Forecasting of Vivo and Advan Handphone Sales Using Cheng Fuzzy Time Series Method

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Abstract. Handphone is one product of technology that has changed the behaviour of human communication by penetrating space and time. Widespread mobile phone product will cause rapid competition between the mobile market, so it is important for cellphone companies to find out how many products will be sold in the future. A company can minimize the risk of unavailability of product stocks and prevent customers from running to other companies by optimizing marketing and sales to get maximum provit. To look for optimal marketing and sales strategies, this study applies the fuzzy time series method which is very useful for the decision making process by combining the analysis of science in the field of computers and statistics that can be used in forecasting sales results. As for the results of the application of fuzzy time series, it is expected that the company can obtain information on sales forecasting of its products to be used as reference material. After matching the simulation results with real in the field, it can be seen that the fuzzy time series cheng method for forecasting the sales of handphones from Indophone Pamekasan uses 60 monthly sales data from January 2014 to December 2018 with the Vivo brand yielding 398.92 and MAPE value = 8.18644%, with the Advan brand give the results of 340.27 and MAPE value = 7.813559%.

Keywords: Handphone, fuzzy time series, sales, forecasting.

1. Introduction

The era of telecommunications technology has hit the joints of human life, where the use of telecommunications technology in helping and alleviating work is needed. One of the telecommunication technology products currently marketed is mobile phones.

Mobile is one product of technology that has changed the behavior of human communication by penetrating space and time. Research firm Gartner recorded an increase in global mobile phone sales in the first quarter of 2018. Mobile phone sales rose 1.3 percent from the same period last year. The total sales volume is 384 million mobile phones, representing 84 percent of the total sales of mobile devices. For sales of all cellphones including feature phones, Gartner recorded 455 million in the first quarter. According to Kevin Restivo, mobile phone sales are increasing because mobile users want computers in their pockets. While this millennial era mobile phones are a daily necessity (primary), Therefore consumers' choice to use mobile phones is currently very high, which causes the rate of increase in mobile phone sales.

Sales is one of the most important indicators in a company. One strategy that can be used in optimizing sales is by analyzing sales forecasting.

Sales forecasting is an activity to predict sales that will occur in the future by using historical data. Forecasting strategies, companies can predict and find out how many products

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will be sold in the future so that it can be used as a reference for planning sales targets. In addition to being used as a reference for planning sales targets, this forecasting strategy can also be used in planning the availability of products to be sold to consumers so that companies can minimize the risk of unavailability of product stocks and prevent customers from running to other companies. Sales forecasting can use several forms of mathematical approaches, one of which is Fuzzy. Fuzzy logic was first developed by Lotfi A. Zadeh through his writing in 1965 on fuzzy set theory [1]. Several methods related to Fuzzy have also developed to date, such as the Fuzzy Time Series method. The Fuzzy Time Series (FTS) method is very useful for the decision making process by combining scientific analysis in the field of Computers and Statistics. The author uses the literature method in this study, namely by studying several books, journals, scientific works and the results of previous studies that have similarities with this research.

In its development, many researchers have used FuzzyTime Series in forecasting in various fields. Tauryawati and Irawan (2014) in their study stated that Fuzzy Time Series Cheng obtained forecasting results more accurately because in their research they had the smallest value of MAE, MSE, MAPE compared to ARIMA when applied to the case of Composite Stock Price Index (CSPI) forecasting [2]. The study has similarities with this research, namely using the fuzzy time series Cheng model to predict sales. The difference in this research with previous research is found in the case study studied, namely in the present study using mobile phone sales.

2. Fuzzy

Fuzzy logic was first made by Lotfi A. Zadeh through his writings in 1965 about fuzzy set theory [3]. Fuzzy logic is a method based on an artificial intelligence system (Artificial Intelligence) that can mimic a human's ability to think into an algorithm that is then run by the engine. This algorithm is used in various data processing applications that cannot be represented in binary form. Fuzzy logic interprets vague statements into a logical understanding [4]. The term fuzzy means vague or unclear, but Fuzzy systems that are built to model this forecasting still have a way of working and clear descriptions based on fuzzy logic theory [3].

3. Fuzzy Time Series

Fuzzy Time Series is one of the soft computing methods that has been applied in Invalid source specified time series data analysis. The Fuzzy Time Series concept introduced by Chen in 1996, the difference between conventional Fuzzy Time Series (FTS) time series lies in the data used in divination. In FTS, the value used is a fuzzy set of real numbers over a predetermined set of universes. So it can be defined that FTS is a method that uses data in the form of fuzzy sets derived from real numbers over the set of universes in the actual data.

3.1 Fuzzy logical relationship on fuzzy time series

According to Fitriyah [5] Relationship is identified based on a fuzzification value from historical data. If the time series F $(t-1)$ variable is clarified as A_i and $F\ (t)$ as A_j, then A_i berellation A_j can be expressed by $A_i \rightarrow A_j$. This can be interpreted as A_i which is located on the left side of the relationship called the current state and A_j which is on the right side of the relationship is called next state and if there is a repeat relationship, it is counted only once. The description of FLR shown in Table 1

Table 1. FLR

Fuzzy Relationship
$A_1 \rightarrow A_1$
$A_1 \rightarrow A_2$
$A_2 \rightarrow A_3$
$A_3 \rightarrow A_3$
$A_3 \rightarrow A_4$
$A_4 \rightarrow A_4$
$A_4 \rightarrow A_3$
$A_4 \rightarrow A_6$
$A_6 \rightarrow A_6$
$A_6 \rightarrow A_7$
$A_7 \rightarrow A_7$
$A_7 \rightarrow A_6$

Fuzzy logical relation group, defuzzification of forecasting value by assuming from prospective data has 3 rules as follows:

a. If the fuzzification result in year-n is A_i dan A_j there is one FLR relation on FLRG, that is, with condition $A\_i \rightarrow A_j$ where the highest degree of membership is at U_j, then the forecast value for $n\ +\ 1$ is the middle value of U_j atau defined by m_j.
b. If the fuzzification result in year-n is A_i dan A_i has more than one FLR on FLRG, that is $A_i \rightarrow A_{j1}, A_{j2}, \ldots, A_{jp}$, with the middle values for $A_{j1}, A_{j2}, \ldots, A_{jm}\ m_{j1}, m_{j2}, \ldots, m_{jp}$ then the forecasting value for $n\ +\ 1$ is $m_{j1}, m_{j2}, \ldots, m_{jp}/p$.
c. If the fuzzification result in year-n is A_i dan A_i does not have FLR value in FLRG where the maximum value in the membership function is at U_j, then the forecasting value for $n\ +\ 1$ is the middle value of U_j or can be defined as m_j.

3. 2 Cheng Fuzzy Time Series Algorithm

Cheng's method has a slightly different way of determining intervals, using Fuzzy Logical Relations (FLR) by entering all relationships and giving weights based on the order and looping of the same FLR. The following are the forecasting stages in time series data using FTS Cheng [3]:

1. Determine the universal set (U) of actual data, namely:
$$U\ =\ [d_{min}, d_{max}] \quad (1)$$
2. Determination of interval width using frequency distribution, with the following steps:
   a. Determine the range with the following formula:
   $$R\ =\ d_{max} - d_{min} \quad (2)$$
   where R is the range: d_{max} is the largest data, d_{min} is the smallest data

b. Determine the number of class intervals using Equation Sturges. The formula is as follows:

$$K = 1 + 3{,}322\ x\ log\ n \quad (3)$$

c. Determine the width of the interval. The formula is as follows:

$$I = (Data\ range\ (R)) \ / \ (Number\ of\ class\ intervals\ (K)) \quad (4)$$

d. Search for middle values. The formula is as follows:

$$m_i = ((lower\ limit + upper\ limit)) \ / \ 2 \quad (5)$$

with i this is the number of fuzzy sets.

3. Fuzzy sets are formed by looking at the number of different frequencies, so the first most frequencies are divided into h equal intervals. Next, the second most frequency is divided into h-1 same interval, the interval at the third most frequency is divided into h-2 equal intervals. This is done at intervals with frequencies that cannot be divided again.
4. Defines the fuzzy A_i set and fuzzifies the actual data observed. For example $A_1, A_2, \ldots, A_p$ is a fuzzy set that has the linguistic value of a linguistic variable, defining the set of fuzzy $A_1, A_2, \ldots, A_p$ on U is as follows:

$$\begin{aligned} A_1 &= {}^{1}/_{u_1} + {}^{0{,}5}/_{u_2} + {}^{0}/_{u_3} + \cdots + {}^{0}/_{u_p} \\ A_2 &= {}^{0{,}5}/_{u_1} + {}^{1}/_{u_2} + {}^{0{,}5}/_{u_3} + \cdots + {}^{0}/_{u_p} \\ A_3 &= {}^{0}/_{u_1} + {}^{0{,}5}/_{u_2} + {}^{1}/_{u_3} + \cdots + {}^{0}/_{u_p} \\ &\vdots \\ A_p &= {}^{0}/_{u_1} + {}^{0}/_{u_2} + {}^{0}/_{u_3} + \cdots + {}^{0{,}5}/_{u_{p-1}} + {}^{1}/_{u_p} \end{aligned} \quad (6)$$

With u_i $(i = 1{,}2, \ldots, p)$ is an element of the universe (U) and a number that is given the symbol "/" denotes the membership degree $\mu_{A_i}(u_i)$ against A_i $(i = 1{,}2, \ldots, p)$ where the value is 0; 0.5 or 1.

5. Create FLR tables based on actual data. FLR can be represented by $A_i \rightarrow A_j$, where A_i is called the current state and A_j is called the next state.
6. Determine the weight of the FLR relation to be a Fuzzy Logical Relationship Group (FLRG) by entering all relationships and giving weights based on the same sequence and repetition. FLR which has the same current state (A_i) is combined into one group into the weighting matrix. Then the weight obtained in the FLR relation is entered into the weighting matrix $(W\ (t))$ whose equation is written as follows:

$$w(t) = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1p} \\ w_{21} & w_{22} & \cdots & w_{2p} \\ . & . & w_{ij} & . \\ w_{p1} & w_{p2} & \cdots & w_{pp} \end{bmatrix} \quad (7)$$

with W is a weighting matrix; w_ij is the weight of the matrix in the first row and the jth column with $i = 1{,}2, \ldots, p$; $j = 1{,}2, \ldots, p$. with i is the interval class of Left Hand Slides (LHS) and j is the interval class of Right Hand Slides (RHS).

7. Then transfer the weight of FLRG into a standardized weighting matrix $(W_n(t))$ whose equation is written as follows:

$$W_n(t) = \begin{bmatrix} {w_{11}}^* & {w_{12}}^* & \cdots & {w_{1p}}^* \\ {w_{21}}^* & {w_{22}}^* & \cdots & {w_{2p}}^* \\ . & . & {w_{ij}}^* & . \\ {w_{p1}}^* & {w_{p2}}^* & \cdots & {w_{pp}}^* \end{bmatrix} \quad (8)$$

with $W_n(t)$ is a standardized weighting matrix with ${w_{ij}}^* = \frac{w_{ij}}{\sum_{j=1}^{p} w_{ij}}$

8. Calculate forecasting values. To produce a forecasting value, the standardized weighting matrix $W_n(t)$ is multiplied by the defuzification matrix, namely matrix L_{df}. Where $L_{df} = \llbracket [m_1, m_2, \ldots, m_p] \rrbracket^T$ with m_i is the middle value of each interval. So that the forecasting calculation becomes:

$$F_t = {w_{i1}}^*(m_1) + {w_{i2}}^*(m_2) + \cdots + {w_{ip}}^*(m_p) \quad (9)$$

3.3 Accuracy of the Forecasting Method

In many forecasting situations, accuracy is seen as a refusal criterion for choosing a forecasting method. In many ways, the word accuracy refers to the goodness of fit, which in turn indicates how far the forecasting model is capable of producing known data [5]. The level of accuracy on the results of the recommendation system is done by looking at the error value in the results. In this study using the MAPE equation (Mean Absolute Percentage Error). In the MAPE calculation, the smaller the MAPE results obtained, the fewer errors in the system [6]. The following formula calculates MAPE:

$$MAPE = \frac{\sum_{i=1}^{n} \left| \frac{q_i - p_i}{q_i} \right|}{N} x100\% \quad (10)$$

With information:
MAPE = average value of error counting
N = number of observations
p_i = value of forecasting data in the i period
q_i = value of actual data in the i period

4. Results and Discussion

In this chapter, we will discuss the problem solving on how to apply Cheng Fuzzy Time Series in forecasting the sale of mobile phones in Pamekasan to Indophone companies in order to increase sales results in the following years which are simulated in the Matlab R2015a programming language.

4.1 Application of Cheng Fuzzy Time Series

Step 1. Data input

Data on handphone sales in Pamekasan in Indophone company will be predicted by using Cheng Fuzzy Time Series method. Actual sales data are shown in Table 2.

Table 2. Actual sales data for Vivo brand mobile phones

Year	Month	Vivo
2014	January	258
	February	276
	March	254
	April	301
	Mei	277
	June	356
	July	301
	August	398
	September	354
	Oktober	308
	November	325
	Desember	489
2015	January	499
	February	387
	March	346
	April	358
	Mei	367
	June	353
	July	378
	August	405
	September	378
	Oktober	389
	November	352
	Desember	388
2016	January	379
	February	384
	March	345
	April	322
	Mei	316
	June	315
	July	361
	August	382
	September	232
	Oktober	329
	November	330
	Desember	495
2017	January	466
	February	321
	March	267
	April	276
	Mei	298
	June	308
	July	388
	August	405
	September	374
	Oktober	345
	November	379
	Desember	475
2018	January	498
	February	456
	March	395
	April	356
	Mei	345
	June	358
	July	367
	August	379
	September	364
	Oktober	356
	November	321
	Desember	453

Step 2. Define universe of discourse

After sorting the actual data on the sale of Vivo brand mobile phones, the smallest value and the largest value of the data are obtained ($d_{min} = 232, d_{max} = 499$). Based on equation (1), the universe can be seen as follows: $U = [232, 499]$

Step 3. Calculate the interval using a frequency distribution

From the 60 data in Table 1, the average difference from equation (2) is 267. Then the number of intervals obtained from equation (3) is 7. Determining the interval width of equation (4) is 38.14

Step 4. Fuzzy sets are formed by looking at the number of different frequencies

Based on Step 3 with a number of intervals of 7, the frequency of density of sales data for Vivo brand mobile phones can be seen in Table 2.

Table 3. Data Density Frequency Sales of Vivo brand mobile phones

u_i	Lower Limit	Limit On	Amount of data	Number of SubInterval	Wide SubInterval
u_1	232	270,14	4	2	19,07
u_2	270,14	308,28	8	4	9,54
u_3	308,28	346,42	12	5	7,63
u_4	346,42	384,56	20	6	6,36
u_5	384,56	422,7	8	4	9,54
u_6	422,7	460,84	2	1	38,14
u_7	460,84	498,98	6	3	12,71

From Table 2, it can be seen that there are 25 subintervals that will be the domain of the fuzzy set formed, so that there are 25 fuzzy sets presented in Table 3.

Step 5. Linguistic Values and Fuzzy Sets

The following are defined fuzzy sets based on Equation (6), for A_1 and A_2:

$$A_1 = \frac{1}{u_1} + \frac{0{,}5}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}} + \frac{0}{u_{19}} + \frac{0}{u_{20}} + \frac{0}{u_{21}} + \frac{0}{u_{22}} + \frac{0}{u_{23}} + \frac{0}{u_{24}} + \frac{0}{u_{25}}$$

$$\vdots$$

$$A_{25} = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}} + \frac{0}{u_{19}} + \frac{0}{u_{20}} + \frac{0}{u_{21}} + \frac{0}{u_{22}} + \frac{0}{u_{23}} + \frac{0.5}{u_{24}} + \frac{1}{u_{25}}$$

The linguistic values of many fuzzifications obtained from fuzzy sets can be seen in Table 3.

Table 4. Linguistic Values

Fuzzification	Linguistic Values
A_1	Very, very dramatically down
A_2	Very down dramatically
A_3	Very down drastically
A_4	Get down drastically
A_5	Very down once
A_6	Very down once

Fuzzification	Linguistic Values
A_7	Down once
A_8	A little down once
A_9	Simply go down
A_{10}	Down
A_{11}	A little down
A_{12}	A little down
A_{13}	Moderate
A_{14}	Rather up
A_{15}	Slightly up
A_{16}	Go up
A_{17}	Just go up
A_{18}	A little up once
A_{19}	Go up once
A_{20}	Very up once
A_{21}	Very much go up once
A_{22}	Drastic
A_{23}	Very drastic increase
A_{24}	Very dramatically up
A_{25}	Very, very dramatically up

Step 6. Fuzzification and FLR.

The fuzzification stage is based on the number of intervals formed. Fuzzification results of sales data for Vivo brand mobile phones can be seen in Table 4

Table 5 Fuzzy intervals use frequency density

A_i	Lower Limit	Lower On	Wide Sub-interval	Middle value (m_i)
A_1	232	251.07	19.07	241.535
A_2	251.07	270.14	19.07	260.605
A_3	270.14	279.68	9.54	274.91
A_4	279.68	289.22	9.54	284.45
A_5	289.22	298.76	9.54	293.99
A_6	298.76	308.3	9.54	303.53
A_7	308.3	315.93	7.63	312.115
A_8	315.93	323.56	7.63	319.745
A_9	323.56	331.19	7.63	327.375
A_{10}	331.19	338.82	7.63	335.005
A_{11}	338.82	346.45	7.63	342.635
A_{12}	346.45	352.81	6.36	349.63
A_{13}	352.81	359.17	6.36	355.99
A_{14}	359.17	365.53	6.36	362.35
A_{15}	365.53	371.89	6.36	368.71
A_{16}	371.89	378.25	6.36	375.07
A_{17}	378.25	384.61	6.36	381.43
A_{18}	384.61	394.15	9.54	389.38
A_{19}	394.15	403.69	9.54	398.92
A_{20}	403.69	413.23	9.54	408.46
A_{21}	413.23	422,.7	9.54	417.97
A_{22}	422,.7	460.91	38.14	441.81
A_{23}	460.91	473.62	12.71	467.27

A_i	Lower Limit	Lower On	Wide Sub-interval	Middle value (m_i)
A_{24}	473.62	486.33	12.71	479.98
A_{25}	486.33	499.04	12.71	492.69

Relationship is identified based on a fuzzification value from historical data. If the time series variable $\boldsymbol{F}(\boldsymbol{t-1})$ is clarified as $\boldsymbol{A_i}$ and $\boldsymbol{F}(\boldsymbol{t})$ as $\boldsymbol{A_j}$, then $\boldsymbol{A_i}$ is related to $\boldsymbol{A_j}$ which can be expressed by $\boldsymbol{A_i}$ notation $-> \boldsymbol{A_j}$. Based on the fuzzy set, the actual data fuzzification and FLR are obtained as in Table 5.

Table 6 Fuzzification and FLR

Year	Mounth	Vivo	Fuzzification	FLR
2014	January	258	A_2	-
	February	276	A_3	$A_2 \rightarrow A_3$
	March	254	A_2	$A_3 \rightarrow A_2$
	April	301	A_6	$A_2 \rightarrow A_6$
	Mei	277	A_3	$A_6 \rightarrow A_3$
	June	356	A_{13}	$A_3 \rightarrow A_{13}$
	July	301	A_6	$A_{13} \rightarrow A_6$
	August	398	A_{19}	$A_6 \rightarrow A_{19}$
	September	354	A_{13}	$A_{19} \rightarrow A_{13}$
	Oktober	308	A_6	$A_{13} \rightarrow A_6$
	November	325	A_9	$A_6 \rightarrow A_9$
	Desember	489	A_{25}	$A_9 \rightarrow A_{25}$
2015	January	499	A_{25}	$A_{25} \rightarrow A_{25}$
	February	387	A_{18}	$A_{25} \rightarrow A_{18}$
	March	346	A_{11}	$A_{18} \rightarrow A_{11}$
	April	358	A_{13}	$A_{11} \rightarrow A_{13}$
	Mei	367	A_{15}	$A_{13} \rightarrow A_{15}$
	June	353	A_{13}	$A_{15} \rightarrow A_{13}$
	July	378	A_{16}	$A_{13} \rightarrow A_{16}$
	August	405	A_{20}	$A_{16} \rightarrow A_{20}$
	September	378	A_{16}	$A_{20} \rightarrow A_{16}$
	Oktober	389	A_{18}	$A_{16} \rightarrow A_{18}$
	November	352	A_{12}	$A_{18} \rightarrow A_{12}$
	Desember	388	A_{18}	$A_{12} \rightarrow A_{18}$
2016	January	379	A_{17}	$A_{18} \rightarrow A_{17}$
	February	384	A_{17}	$A_{17} \rightarrow A_{17}$
	March	345	A_{11}	$A_{17} \rightarrow A_{11}$
	April	322	A_8	$A_{11} \rightarrow A_8$
	Mei	316	A_8	$A_8 \rightarrow A_8$
	June	315	A_7	$A_8 \rightarrow A_7$
	July	361	A_{14}	$A_7 \rightarrow A_{14}$
	August	382	A_{17}	$A_{14} \rightarrow A_{17}$
	September	232	A_1	$A_{17} \rightarrow A_1$
	Oktober	329	A_9	$A_1 \rightarrow A_9$
	November	330	A_9	$A_9 \rightarrow A_9$
	Desember	495	A_{25}	$A_9 \rightarrow A_{25}$
2017	January	466	A_{23}	$A_{25} \rightarrow A_{23}$

Year	Mounth	Vivo	Fuzzification	FLR
	February	321	A_8	$A_{23} \rightarrow A_8$
	March	267	A_2	$A_8 \rightarrow A_2$
	April	276	A_3	$A_2 \rightarrow A_3$
	Mei	298	A_5	$A_3 \rightarrow A_5$
	June	308	A_6	$A_5 \rightarrow A_6$
	July	388	A_{18}	$A_6 \rightarrow A_{18}$
	August	405	A_{20}	$A_{18} \rightarrow A_{20}$
	September	374	A_{16}	$A_{20} \rightarrow A_{16}$
	Oktober	345	A_{11}	$A_{16} \rightarrow A_{11}$
	November	379	A_{17}	$A_{11} \rightarrow A_{17}$
	Desember	475	A_{24}	$A_{17} \rightarrow A_{24}$
2018	January	498	A_{25}	$A_{24} \rightarrow A_{25}$
	February	456	A_{22}	$A_{25} \rightarrow A_{22}$
	March	395	A_{19}	$A_{22} \rightarrow A_{19}$
	April	356	A_{13}	$A_{19} \rightarrow A_{13}$
	Mei	345	A_{11}	$A_{13} \rightarrow A_{11}$
	June	358	A_{13}	$A_{11} \rightarrow A_{13}$
	July	367	A_{15}	$A_{12} \rightarrow A_{15}$
	August	379	A_{17}	$A_{15} \rightarrow A_{17}$
	September	364	A_{14}	$A_{17} \rightarrow A_{14}$
	Oktober	356	A_{13}	$A_{14} \rightarrow A_{13}$
	November	321	A_8	$A_{13} \rightarrow A_8$
	Desember	453	A_{22}	$A_8 \rightarrow A_{22}$

Step 7. Weight of FLRG

Based on equation (7), the FLRG weight matrix can be obtained as follows:

$$W = \begin{vmatrix}
0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&2&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&0&0&1&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&0&0&0&0&1&0&0&0&0&0&0&0&1&1&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0\\
0&1&0&0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0\\
0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&2\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&1&0&0&0&0&2&0&0&0&1&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0\\
0&0&0&0&0&2&0&1&0&0&1&0&0&0&2&1&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&1&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&1&0&0&1&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&1&0&1&0&0&0&0&0&0\\
1&0&0&0&0&0&0&0&0&1&0&0&1&0&0&1&0&0&0&0&0&0&1&0&0\\
0&0&0&0&0&0&0&0&0&1&1&0&0&0&0&1&0&0&1&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&2&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&2&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&1&1&0&1&1
\end{vmatrix}$$

Step 8. The results of the standardized weighting matrix ($W_n\ (t)$)

Based on equation (8), we can obtain the standardized weighting matrix results as follows:

$$W_n(t) = \begin{cases}
0, for\ W\ others \\
\frac{2}{7}, untuk\ W_{13\ 6}, W_{13\ 15} \\
\frac{1}{4}, untuk\ W_{6\ 3}, W_{6\ 9}, W_{6\ 18}, W_{6\ 19}, W_{8\ 2}, W_{8\ 7}, W_{8\ 8}, W_{8\ 22}, W_{11\ 8}, W_{11\ 17}, W_{16\ 14}, W_{18\ 11}, W_{18\ 12}, W_{18\ 17}, W_{18\ 20}, \\
W_{25\ 18}, W_{25\ 22}, W_{25\ 23}, W_{25\ 25} \\
\frac{1}{7}, untuk\ W_{13\ 8}, W_{13\ 11}, W_{13\ 16} \\
\frac{1}{3}, untuk\ W_{2\ 6}, W_{3\ 2}, W_{3\ 5}, W_{3\ 13}, W_{9\ 9}, W_{16\ 11}, W_{16\ 18}, W_{16\ 20} \\
\frac{1}{2}, untuk\ W_{11\ 13}, W_{14\ 13}, W_{14\ 17}, W_{15\ 13}, W_{15\ 16} \\
\frac{2}{3}, untuk\ W_{2\ 3}, W_{9\ 25} \\
\frac{1}{5}, untuk\ W_{17\ 1}, W_{17\ 11}, W_{17\ 14}, W_{17\ 17}, W_{17\ 24} \\
1, untuk\ W_{1\ 9}, W_{5\ 6}, W_{7\ 14}, W_{12\ 18}, W_{19\ 13}, W_{20\ 16}, W_{22\ 19}, W_{23\ 8}, W_{24\ 25}
\end{cases}$$

Step 9. Process of Defining Forecast Value

There are two stages in the defuzzification process namely the first, looking for the middle value in each interval based on equation (5) and the second, calculating the forecasting value based on equation (9). If the first period fuzzification result is A_i, and A does not have FLR in FLRG with condition $A_i \rightarrow \emptyset$, then the forecast value is the middle value of A_i. Thus the defuzzification of FLRG in table 6 is obtained as follows:

Table 7. Weight of FLRG and Defuzzification

Current State (A_i)	Next State (A_j)	Forecasting
$A_1 \rightarrow$	A_9	327,38
$A_2 \rightarrow$	A_3, A_6	284,45
$A_3 \rightarrow$	A_2, A_5, A_{13}	303.53
$A_4 \rightarrow$	Ø	284,45
$A_5 \rightarrow$	A_6	303,53
$A_6 \rightarrow$	A_3, A_9, A_{18}, A_{19}	347,65
$A_7 \rightarrow$	A_{14}	362,35
$A_8 \rightarrow$	A_2, A_7, A_8, A_{22}	333,57
$A_9 \rightarrow$	A_9, A_{25}	437,58
$A_{10} \rightarrow$	Ø	335,01
$A_{11} \rightarrow$	A_8, A_{13}, A_{17}	353,29
$A_{12} \rightarrow$	A_{18}	389,38
$A_{13} \rightarrow$	A_6, A_8, A_{11}, A_{15}, A_{16}	340,28
$A_{14} \rightarrow$	A_{13}, A_{17}	368,71
$A_{15} \rightarrow$	A_{13}, A_{17}	368,71
$A_{16} \rightarrow$	A_{11}, A_{18}, A_{20}	380,16
$A_{17} \rightarrow$	A_1, A_{11}, A_{14}, A_{17}, A_{24}	361,39
$A_{18} \rightarrow$	A_{11}, A_{12}, A_{17}, A_{20}	370,54
$A_{19} \rightarrow$	A_{13}	355,99
$A_{20} \rightarrow$	A_{16}	375,07
$A_{21} \rightarrow$	Ø	417,97
$A_{22} \rightarrow$	A_{19}	398,92
$A_{23} \rightarrow$	A_8	319,75
$A_{24} \rightarrow$	A_{25}	492,69
$A_{25} \rightarrow$	A_{18}, A_{22}, A_{23}, A_{25}	447,78

The results of forecasting sales of Vivo brand mobile phones from January 2014 to December 2018 can be seen in Table 7 as follows:

Table 8 Results of forecasting sales of Vivo brand mobile phones

Year	Mounth	Vivo	Fuzzifikasi	Forecasting
2014	January	258	A_2	-
	February	276	A_3	284,45
	March	254	A_2	303,53
	April	301	A_6	284,45
	Mei	277	A_3	347,65
	June	356	A_{13}	303,53
	July	301	A_6	340,28
	August	398	A_{19}	347,65
	September	354	A_{13}	355,99
	Oktober	308	A_6	340,28
	November	325	A_9	347,65
	Desember	489	A_{25}	437,58

Year	Mounth	Vivo	Fuzzifikasi	Forecasting
2015	January	499	A_{25}	447,78
	February	387	A_{18}	447,78
	March	346	A_{11}	370,54
	April	358	A_{13}	353,29
	Mei	367	A_{15}	340,28
	June	353	A_{13}	368,71
	July	378	A_{16}	340,28
	August	405	A_{20}	380,16
	September	378	A_{16}	375,07
	Oktober	389	A_{18}	380,16
	November	352	A_{12}	370,54
	Desember	388	A_{18}	389,38
2016	January	379	A_{17}	370,54
	February	384	A_{17}	361,39
	March	345	A_{11}	361,39
	April	322	A_{8}	353,29
	Mei	316	A_{8}	333,57
	June	315	A_{7}	333,57
	July	361	A_{14}	362,35
	August	382	A_{17}	368,71
	September	232	A_{1}	361,39
	Oktober	329	A_{9}	327,38
	November	330	A_{9}	437,58
	Desember	495	A_{25}	437,58
2017	January	466	A_{23}	447,78
	February	321	A_{8}	319,75
	March	267	A_{2}	333,57
	April	276	A_{3}	284,45
	Mei	298	A_{5}	303,53
	June	308	A_{6}	303,53
	July	388	A_{18}	347,65
	August	405	A_{20}	370,54
	September	374	A_{16}	375,07
	Oktober	345	A_{11}	380,16
	November	379	A_{17}	353,29
	Desember	475	A_{24}	361,39
2018	January	498	A_{25}	492,69
	February	456	A_{22}	447,78
	March	395	A_{19}	398,92
	April	356	A_{13}	355,99
	Mei	345	A_{11}	340,28
	June	358	A_{13}	353,29
	July	367	A_{15}	340,28
	August	379	A_{17}	368,71
	September	364	A_{14}	375,71

Year	Mounth	Vivo	Fuzzifikasi	Forecasting
	Oktober	356	A_{13}	368,71
	November	321	A_8	340,28
	Desember	453	A_{22}	333,57
2019	January	-		398,92

Forecasting on this FTS Cheng method looks at the fuzzification of previous data, forecasting the sale of Vivo brand mobile phones for January 2019 using fuzzification in December 2018, namely A_{25} with forecasting results of 398.92 points.

4.2. Cheng Fuzzy Time Series simulation results

In this step, the data that has been applied using the Cheng Fuzzy Time Series method is solved by using Matlab R2015a. The results of the simulation of 60 sales data on Vivo brand mobile phones using the Matlab R2015a software can be seen in Table 8.

Table 9 Data from the sales simulation of the Vivo brand mobile phone

Year	Mounth	Vivo	Forecasting	Eror
2014	January	258	-	
	February	276	284.4464	8.4464
	March	254	303.5179	49.5179
	April	301	284.45464	16.5536
	Mei	277	347.6205	70.6205
	June	356	303.5179	52.4821
	July	301	340.2531	39.2531
	August	398	347.6205	50.3795
	September	354	355.9643	1.9643
	Oktober	308	340.2531	32.2531
	November	325	347.6205	22.6205
	Desember	489	437.5476	51.4524
2015	January	499	447.7455	51.2545
	February	387	370.5062	16.4938
	March	346	370.5062	24.5062
	April	358	353.2625	4.7375
	Mei	367	340.2531	26.7496
	June	353	368.6786	15.6786
	July	378	340.2531	37.7469
	August	405	380.1214	24.8786
	September	378	375.0357	2.9643
	Oktober	389	380.1214	8.8786
	November	352	370.5062	18.5062
	Desember	388	389.3393	1.3393
2016	January	379	370.5062	8.4938
	February	384	361.5586	22.4414
	March	345	361.5586	16.5586
	April	322	353.2625	31.2625
	Mei	316	333.5554	17.5554
	June	315	333.5554	18.5554
	July	361	362.3214	1.3214

	August	382	368.6786	13.3214
	September	232	361.5586	129.5586
	Oktober	329	327.3571	1.6429
	November	330	437.5476	107.5476
	Desember	495	437.5476	57.4524
2017	January	466	447.7455	18.2545
	February	321	319.7286	1.2714
	March	267	333.5554	66.5554
	April	276	284.4464	8.4464
	Mei	298	303.5179	5.5179
	June	308	303.5179	4.4821
	July	388	347.6205	40.3795
	August	405	370.5062	34.4938
	September	374	375.0357	1.0357
	Oktober	345	380.1214	35.1214
	November	379	353.2625	25.7375
	Desember	475	361.5586	113.4414
2018	January	498	492.6429	5.3571
	February	456	447.7455	8.2545
	March	395	398.875	3.875
	April	356	355.9643	0.035714
	Mei	345	340.2531	4.7469
	June	358	353.2625	4.7375
	July	367	340.2531	26.7469
	August	379	368.6786	10.3214
	September	364	361.5586	2.4414
	Oktober	356	368.6786	12.6786
	November	321	340.2531	19.2531
	Desember	453	333.5554	119.4446
2019	January		398.875	

Based on manual calculations and the results of Matlab software shows the same results, the following graph displayed from the results of Matlab software can be seen in Figure 1.

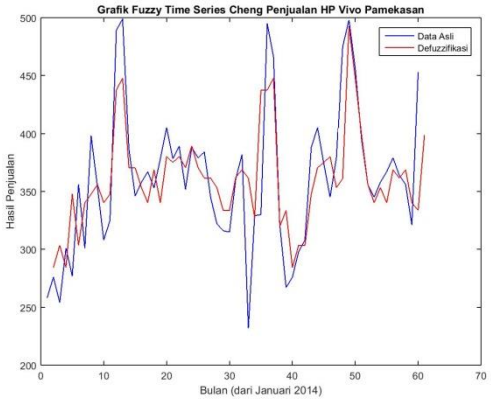

Fig. 1. Forecasting Graphs for Sales of Vivo Mobile Phones

Based on Figure 1, graphs in blue are graphs of actual data on sales of Vivo brand mobile phones, while graphs in red are graphs of forecasted data using Cheng Fuzzy Time Series method. Forecasting the sale of the Vivo brand mobile phone from Indophone Pamekasan using 60 monthly sales data from January 2014 to December 2018 using the fuzzy time series Cheng method, the MAPE value = 8,18644%.
While the results of the Advan brand forecasting use the same steps based on Table 9.

Table 10 Data on the results of sales forecasting for Advan brand mobile phones

Year	Mounth	Advan	Forecasting	Eror
2014	January	256	-	
	February	287	316.8679	29.8679
	March	263	292.8286	29.8286
	April	298	293	5.3986
	Mei	343	354.3631	11.3631
	June	295	316.7771	21.7771
	July	364	354.631	9.6369
	August	376	330.2482	45.7518
	September	365	302.2024	62.7976
	Oktober	342	330.2482	11.7518
	November	358	316.7771	41.2229
	Desember	467	340.7257	126.2743
2015	January	431	388	42.619
	February	342	345	2.5357
	March	332	316.7771	15.2229
	April	309	291.0143	17.9857
	Mei	366	347.7863	18.2137
	June	288	330.2482	42.2482
	July	315	292.8286	22.1714
	August	351	325.1229	25.8771
	September	280	340.7257	60.7257
	Oktober	275	287.8393	12.8393
	November	261	258.0548	2.9452
	Desember	305	292.6018	12.3982
2016	January	288	334.3304	46.3304
	February	255	292.8286	37.8286
	March	340	316.8679	23.1321
	April	260	316.7771	56.7771
	Mei	285	292.6018	7.6018
	June	269	287.8393	18.8393
	July	213	258.0548	45.0548
	August	398	413	14.5714
	September	337	335	1.5357
	Oktober	281	291.0143	10.0143
	November	306	287.8393	18.1607
	Desember	378	334.3304	43.6696
2017	January	239	302.2024	63.2024
	February	261	262.8929	1.8929
	March	291	292.6018	1.6018
	April	270	292.8286	22.8286
	Mei	287	258.0548	28.9452

Year	Mounth	Advan	Forecasting	Eror
	June	303	292.8286	10.1714
	July	354	334.3304	19.6696
	August	321	340.7257	19.7257
	September	313	325.1229	12.1229
	Oktober	315	325.1229	32.7863
	November	317	340.7257	8.1229
	Desember	358	347.7863	32.8771
2018	January	312	330.2482	28.7257
	February	366	347.7863	18.2137
	March	312	316.7771	18.2482
	April	340	291.0143	7.7863
	Mei	334	287.8393	17.2229
	June	281	291.0143	10.0143
	July	306	287.8393	18.1607
	August	315	334.3304	19.3304
	September	289	325.1229	36.1229
	Oktober	286	291.8286	6.8286
	November	290	291.8286	2.8286
	Desember	354	291.8286	61.1714
2019	January		340.7257	

Based on manual calculations and the results of Matlab software shows the same results, the following graph displayed from the results of Matlab software can be seen in Figure 2.

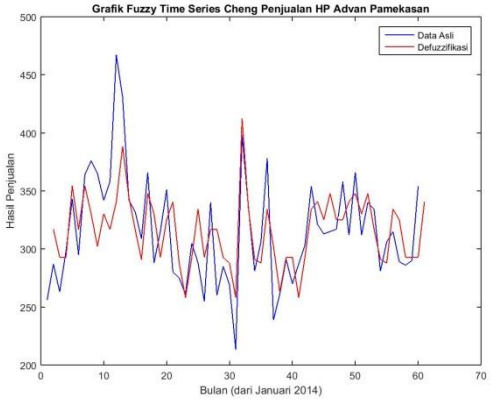

Fig. 2. Forecasting Graphs for Sales Results of Advan brands

Based on Figure 2, graphs in blue are graphs of actual data on sales of Advan brand mobile phones, while graphs in red are graphs of forecasted data using Cheng Fuzzy Time Series method. Forecasting the sale of Samsung brand mobile phones from Indophone Pamekasan using 60 monthly sales data from January 2014 to December 2018 using the fuzzy time series Cheng method, the MAPE value = 7.237288%.

5. CONCLUSION

The conclusions from this study are:

After matching the simulation results with real in the field it can be seen that the Cheng Fuzzy Time Series method for forecasting the sale of Samsung brand mobile phones from Indophone Pamekasan uses 60 monthly sales data from January 2014 to December 2018 to provide results with the Vivo brand 398.92 and MAPE value = 8.18644 %, with the Advan brand giving the results of 340.27 and the MAPE value = 7.813559%.

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