A_{j_k}$.

Step 7. Defuzzification. If the forecast of $F(t)$ is $A_{j_1}, A_{j_2}, \ldots, A_{j_k}$, the defuzzified result is equal to the arithmetic average of the midpoints of $A_{j_1}, A_{j_2}, \ldots, A_{j_k}$.

3. Forecasting with Weighted Fuzzy Time Series

Different with forecasting using fuzzy time series, forecasting using weighted fuzzy time series adds weight after defuzzification step. The steps of forecasting using Weighted Fuzzy Time Series (WFTS) method [16] are given as follows:

Step 1. Define the universe of discourse U.

Step 2. Divide the universal of discourse U with the same interval.

Step 3. Define fuzzy set on a universal discourse called U.

Step 4. Determine the fuzzy logical relationship.

Step 5. Establish group the fuzzy logical relationship.

Step 6. Forecast, with fuzzy time series method.

Step 7. Defuzzification.

Step 8. Assign weights. Suppose the forecast of $F(t)$ is $A_{j1}, A_{j2}, \ldots, A_{jk}$. The corresponding weight for $A_{j1}, A_{j2}, \ldots, A_{jk}$, say $w_1', w_2', \ldots, w_k'$ are

$$w_i' = \frac{w_i}{\sum_{h=1}^{k} w_i} \tag{3}$$

where $w_1 = 1$ and $w_i = c^{i-1}$ for $c \geq 1$ and $2 \leq i \leq k$. Changed to weight matrix form, equation (3) will be

$$w(t) = \left[\frac{w_1}{\sum_{h=1}^{k} w_i}, \frac{w_2}{\sum_{h=1}^{k} w_i}, \ldots, \frac{w_k}{\sum_{h=1}^{k} w_i} \right] \tag{4}$$

$$w(t)=\left[\frac{1}{\sum_{h=1}^{k}w_i},\frac{c}{\sum_{h=1}^{k}w_i},\frac{c^2}{\sum_{h=1}^{k}w_i},\ldots,\frac{c^{k-1}}{\sum_{h=1}^{k}w_i}\right] \tag{5}$$

where w_k is the corresponding weight for A_{ij}.

Step 9. Calculate the final forecast values. The final forecast is equal to the product of the defuzzified matrix and the transpose of the weight matrix:

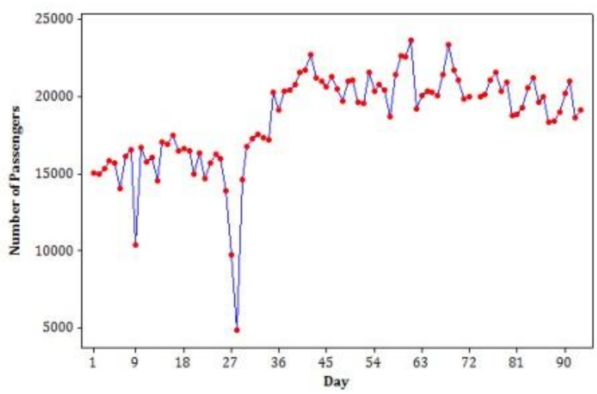
$$\hat{F}(t)=M(t)\times W(t)^T=[m_{j_1},m_{j_2},\ldots,m_{j_k}]\times\left[\frac{1}{\sum_{h=1}^{k}w_i},\frac{c}{\sum_{h=1}^{k}w_i},\ldots,\frac{c^{k-1}}{\sum_{h=1}^{k}w_i}\right]^T \tag{6}$$

where $\times$ is the matrix product operator.

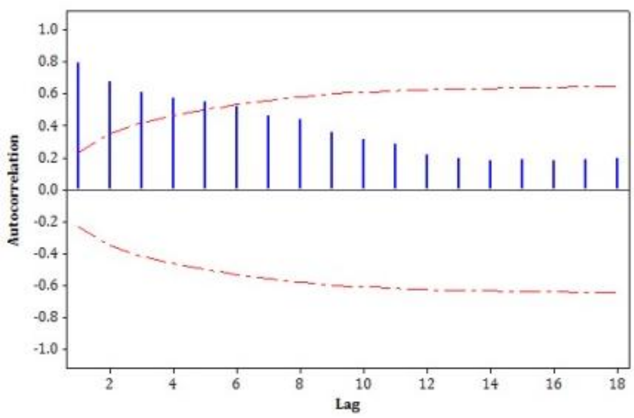
4. Application on Forecasting The Trans Jogja's Passengers

4.1. Determining Stationary Data

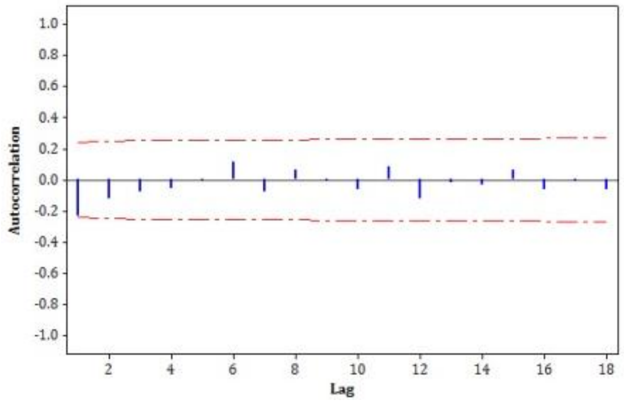
Before predicting the number of Trans Jogja's passengers using the Weighted Fuzzy Time series, the data must be stationered. The data [18] that used in this research is data of Trans Jogja's passengers count based from the ticket sales in the period of 1 July2014 to 29 September2014. The number of data is 91 data taken from daily data of Trans Jogja passengers. The data are divided into 72 training and 19 testing data. Checkingdata is done by using Minitab 16,by ploting data using Autocorelation Function (ACF). Here is the plot of the data of passengers, followed by ACF plot.



(a)



(b)



(c)

Fig. 1. (a) The data plot of Trans Jogja's passengers; (b) The ACF of original data; (c) The ACF plot of resulting data after differentiation.

Fig. 1 (b) displays that there are some lags that come out of the significance line.It means that the data are not stationary. Thus, to obtain stationary data, diferencing the data is a must. In this paper, differencing the data is conducted using Minitab16 or manually by [19]:

$$P_{t+1} = Y_{t+1} - Y_t \tag{7}$$

We need to plot the ACF to see the data of Trans Jogja's passengers after the differencing process. Fig. 1(c) shows that there is no lag came out of the significance line. It means that the data has been stationary with one differentiation. Furthermore, by using resulting data after differentiation that has already stationared (hereinafter called stationary data), the passengers of Trans Jogja can be forecasted by using the Weighted Fuzzy Time Series (WFTS).

4.2. Forecasting Trans Jogja's Passengers Using Weighted Fuzzy Time Series

The forecasting process of Trans Jogja's passengers with stationary data that has been obtained is conducted by the following steps:

Step 1. Define the universal discourse U.

Based on obtained stationary data, the smallest datum is -6106 and the largest datum 9772. So, the universal of discourse for this data is $U = [-7250 \quad 10250]$.

Step 2. Divide the universal of discourse U with the same interval.

To simplify universal set of partitions into particular parts, the data is changed to the form of chart. The chart is represented in Fig 2(a).Based on the chart, the universal of discourse U is partitioned into 7 sections with long intervals (2500) of each section. The sections are: $u_1 = [-7250 \quad -4750]$, $u_3 = [-2250 \quad 250]$ $u_3 = [-2250 \quad 250]$, $u_4 = [250 \quad 2750]$, $u_5 = [2750 \quad 5250]$, $u_6 = [5250 \quad 7750]$, and $u_7 = [7750 \quad 10250]$.

Step 3. Define fuzzy set on a universal of discourse called U.

The next step is to define the intervals into a fuzzy set. In this study, the writer used 5 linguistic variables: A_1 = very very little, A_2 = very little, A_3 = a little A_4 = moderate, A_5 = much, A_6 = very much, and A_7 = very very much.Then, the writer defined fuzzy sets A_1, A_2, A_3, A_4, A_5, A_6 and A_7 on the universal of discourse U:

$$A_1 = \frac{1}{u_1} + \frac{0.5}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7}.$$

$$A_2 = \frac{0.5}{u_1} + \frac{1}{u_2} + \frac{0.5}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7}.$$

$$A_3 = \frac{0}{u_1} + \frac{0.5}{u_2} + \frac{1}{u_3} + \frac{0.5}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7}.$$

$$A_4 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0.5}{u_3} + \frac{1}{u_4} + \frac{0.5}{u_5} + \frac{0}{u_6} + \frac{0}{u_7}.$$

$$A_5 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0.5}{u_4} + \frac{1}{u_5} + \frac{0.5}{u_6} + \frac{0}{u_7}.$$

$$A_6 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0.5}{u_5} + \frac{1}{u_6} + \frac{0.5}{u_7}.$$

$$A_7 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0.5}{u_6} + \frac{1}{u_7}.$$

From the fuzzy sets, it is known that this study uses a triangular membership functions.

Step 4. Determine the fuzzy logical relationship.

Fuzzy logical relationship (FLR) is used in forecasting established by partitioning the universal of discourse and defining of fuzzy sets. Establishment of the FLR conducted based on fuzzy logic: if $P_t = A_i$ then $\hat{P}_i = \hat{A}_{i+1}$.

Step 5. Group or establish the fuzzy logical relationship.

In this step, the FLR on step 4 is grouped for each fuzzy set. The result of grouping fuzzy logic relationship is shown on Table 1.

Table 1. Group of Fuzzy Logical Relationship (FLR)

Group	LHS	RHS	Number of RHS
1	A_1	A_6, A_7	2
2	A_2	A_1, A_4	2
3	A_3	A_4, A_3, A_4, A_4, A_4, A_4, A_3, A_3, A_3, A_4, A_4, A_3, A_2, A_3, A_5, A_4, A_4, A_4, A_3, A_3, A_4, A_3, A_4, A_3, A_3, A_4, A_4, A_3, A_4, A_4, A_3, A_4, A_3, A_3, A_3	35
4	A_4	A_4, A_3, A_4, A_1, A_3, A_3, A_3, A_3, A_4, A_3, A_4, A_4, A_3, A_3, A_4, A_3, A_3, A_3, A_3, A_3, A_3, A_4, A_3, A_2, A_4, A_3, A_4, A_3	28
5	A_5	A_3	1
6	A_6	A_3	1
7	A_7	A_4	1

Step 6-7. Forecast and Defuzzification. In this step, the first thing to do is determining the midpoint of each interval fuzzy sets. There are $m_1 = -6000$, $m_2 = -3500$, $m_3 = -1000$, $m_4 = 1500$, $m_5 = 4000$, $m_6 = 6500$, dan $m_7 = 9000$.

Step 8-9. Assigning weights and calculating the value of forecasting result.After acquiring the midpoint of the interval fuzzy sets, the next step is defuzzifying. The Table 2 shown the defuzzification results of each linguistic variable with *c* = 2.

Table 2. The Value of Forecast Result

Fuzzy Sets	Computation
A1	$\hat{A}_{t+1} = \frac{m_6 + 2m_7}{1+2} = \frac{6500 + 2(9000)}{3} = 8166.667 = 8166$
A2	$\hat{A}_{t+1} = \frac{m_1 + 2m_4}{1+2} = \frac{-6000 + 2(1500)}{3} = -1000$
A3	$\hat{A}_{t+1} = \frac{m_4 + 2m_3 + 4m_4 + \cdots + 2^{34}m_3}{1+2+4+\cdots+2^{34}} = \frac{1500 + 2(-1000) + 4(1500) + \cdots + 2^{34}(10000)}{34359738367} = \frac{-2.67123E+13}{34359738367} = -777.4316699 = -777$
A4	$\hat{A}_{t+1} = \frac{m_4 + 2m_3 + 4m_4 + \cdots + 2^{27}m_3}{1+2+4+\cdots+2^{27}} = \frac{1500 + 2(-1000) + 4(1500) + \cdots + 2^{27}(10000)}{268435455} = \frac{-74399722500}{268435455} = -277.1605655 = -277$
A5	$\hat{A}_{t+1} = m_3 = -1000$
A6	$\hat{A}_{t+1} = m_3 = -1000$
A7	$\hat{A}_{t+1} = m_4 = 1500$

4.3. Return of the Differencing Data

After acquiring the value of forecasting results, the result data from the stationary data is returned to the original data to obtain the results of forecasting. Based on the equation (7), the return of the differencing data to the stationary data is obtained by equation

$$\hat{Y}_{t+1} = \hat{P}_{t+1} + Y_t \tag{8}$$

The forecasting result that are needed as training data are shown on Table 3 and Table 4 show the testing data. The data forecasting result with weighted fuzzy time series method is still in the form of differencing data. Table 3 shows that data from the forecasting resultinforms the number passengers on day-*t*.

Table 3. The Forecasting Result of Training Data

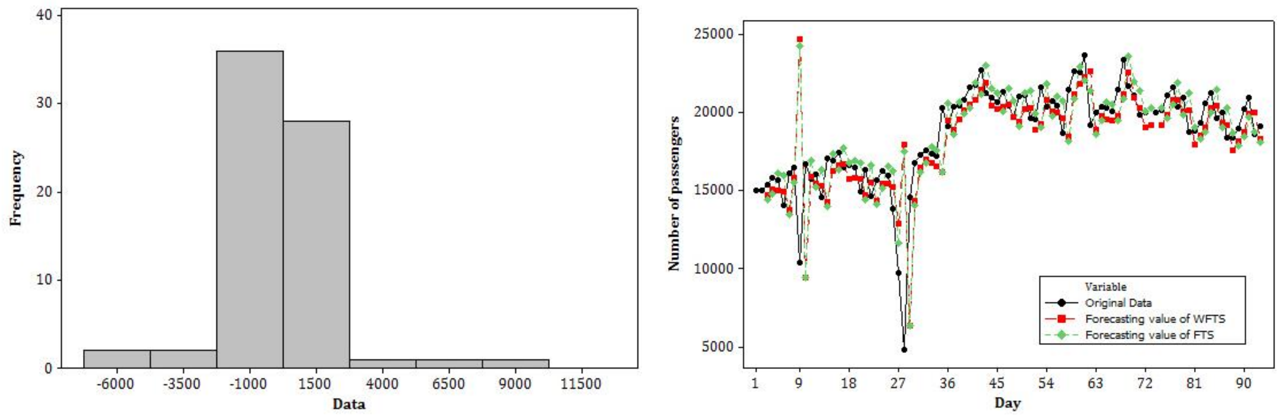
Day	Y_t	Result		Day	Y_t	Result		Day	Y_t	Result		Day	Y_t	Result	
		$\hat{P}_t$	$\hat{Y}_t$			$\hat{P}_t$	$\hat{Y}_t$			$\hat{P}_t$	$\hat{Y}_t$			$\hat{P}_t$	$\hat{Y}_t$
1	15015			25	15987	-777	15477	37	20357	-277	18874	55	20761	-277	20067
2	14978			26	13862	-777	15210	38	20450	-777	19580	56	20419	-777	19984
3	15346	-277	14701	27	9759	-1000	12862	39	20813	-277	20173	57	18710	-777	19642
4	15825	-277	15069	28	4834	8166	17925	40	21602	-277	20536	58	21455	-277	18433
5	15707	-777	15048	29	14606	1500	6334	41	21727	-777	20825	59	22637	-277	21178
6	14046	-777	14930	30	16776	-277	14329	42	22709	-277	21450	60	22590	-777	21860
7	16108	-277	13769	31	17297	-277	16499	43	21225	-777	21932	61	23653	-277	22313
8	16514	-277	15831	32	17548	-277	17020	44	20981	-777	20448	62	19195	-1000	22653
9	10408	8166	24680	33	17333	-777	16771	45	20662	-777	20204	63	20037	-277	18918
10	16670	-1000	9408	34	17201	-777	16556	46	21294	-277	20385	64	20346	-277	19760
11	15754	-777	15893	35	20297	-1000	16201	47	20476	-777	20517	65	20262	-777	19569
12	16070	-277	15477	36	19151	-777	19520	48	19691	-777	19699	66	20055	-777	19485
13	14568	-777	15293	19	16496	-777	15853	49	21001	-277	19414	67	21452	-277	19778
14	17050	-277	14291	20	14974	-777	15719	50	21099	-777	20224	68	23348	-277	21175
15	16920	-777	16273	21	16336	-277	14697	51	19662	-777	20322	69	21718	-777	22571
16	17459	-277	16643	22	14654	-777	15559	52	19576	-777	18885	70	21086	-777	20941
17	16500	-777	16682	23	15700	-277	14377	53	21583	-277	19299	71	19820	-777	20309
18	16630	-777	15723	24	16254	-277	15423	54	20344	-777	20806	72	19991	-777	19043

Similar to Table 3, Table 4 shows that the data from the forecasting results are changed to be the data of forecasting passenger, but in the form of testingdata. Testing data in Table 4 are not used to build the model (the rules of fuzzy relationship).

Table 4. The Forecasting Result of Testing Data

Day	Y_t	Result $\hat{P}_t$	Result $\hat{Y}_t$	Day	Y_t	Result $\hat{P}_t$	Result $\hat{Y}_t$	Day	Y_t	Result $\hat{P}_t$	Result $\hat{Y}_t$	Day	Y_t	Result $\hat{P}_t$	Result $\hat{Y}_t$
1	20163	-777	19214	6	18742	-777	20164	11	19606	-777	20443	16	20241	-277	18724
2	21097	-277	19886	7	18844	-777	17965	12	19987	-277	19329	17	20987	-277	19964
3	21593	-277	20820	8	19309	-277	18567	13	18376	-777	19210	18	18618	-1000	19987
4	20380	-777	20816	9	20561	-277	19032	14	18422	-777	17599	19	19099	-277	18341
5	20941	-277	20103	10	21220	-277	20284	15	19001	-277	18145				

Based on Table 3 and Table 4, the results of forecasting with the original data is shown in the following Fig. 2.



(a) (b)

Fig. 2. (a) The chart of stationary data; (b) The plot of original data and forecasting result.

Here is a comparison of the value of MAPE and MSEfor the training data that is used to seethe results of forecastingusing the Fuzzy Time Series and Weighted Fuzzy Time Series Method.

Table 5. The Value of MAPE and MSE

Fuzzy Time Series [11]			Weighted Fuzzy Time Series [16]		
Training	MAPE : 13.98%	MSE : 9078581.286	Training	MAPE : 12.28 %	MSE : 8789055.686
Testing	MAPE : 5.90%	MSE: 1798624.316	Testing	MAPE : 4.89 %	MSE : 1023784.947

Table 5 show that MAPE and MSE values on the testing data has a lower value than the value of MAPE and MSE on the training data. It means that the forecasting model is acceptable to forecast the future. MAPE and MSE values with weighted fuzzy time series model is smaller than the value of MAPE and MSE with fuzzy time series. It means that forecasting Trans Jogja passengers with weighted fuzzy time series model is better than fuzzy time series model.

5. Conclusion

The result of the forecasting process with WFTS model is better than forecast with fuzzy time series model. Since, the values of MAPE and MSE with fuzzy time series model is bigger than the values of MAPE and MSE with weighted fuzzy time series model.However, this study did not consider the seasonal effect. In Indonesia, the effect of eid mubarokday makes the number of Trans Jogja passengers increase significantly.

Therefore, it is expected that some future researchers concentrate on forecastingTrans Jogja's passengersin the seasonal moments.

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References

[1] Badan, P. S. (2010). Resident Cencus 2010. Retrieved December 6, 2014, from http://sp2010.bps.go.id/index.php/site?id=3400000000&wilayah=DI-Yogyakarta

[2] The Government Daerah Istimewa Yogyakarta. (2013). *Profil Dinas Perhubungan, Komunikasi dan Informatika Daerah Istimewa* Yogyakarta. Yogyakarta: Dishubkominfo DIY.

[3] Hidayat, S., Kencana, I., & Jayanegara, K. (2013). Prediksi pengguna bus trans sarbagita dengan metode adaptive neuro fuzzy inference system. *E-Jurnal Matematika, 2(3)*, 46-52.

[4] When-Xia, S., Ti, S., & Hai, Z. (2009). Study on bus passenger capacity forecast based on regression analysis including time series. *Proceedings of the ICTMTMA: Vol. 2. Measuring Technology and Mechatronics Automation* (pp. 381-384), Hunan: IEEE.

[5] Song, Q., & Chissom, B. S. (1993). Fuzzy time series and its models. *Fuzzy Sets and System, 54*, 269-277.

[6] Song, Q., & Chissom, B. S. (1993). Forecasting enrollments with fuzzy time series-part I. *Fuzzy Sets and System, 54*, 1-9.

[7] Song, Q., & Chissom, B. S. (1994). Forecasting enrollments with fuzzy time series-part II. *Fuzzy Sets and System, 62*, 1-8.

[8] Nurhayadi, S. A., & Abadi, A. M. (2014). Fuzzy model optimation for time series data using a translation in the extent of mean error. *Journal of Mathematics, 10(2)*, 267-274.

[9] Shah, M. (2007). Fuzzy time series*:* A realistic method to forecast gross domestic capital of India. *ASC*, *41*, pp. 255-264.

[10] Abadi, A. M., Subanar, W., & Saleh, S. (2009). Contructing fuzzy time series using combination of table lookup and singular value decomposition methods and its application to forecasting inflation rate. *Journal Ilmu Dasar*, *10(2)*, 190-198.

[11] Chen, S. M. (1996). Forecasting enrollments based on fuzzy time series. *Fuzzy Sets and Systems, 81(3)*, 311–319.

[12] Yu, H.-K. (2005). Weighted fuzzy time series models for taiex forecasting. *Phisica A: Statistical Mechanics and Its Applications, 349*, 609-624.

[13] Lee, M. H. & Suhartono. (2012). A weighted fuzzy time series for forecasting seasional data. *Journal of Quality Measurement and Analysis*, *8(1)*, 85-95.

[14] Suhartono, & Lee, M. H. (2011). A hybrid approach based on winter's model and weighted fuzzy time series for forecasting trend and seasional data. *Journal of Mathematics and Statistics, 7(3)*, 177-183.

[15] Suhatono, Lee, M. H., & Javedani, H. (2011). A weighted fuzzy integrated time series for forecasting tourist arrivals. *Journal of Informatics Engineering and Information Science, 252*, 206-217.

[16] Lee, M. H. & Suhartono. (2010). A novel weighted fuzzy time series model for forecasting seasonal data. presented at the 2nd International Conference on Mathematical Sciences, Kuala Lumpur, Malaysia.

[17] Cheng, C. H., Chen, T. L., Teoh, H. J., & Chiang, C. H. (2008). Fuzzy time series based on adaptive expectation model for TAIEX forecasting. *Expert Systems with Applications, 34(2)*, 1126–1132.

[18] Dinas Perhubungan komunikasi dan inrofmatika DIY. (2014). Report 2012-2014. Yogyakarta: Trans Jogja sector.

[19] Nason, G. P. (2006). Stationary and non-stationary time series. In H. Mader, & S. C. Coles (Eds), *Statistics in Volcanology,* chapter 11. Geological Society of London.

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