**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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**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.

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

**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)[1] which used the concept of logical fuzzyto develop the basis of fuzzy time seriesusing time-invariant and time-variantfor forecasting.  Several methods of fuzzy time seriesforecastingwhich have been developed are a method of Chen (1996[2] and 2002) [3] and Chen and Hsu (2004)[4], the method of Markov Chain (Sullivan and Woodall, 1994)[5], the method of percentage change (Stevenson and Porter, 2009)[6], the implementation of the network backpropagation (Huarng and Yu,2006*)*[7], and multiple-attributefuzzy time series (Cheng et al, 2008)[8].

Forecasting with fuzzy time series has also been tested by some researchers as practiced by Hansun (2012)[9] and Fauziah et al (2016)[10] with Fuzzy Time Series Chen, Rahmadiani (2012)[11] with Fuzzy Neural network, Handayani and Anggraini (2015)[12] by the method of Chen and the method of Lee, Rukhansyah Et all (2015)[13] with Fuzzy Time Series Markov Chain, Hasudungan (2016)[14] with Fuzzy Time Series-Genetic Algorithm and Elfajar et al (2017)[15] with fuzzy time series invariant.

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 Further research on fuzzy time series conducted by Zulfikar and Mayvita (2017)[16] 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 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.

**METHODS**

Population and sample in this research is the daily data index of the Jakarta Stock Exchange (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](http://www.finance.google.com).finance.google. com)[17].

This method is used 5 (five) following steps: (1) Defining the universal of data collection, (2) Distributing 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 follows:

**Table. I Rule Fuzzy Time Series First Order Time-Invariant Chen and**

 **Hsu[4]**

|  |  |  |
| --- | --- | --- |
| **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 Aj.
* If the data does not have data n-3, then:
1. if the difference between n-1 and n-2> half intervals Aj then the value is expressed as upward forecast 0.75 point interval Aj.
2. if the difference between n-1 and n-2 = half interval Aj then the value is expressed as a middle-value prediction intervals Aj.
3. if the difference between n-1 and n-2 <half the interval Aj then the value is expressed as downward interval forecast Aj.
 | * If DIFF is worth positive then:
1. if the value **(DIFF x 2 + Data n-1)** Notin the interval Aj then the value is expressed as upward forecast 0.75 point interval Aj.
2. if the value **(DIFF / 2 + Data n-1)** Notin the interval Aj then the value is expressed as downward 0:25 forecasts point interval Aj.
3. Point (a) and point (b) is not met, then the value of the forecast stated at the middle interval value Aj
 | * If DIFF is negative then:
1. if the value **(DIFF / 2 + Data n-1)** Noin the interval Aj then the value is expressed as downward 0:25 forecasts point interval Aj.
2. if the value **(DIFF x 2 + Data n-1)** Noin the interval Aj then the value is expressed as upward forecast 0.75 point interval Aj.
3. If Point (a) and point (b) is not met, then the value of the forecast stated at the middle-value intervals Aj.
 |

**Modification Technique**

Technique modifications made in this study is performed at redivided  interval stepin 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.

**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) |
| 1. **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)[18] which is calculated based on the following equation: AFER =$\frac{\frac{|Data Aktual – Data Peramalan|}{Data Aktual)}}{n}$ x 100% ...(2) |

**RESULT**

Data description that used in this research are as follow :

**Table II.  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 are as follows :

**Table III. 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 IV. 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 as follows:

**Table V. Defining The fuzzy sets After Modification For JSX Index Data**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Fuzzy Set** | **Universe** | **Interval Length** | **Interval** |  | **Fuzzy Set** | **Universe** | **Interval Length** | **Interval** |
| A1 | U1.1 | 50.00 | 5250 | - | 5300 |  | A9 | U5.2 | 25.00 | 5675 | - | 5700 |
| A2 | U1.2 | 50.00 | 5300 | - | 5350 |  | A10 | U5.3 | 25.00 | 5700 | - | 5725 |
| A3 | U2.1 | 33.33 | 5350 | - | 5383 |  | A11 | U5.4 | 25.00 | 5725 | - | 5750 |
| A4 | U2.2 | 33.33 | 5383 | - | 5417 |  | A12 | U6.1 | 25.00 | 5750 | - | 5775 |
| A5 | U2.3 | 33.33 | 5417 | - | 5450 |  | A13 | U6.2 | 25.00 | 5775 | - | 5800 |
| A6 | U3 | 100.00 | 5450 | - | 5550 |  | A14 | U6.3 | 25.00 | 5800 | - | 5825 |
| A7 | U4 | 100.00 | 5550 | - | 5650 |  | A15 | U6.4 | 25.00 | 5825 | - | 5850 |
| A8 | U5.1 | 25.00 | 5650 | - | 5675 |  | A16 | U7 | 100.00 | 5850 | - | 5950 |

**Tabel VI. Defining Fuzzy Set After Modification For LQ-45 Index Data**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Fuzzy Set** | **Universe** | **Interval Length** | **Interval** |  | **Fuzzy Set** | **Universe** | **Interval Length l** | **Interval** |
| A1 | U1.1 | 2.50 | 875 | - | 877.5 |  | A19 | U4.4 | 3.33 | 945 | - | 948 |
| A2 | U1.2 | 2.50 | 878 | - | 880 |  | A20 | U4.5 | 3.33 | 948 | - | 952 |
| A3 | U1.3 | 2.50 | 880 | - | 882.5 |  | A21 | U4.6 | 3.33 | 952 | - | 955 |
| A4 | U1.4 | 2.50 | 882.5 | - | 885 |  | A22 | U5.1 | 2.86 | 955 | - | 958 |
| A5 | U1.5 | 2.50 | 885 | - | 887.5 |  | A23 | U5.2 | 2.86 | 958 | - | 961 |
| A6 | U1.6 | 2.50 | 887.5 | - | 890 |  | A24 | U5.3 | 2.86 | 961 | - | 964 |
| A7 | U1.7 | 2.50 | 890 | - | 893 |  | A25 | U5.4 | 2.86 | 964 | - | 966 |
| A8 | U1.8 | 2.50 | 893 | - | 895 |  | A26 | U5.5 | 2.86 | 966 | - | 969 |
| A9 | U2.1 | 6.67 | 895 | - | 902 |  | A27 | U5.6 | 2.86 | 969 | - | 972 |
| A10 | U2.2 | 6.67 | 902 | - | 908 |  | A28 | U5.7 | 2.86 | 972 | - | 975 |
| A11 | U2.3 | 6.67 | 908 | - | 915 |  | A29 | U6.1 | 4.00 | 975 | - | 979 |
| A12 | U3.1 | 5.00 | 915 | - | 920 |  | A30 | U6.2 | 4.00 | 979 | - | 983 |
| A13 | U3.2 | 5.00 | 920 | - | 925 |  | A31 | U6.3 | 4.00 | 983 | - | 987 |
| A14 | U3.3 | 5.00 | 925 | - | 930 |  | A32 | U6.4 | 4.00 | 987 | - | 991 |
| A15 | U3.4 | 5.00 | 930 | - | 935 |  | A33 | U6.5 | 4.00 | 991 | - | 995 |
| A16 | U4.1 | 3.33 | 935 | - | 938 |  | A34 | U7.1 | 10.00 | 995 | - | 1005 |
| A17 | U4.2 | 3.33 | 938 | - | 942 |  | A35 | U7.2 | 10.00 | 1005 | - | 1015 |
| A18 | U4.3 | 3.33 | 942 | - | 945 |  |  |  |  |  |  |  |

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[16]).

 After analysis of actual data, the final result and the predicted value of the JSX index LQ-45 obtained after modification of the technique is as follows (presented to 30 data):

**Table VII. 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 VIII. Actual and Predicted LQ-45 Index With Modified Technique**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **No** | **Tanggal** | **FLR** | **Actual** | **Predicted** | **Variance** | **AFER** |
| 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% |
| 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 are as follows :

**Table IX.  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 % |

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|  |
| **Figure 1. Comparison Actual and Predicted JSX Index Before Modification** |
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|  |
| **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.

**CONCLUSION**

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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