Econometric: Modification Technique of Fuzzy Time Series First Order and Time-invariant Chen and Hsu to Increase the Forecasting Accuracy of Value Stock Index in Indonesia

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Keywords: Stocks Forecasting, Fuzzy Time Series, Chen and Hsu, First Order And Time Invariant.

Abstract: This econometric research aims to develop the fuzzy time series - Chen and Hsu first order and time-invariant for forecasting the value of stocks. Process modifications made to the methods of fuzzy time series - Chen and Hsu because there are still some significant fluctuation variances in some period of data and trend predictions do not fully follow the actual trend of the stock price movement. The modifications had conducted at the redivided interval step and assuming that all group intervals data have the same opportunity to improve the accuracy of forecasting. The data used in this research are the index of Jakarta Stock Exchange (JSX) and index of LQ-45 from July to August 2017. The results of this research have found that the modification of fuzzy time series at intervals redivided step able to provide better forecasting accuracy.

1 INTRODUCTION

Fuzzy Time series Techniques is one of the techniques that are currently developed for forecasting and are widely used in predicting the movement of the stock value. This technique uses a first order time-invariant method which is included in the concept of artificial intelligence and used to conduct forecasting and economic magnitudes. This technique was first proposed by Song and Chissom (1993) which used the concept of logical fuzzy to develop the basis of fuzzy time series using time-invariant and time-variant for forecasting. Several methods of fuzzy time series forecasting which have been developed are a method of Chen (1996 and 2002) and Chen and Hsu (2004), the method of Markov Chain (Sullivan and Woodall, 1994), the method of percentage change (Stevenson and Porter, 2009), the implementation of the network back propagation (Huarng and Yu,2006), and multiple-attribute fuzzy time series (Cheng et al, 2008).

Forecasting with fuzzy time series has also been tested by some researchers as practiced by Hansun (2012) and Fauziah et al (2016) with Fuzzy Time Series Chen, Rahmadiani (2012) with Fuzzy Neural network, Handayani and Anggraini (2015) by the method of Chen and the method of Lee, Rukhansyah Et all (2015) with Fuzzy Time Series Markov Chain, Hasudungan (2016) with Fuzzy Time Series-Genetic Algorithm and Elfajar et al (2017) with fuzzy time series invariant.

Further research on fuzzy time series conducted by Zulfikar and Mayvita (2017) who conducted tests on Fuzzy Time Series Chen and Hsu to predict the value of the sharia stock index in Jakarta Islamic Index. The results obtained were tested methods provide predictions quite well with the value of Mean Square Error (MSE) = 1.88 and an error Average Forecasting Error Rate (Afer) = 0.006%, although still found the existence of some fluctuation variance was significant in a period of data and looks that the trend prediction of stock movement within some period of time did not fully follow the actual trend of sharia stock price movement in the Jakarta Islamic Index. Based on this, it can be said that the method of fuzzy time series - Chen and Hsu still gave the weakness in predicting the stock value for some period of time.

2 METHODS

Our population and sample used in this research were daily data index of the Jakarta Stock Exchange

Zulfikar, R., Mayvita, A. and , P.
Econometric: Modification Technique of Fuzzy Time Series First Order and Time-invariant Chen and Hsu to Increase the Forecasting Accuracy of Value Stock Index in Indonesia.
DOI: 10.5220/0009022100002297
In *Proceedings of the Borneo International Conference on Education and Social Sciences (BICESS 2018)*, pages 421-428
ISBN: 978-989-758-470-1

(JSX) and the LQ-45 index period from January 10, 2017, until August 10, 2017 Data used in this research is secondary data obtained from sites finance google (www.finance.google. com).

This method is used 5 (five) following steps: (1) Defining the universal of data collection, (2) SDistributing Data to the universal of data collection, (3) Defining the fuzzy sets, (4) Performing the Fuzzy Logical Relationship (FLR) and (5) Determining the difference of data n-1 and n-2 Data based on 3 (three) rules of fuzzy time series first order and time-invariant Chen and Hsu as explained in Table 1 below.

Table 1. Rule Fuzzy Time Series First Order Time-Invariant (Chen and Hsu, 2004)

Rule 1	Rule 2	Rule 3
• If the data does not have data n-2 and n-3, then used is the *middle value* of Fuzzy set A_j. • If the data does not have data n-3, then: a. if the difference between n-1 and n-2> half intervals A_j then the value is expressed as upward forecast 0.75 point interval A_j. b. if the difference between n-1 and n-2 = half interval A_j then the value is expressed as a middle-value prediction intervals A_j. c. if the difference between n-1 and n-2 <half the interval A_j then the value is expressed as downward interval forecast A_j.	• If DIFF is worth positive then: a. if the value **(DIFF x 2 + Data n-1)** Not in the interval A_j then the value is expressed as upward forecast 0.75 point interval A_j. b. if the value **(DIFF / 2 + Data n-1)** Not in the interval A_j then the value is expressed as downward 0:25 forecasts point interval A_j. c. Point (a) and point (b) is not met, then the value of the forecast stated at the middle interval value A_j	• If DIFF is negative then: a. if the value **(DIFF / 2 + Data n-1)** No in the interval A_j then the value is expressed as downward 0:25 forecasts point interval A_j. b. if the value **(DIFF x 2 + Data n-1)** No in the interval A_j then the value is expressed as upward forecast 0.75 point interval A_j. c. If Point (a) and point (b) is not met, then the value of the forecast stated at the middle-value intervals A_j.

2.1 Modification Technique

Technique modifications made in this study is performed at redivided interval step in which is conducted by dividing the interval by the number smallest data first into two parts of equal length, the interval with the amount of data the second smallest to 3 equal lengths, interval by the number of data third smallest into 4 parts of equal length, and so on until the entire interval is divided into several subintervals of equal length.

2.2 Operational Definitions

The operational definition used in this study are:

1. **Mean Square Error (MSE)**, MSE is used to compare the accuracy of various methods of forecasting (Chen and Hsu, 2004)[4], where the formula for calculating the MSE is as follows:

MSE =(Historical data -Data actual results of forecasting2)/Total Data (1)

2. **Average Forecasting Error Rate (AFER),** AFER is used to determine the amount of data errors occurring in forecasting results against actual data (Jilani, Burney and Ardil, 2007) which is calculated based on the following equation:

$$\textbf{AFER} = \frac{\frac{|\text{Actual} - \text{Forecast}|}{\text{Actual}}}{n} \textbf{x 100\%} \quad (2)$$

3 RESULT

Data description that used in this research for JSX and LQ-45 are showed in Table 2.

Table 2. Data Description (Stock Exchange Index of JSX and LQ-45)

No	Description	JSX	LQ-45
1	Number	150 data	150 data
2	Maximum	5250.97	875.51
3	Minimum	5915.36	997.51
4	Variance Maximum	59.81	13.46
5	Variance Minimum	-146.43	-28.95
6	Number of Intervals	7	7
7	Length of Intervals	100	100

After knowing the length and number of intervals, the next step is distributed all data into each interval and the results showed in Table 3 and Table 4 which is explained intervals before and after modification for JSX (Table 3) dan LQ-45 (Table 4).

Table 3. Comparison Redivided Interval between Fuzzy Time Series Before Modification and After Modification For JSX Index Data

No	Code	Length	Number Of Data	Before Modification		After Modification	
1	U1	[5250-5350]	18	Divided Into 2 Intervals	U1.1, U1.2	Divided Into 5 Intervals	U1.1,U1.2, U1.3,U1.4, U1.5
2	U2	[5350-5450]	28	Divided Into 3 Intervals	U2.1, U.2.2, U2.3	Divided Into 6 Intervals	U2.1,U2.2, U2.3, U2.4, U2.5, U2.6, U2.7
3	U3	[5450-5550]	6	Not Change	U3	Divided Into 2 Intervals	U3.1,U3.2
4	U4	[5550 -5650]	17	Not Change	U4	Divided Into 4 Intervals	U4.1,U4.2, U4.3,U4.4
5	U5	[5650 -5750]	35	Divided Into 4 Intervals	U5.1, U5.2, U5.3, U5.4	Divided Into 7 Intervals	U5.1,U5.2, U5.3,U5.4, U5.6,U5.7
6	U6	[5750 -5850]	35	Divided Into 4 Intervals	U6.1, U6.2, U6.3, U6.4	Divided Into 7 Intervals	U6.1,U6.2, U6.3,U6.4, U6.6,U6.7
7	U7	[5850 -5950]	11	Not Change	U7.	Divided Into 3 Intervals	U7.1, U7.2,U7.3

Table 4. Comparison Redivided Step Interval between Before and After Modification for LQ-45 Index Data

No	Code	Interval	Number Of Data	Universe Before Modification		Universe After Modification	
1	U1	[875-895]	35	Divided Into 4 intervals	U1.1, U1.2, U1.3, U1.4	Divided Into 6 intervals	U1.1, U1.2, U1.3, U1.4, U1.5, U1.6
2	U2	[895 - 915]	11	Not Change	U2	Divided Into 2 intervals	U2.1, U2.2,
3	U3	[915 - 935]	20	Not Change	U3	Divided Into 3 intervals	U3.1, U3.2, U3.3
4	U4	[935 - 955]	27	Divided Into 2 interval2	U4.1, U4.2	Divided Into 4 intervals	U4.1, U4.2, U4.3, U4.4
5	U5	[955 - 975]	34	Divided Into 3 interval2	U5.1, U5.2, U5.3	Divided Into 5 intervals	U5.1, U5.2, U5.3, U5.4, U5.5
6	U6	[975 - 995]	22	Not Change	U6	Divided Into 4 intervals	U6.1, U6.2, U6.3, U6.4
7	U7	[995-1015]	1	Not Change	U7	Not Change	U7

Furthermore, redivided step results as shown in table 3 and 4 are distributed into each new interval and followed by a phase of defining the fuzzy set which describe in Table 5 (for JSX) and Table 6 (for LQ-45).

Table 5. Defining the fuzzy sets After Modification For JSX Index Data

Fuzzy Set	Length	Min	Max
A1	50.00	5250	5300
A2	50.00	5300	5350
A3	33.33	5350	5383
A4	33.33	5383	5417
A5	33.33	5417	5450
A6	100.00	5450	5550
A7	100.00	5550	5650
A8	25.00	5650	5675

Fuzzy Set	Length	Min	Max
A9	25.00	5675	5700
A10	25.00	5700	5725
A11	25.00	5725	5750
A12	25.00	5750	5775
A13	25.00	5775	5800
A14	25.00	5800	5825
A15	25.00	5825	5850
A16	100.00	5850	5950

Table 6. Defining Fuzzy Set After Modification for LQ-45 Index Data

Fuzzy Set	Length	Min	Max
A1	2.50	875	877.5
A2	2.50	878	880
A3	2.50	880	882.5
A4	2.50	882.5	885
A5	2.50	885	887.5
A6	2.50	887.5	890
A7	2.50	890	893
A8	2.50	893	895
A9	6.67	895	902
A10	6.67	902	908
A11	6.67	908	915
A12	5.00	915	920
A13	5.00	920	925
A14	5.00	925	930
A15	5.00	930	935
A16	3.33	935	938
A17	3.33	938	942
A18	3.33	942	945

Fuzzy Set	Length	Min	Max
A19	3.33	945	948
A20	3.33	948	952
A21	3.33	952	955
A22	2.86	955	958
A23	2.86	958	961
A24	2.86	961	964
A25	2.86	964	966
A26	2.86	966	969
A27	2.86	969	972
A28	2.86	972	975
A29	4.00	975	979
A30	4.00	979	983
A31	4.00	983	987
A32	4.00	987	991
A33	4.00	991	995
A34	10.00	995	1005
A35	10.00	1005	1015

The advanced stages such as forming Fuzzy Logical Relationship (FLR) and determine the difference of the data n-1, n-2 and n-3 by 3 (three) rule fuzzy time Chen - Hsu carried out in accordance technique Chen fuzzy time - Hsu without any modifications (see also Zulfikar and Mayvita, 2017)

After analysis of actual data, the final result and the predicted value of the JSX and LQ-45 which presented to 30 dataobtained after modification of the technique is showed in Table 7 (for JSX) and Table 8 (for LQ-45).

Table 7. Actual and Predicted JSX Index with Modified Technique

No	Tanggal	FLR			Actual	Predicted	Variance	AFER
1	10-Jan-17	A3	→	A2	5292.75	885.63	-2.250	-0.04%
2	11-Jan-17	A2	→	A2	5272.98	883.75	-7.020	-0.13%
3	12-Jan-17	A2	→	A1	5270.01	878.75	-9.990	-0.19%
4	13-Jan-17	A1	→	A3	5266.94	878.13	6.940	0.13%
5	17-Jan-17	A3	→	A3	5294.78	886.25	-5.220	-0.10%
6	18-Jan-17	A3	→	A1	5298.95	886.25	-1.050	-0.02%
7	19-Jan-17	A1	→	A1	5254.31	876.25	-5.690	-0.11%
8	20-Jan-17	A1	→	A3	5250.97	876.25	-9.030	-0.17%
9	23-Jan-17	A3	→	A3	5292.09	883.75	-7.910	-0.15%
10	24-Jan-17	A3	→	A4	5293.78	883.75	-6.220	-0.12%
11	25-Jan-17	A4	→	A4	5317.63	888.75	-2.370	-0.04%
12	26-Jan-17	A4	→	A3	5312.84	886.25	-7.160	-0.13%
13	27-Jan-17	A3	→	A3	5302.66	883.13	7.660	0.14%
14	30-Jan-17	A3	→	A4	5294.10	876.25	-0.900	-0.02%
15	31-Jan-17	A4	→	A6	5327.16	886.25	7.160	0.13%
16	1-Feb-17	A6	→	A6	5353.71	891.25	-4.623	-0.09%
17	2-Feb-17	A6	→	A8	5360.77	893.75	6.603	0.12%
18	3-Feb-17	A8	→	A7	5396.00	898.33	4.333	0.08%
19	6-Feb-17	A7	→	A6	5381.48	898.33	6.480	0.12%
20	7-Feb-17	A6	→	A7	5361.09	893.75	6.923	0.13%
21	8-Feb-17	A7	→	A7	5372.08	894.38	-2.920	-0.05%
22	9-Feb-17	A7	→	A9	5371.67	893.75	-3.330	-0.06%
23	10-Feb-17	A9	→	A7	5409.56	898.33	1.227	0.02%
24	13-Feb-17	A7	→	A7	5380.67	893.75	5.670	0.11%
25	14-Feb-17	A7	→	A6	5378.00	893.75	3.000	0.06%
26	15-Feb-17	A6	→	A6	5350.93	886.25	-7.403	-0.14%
27	16-Feb-17	A6	→	A5	5359.29	888.75	0.957	0.02%
28	17-Feb-17	A5	→	A6	5340.99	886.25	0.990	0.02%
29	21-Feb-17	A6	→	A7	5358.68	891.25	0.347	0.01%
30	22-Feb-17	A7	→	A8	5372.75	893.75	-2.250	-0.04%

Table 8. Actual and Predicted LQ-45 Index with Modified Technique

No	Tanggal	FLR			Actual	Predicted	Variance	ESER
1	10-Jan-17	A5	→	A4	885.22	885.63	-0.405	-0.05%
2	11-Jan-17	A4	→	A2	882.52	883.75	-1.230	-0.14%
3	12-Jan-17	A2	→	A2	879.53	878.75	0.780	0.09%
4	13-Jan-17	A2	→	A5	878.90	878.13	0.775	0.09%
5	17-Jan-17	A5	→	A5	885.28	886.25	-0.970	-0.11%
6	18-Jan-17	A5	→	A1	886.48	886.25	0.230	0.03%
7	19-Jan-17	A1	→	A1	875.51	876.25	-0.740	-0.08%
8	20-Jan-17	A1	→	A4	875.86	876.25	-0.390	-0.04%
9	23-Jan-17	A4	→	A4	884.17	883.75	0.420	0.05%
10	24-Jan-17	A4	→	A6	884.31	883.75	0.560	0.06%
11	25-Jan-17	A6	→	A5	889.22	888.75	0.470	0.05%
12	26-Jan-17	A5	→	A4	886.62	886.25	0.370	0.04%
13	27-Jan-17	A4	→	A1	882.74	883.13	-0.385	-0.04%

No	Tanggal	FLR			Actual	Predicted	Variance	AFER
14	30-Jan-17	A1	→	A5	877.35	876.25	1.100	0.13%
15	31-Jan-17	A5	→	A7	886.24	886.25	-0.010	0.00%
16	1-Feb-17	A7	→	A8	891.04	891.25	-0.210	-0.02%
17	2-Feb-17	A8	→	A9	893.30	893.75	-0.450	-0.05%
18	3-Feb-17	A9	→	A9	899.48	898.33	1.147	0.13%
19	6-Feb-17	A9	→	A8	896.64	898.33	-1.693	-0.19%
20	7-Feb-17	A8	→	A8	893.89	893.75	0.140	0.02%
21	8-Feb-17	A8	→	A8	894.45	894.38	0.075	0.01%
22	9-Feb-17	A8	→	A9	893.89	893.75	0.140	0.02%
23	10-Feb-17	A9	→	A8	900.72	898.33	2.387	0.26%
24	13-Feb-17	A8	→	A8	893.72	893.75	-0.030	0.00%
25	14-Feb-17	A8	→	A5	894.40	893.75	0.650	0.07%
26	15-Feb-17	A5	→	A6	887.40	886.25	1.150	0.13%
27	16-Feb-17	A6	→	A5	888.20	888.75	-0.550	-0.06%
28	17-Feb-17	A5	→	A7	886.34	886.25	0.090	0.01%
29	21-Feb-17	A7	→	A8	891.78	891.25	0.530	0.06%
30	22-Feb-17	A8	→	A9	893.11	893.75	-0.640	-0.07%

After performing analysis of actual data, the obtained results from the fuzzy time series Chen and Hsu before and after modification for JSX and LQ-45 are described in Table 9 and we illustrade in Figure 1,2,3 and 4 below.

Table 9. Comparison of MSE and AFER before and after Modification

Parameter	Before Modification		After Modification	
	JSX	LQ-45	JSX	LQ-45
Variance	3.782	-0.419	0.4761	0.114
MSE	378.471	25.553	50.827	1.277
AFER	0.0685 %	-0.0449 %	0.0081%	0.0120 %

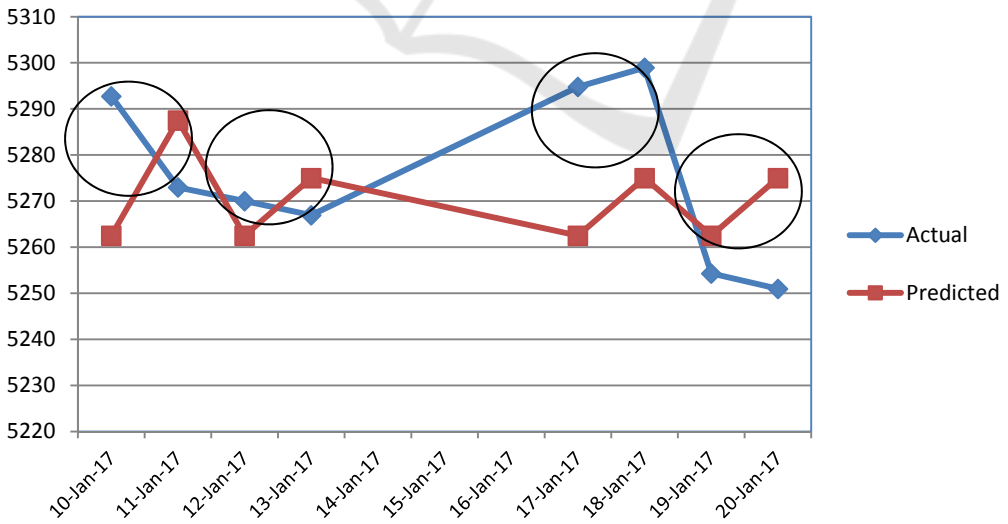

Figure 1. Comparison Actual and Predicted JSX Index before Modification

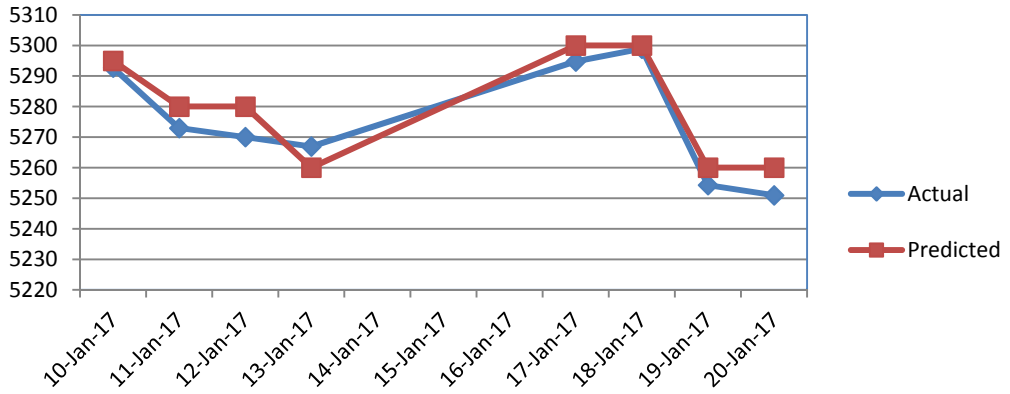

Figure 2. Comparison Actual and Predicted JSX Index after Modification

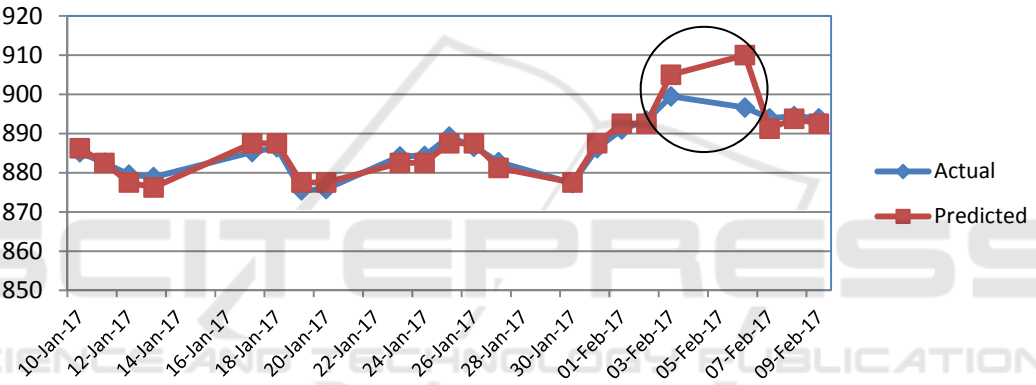

Figure 3. Comparison Actual and Predicted LQ-45 Index Before Modification

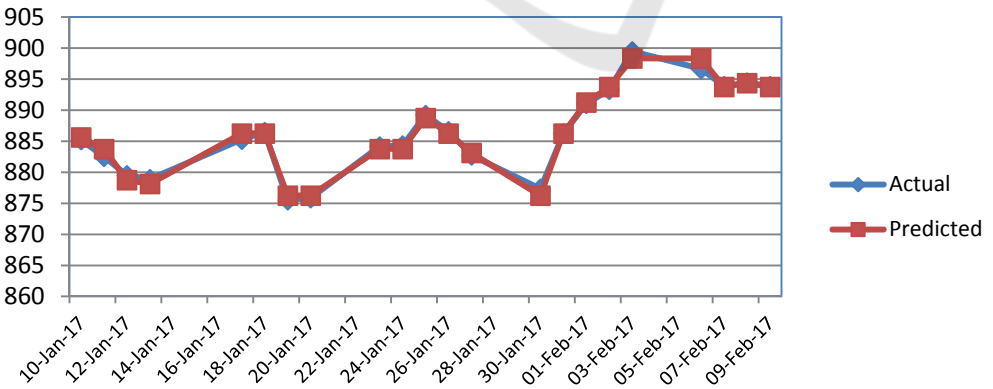

Figure 4. Comparison Actual and Predicted LQ-45 Index after Modification

Based on Figure 1 and Figure 3 shows that the stock value of JSX and LQ-45 before the modification still showed some significant variances and can decrease the value of forecasting accuracy index value. However, this is not shown in figure 2 and figure 4 that do forecasting with technical

modifications and line index value between actual and predicted tends to coincide and be able to follow the pattern of the value of stock index JSX and LQ-45.

4 CONCLUSIONS

This research showed that the index of JSX after using the technique of a modified fuzzy time series is able to provide value Mean Square Error (MSE) = 0.476, and Average Forecasting Error (AFER) = 0.0081% where the obtained value is much lower than is possible using Fuzzy Time Series unmodified (MSE = 3,782 and AFER = 0.0685%). On the index of LQ-45, the modified fuzzy time series technic is able to provide the MSE = -0.0449 and AFER = 0.0120% which is also lower than the prediction using the technique of fuzzy time series unmodified (MSE = -0.419 and AFER = 0.114%). The results of this research have found that the modification of fuzzy time series at intervals redivided step able to provide better forecasting accuracy.

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