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Digital Transformation Business Strategy in Post Covid-19

PREDICTION OF STOCK CLOSE PRICE ON THE FIVE BEST ISSUERS FORBES GLOBAL 2000 VERSION USING CHEN'S FUZZY TIME SERIES METHOD

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Abstract: Changes in stock prices are an uncertain situation. This often makes investors confused when to sell, buy or hold their stocks. Therefore, this study discusses the prediction of stock close prices in the five best issuers according to the Forbes 2000 version, namely for BBRI, BBCA, BMRI, TLKM, and BBNI stock. The method used is the Chen model of fuzzy time series. Prediction calculations are carried out with MATLAB 2013a software. The accuracy of the prediction results is calculated using the MAPE (Mean Absolute Percentage Error) formula. The results obtained in this study indicate that the stock of the five issuers can be predicted using the Chen's Fuzzy Time Series with each level of accuracy is 96.7%, 96.8%, 97.7%, 97.8%, and 97.2% for BBRI, BBNI, BBCA, BMRI, and TLKM.

Keywords: stock price, prediction, Chen's fuzzy time series

1. Introduction

Stocks are part of the investment that is in great demand today. This is supported by several factors, including the increasing number of media that can be used to buy and sell stocks, online through applications or offline by coming directly to financial institutions. In addition, the public is also more understanding that stocks can provide benefits in the future if the purchase or sale of stocks is done at the right time.

However, every day the stock price changes very volatile. Uncertain circumstances like this make investors confused about when is the best time to make transaction to buy or sell their stock. Stock price predictions are needed so that investors have a basis for planning and deciding when to sell or buy stock.

Several methods that can be used to predict future data include the single exponential smoothing method and the fuzzy time series method [2]. The fuzzy time series method is a development of fuzzy logic. This fuzzy time series has been widely used to predict a situation in the future using past conditions. One of the fuzzy time series models that is often used is Chen's fuzzy time series. Many studies show that Chen's fuzzy time series can be used to predict future conditions.

In this article, a study is conducted to predict stock prices using the Chen's fuzzy time series method. The stock price that is predicted is the share price of the issuer's version of Forbes 2000 for the stock of BRI (BBRI), BCA (BBCA), Mandiri (BMRI), Telkom Indonesia (TLKM), and BNI (BBNI). Calculation accuracy is determined by calculating the MAPE (Mean Absolute Percentage Error) value.

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2. Literature Review

Stock is one of the most popular financial market instruments. Issuing stock is one of the company's choices when deciding to fund the company. On the other hand, stocks are an investment instrument that many investors choose because they are able to provide an attractive level of profit.

Forecasting is the process of predicting future data by paying attention to past data using some form of mathematical model. Fuzzy time series is a data forecasting method that uses fuzzy principles as a basis. Forecasting using fuzzy time series can capture patterns from past data and then use it to project future data.

There are several fuzzy time series models, including the Chen, Cheng and Markov Chain fuzzy time series. In research Chen's Fuzzy Time Series is used to predict gold prices. In this study, the determination of the interval is determined based on the average. The results show that Chen's Fuzzy Time Series can predict gold prices for the next day. In addition, there is also research, which uses Chen's Fuzzy Time Series to predict Rainfall in Samarinda City. In this study, the determination of the interval is also determined based on the average. From the results of this study, it was found that the Chen's Fuzzy Time Series method can be used to predict rainfall in the future. Meanwhile, research [1] also uses Chen's Fuzzy Time Series to predict Rainfall. In this study, the length of the interval was determined using the Sturgess formula. Furthermore, the results of rainfall prediction using Chen's Fuzzy Time Series are compared with Markov Chain's Fuzzy Time Series. From the results of this study, it was found that the Chen's Fuzzy Time Series method provides an accurate value when compared to other methods for predicting rainfall in the future.

Therefore, in this study, the Chen's Fuzzy Times Series method is used to predict future stock prices by determining the length of the interval using the Sturges Formula.

3. Method

Data we used in this study is obtained from yahoo finance [8]. The variable we used is the daily stock price of BBRI, BBCA, BMRI, TLKM, and BBNI for Jan 2010 to Dec 2021. Calculation of prediction data is done with the help of MATLAB software.

The steps of stock price prediction using Chen's Fuzzy Time Series (FTS) is given as follow:

a. Building the *universe of discourse* (U)

$$U = [D_{min}; D_{max}]$$

with:
D_{min} : Minimum data
D_{max} : Maximum data

b. Determine the Interval

a. Determine the range with the following formula:

$$R = D_{max} - D_{min} \tag{1}$$

b. Determine the number of class interval with the Sturges formula:

$$k = 1 + 3{,}322 \log(N) \tag{2}$$

with N is the number of data.

c. Determine the width interval

$$l = \frac{D_{max} - D_{min}}{k} \tag{3}$$

d. Determine the midpoint data for each U:

$$m_i = \frac{batas\ bawah + batas\ atas}{2} \tag{4}$$

where is:

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$$u_1 = (D_{min}\ ;\ D_{min} + l)$$
$$u_2 = (D_{min} + l;\ D_{min} + 2l)$$
$$u_3 = (D_{min} + 2l;\ D_{min} + 3l)$$
$$\vdots$$
$$u_n = (D_{min} + (k-1);\ D_{min} + nl)$$

c. Define the fuzzy set for each Ai and then do the fuzzification for actual data.
d. Building the table of Fuzzy Logic Relationship (FLR) based on actual data. FLR is written as $A_i \rightarrow A_j$, with A_i as current state and A_j as next state.
e. Determine the Fuzzy Logic Relationship Group (FLRG)
f. Calculate the prediction:
   On the Chen's Fuzzy time series there are some rules that have to be consider to predict data:
   Rule 1: If there are fuzzy set that have no fuzzy relation, suppose if Ai→Ø, and then there is data on (t-1) period that fall in Ai, then the value of the prediction Ft is mj(t-1), with mj(t-1) is the midpoint from interval of uj on the group of fuzzy logic relation that formed on the (t-1) data.
   Rule 2: If there is one fuzzy logic relation on the row of fuzzy logic relation group, suppose Ai→Aj and there is data on the period of (t-1) is in the Ai, then the value of prediction of Ft is mj(t-1), with mj(t-1) is the midpoint of uj interval on the fuzzy logic relation group that formed on the (t-1) data.
   Rule 3: If there is a fuzzy relation group Ai→Ai, Aj, …, Ap then Ft is the predict value that suit to Ai, Aj, …, Ap. With the following equation:

$$Ft = \frac{m1_{(t-1)} + m2_{(t-1)} + \cdots + mp_{(t-1)}}{p} \tag{5}$$

g. Accuracy the value of Stock Price is calculated by determine the value of MAPE Mean Absolute Percentage Error (MAPE)

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{D_i - F_i}{D_i}\right| \times 100\% \tag{6}$$

4. Results and Discussion

The data of BBRI stock closing price for Jan 2015 to Dec 2021 is showing on the following figure:
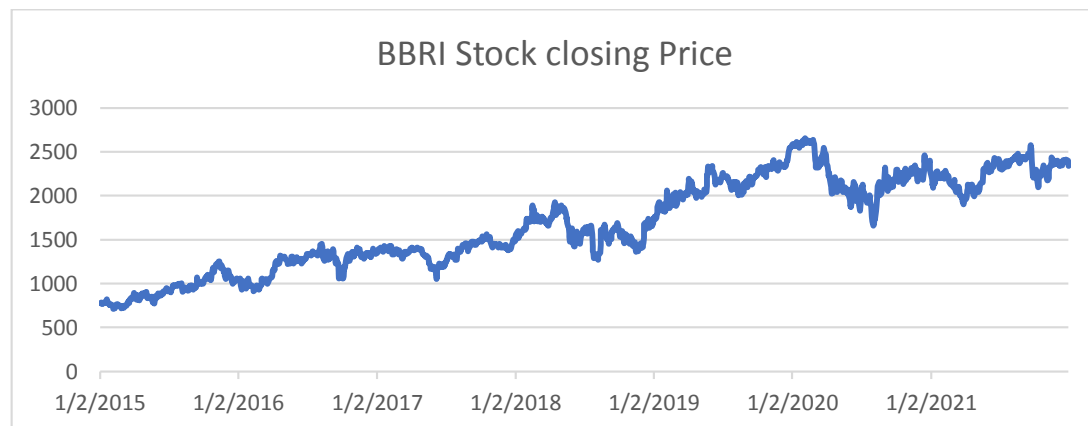

Figure 1: Data Close of BBRI stock price for Jan 2015 to Dec 2021

Prediction of BBRI stock price using Fuzzy time series Chen is done with the following steps:

1. $U = [Dmin - D_1; Dmax + D_2]$
   $= [1660 - 3; 4890 - 5]$
   $= [1657; 4895]$

2. Determine the interval:
   a. Range:
      $$R = D_{max} - D_{min} = 4895 - 1657 = 3238$$
   b. Number of class interval:
      k = 1+ 3.322 log(N) = 1 + 3.322   log (1752) = 11.72 = 12
   c. Interval width:
      $$l = \frac{D_{max} - D_{min}}{k} = \frac{3238}{12} = 269,17$$
   d. Midpoint:
      $$m_i = \frac{batas\ bawah + batas\ atas}{2}$$
      Midpoint for each interval is given as follow:
      U_1: 1657 - 1929 midpoint A_1: 1794
      U_2: 1929 - 2198 midpoint A_2: 2064
      U_3: 2198 - 2468 midpoint A_3: 2333
      U_4: 2468 - 2737 midpoint A_4: 2603
      U_5: 2737 - 3006 midpoint A_5: 2872
      U_6: 3006 - 3275 midpoint A_6: 3141
      U_7: 3275 - 3544 midpoint A_7: 3410
      U_8: 3544 - 3813 midpoint A_8: 3679
      U_9: 3813 - 4082 midpoint A_9: 3948
      U_{10}: 4082 - 4352 midpoint A_{10}: 4218
      U_{11}: 4352 - 4621 midpoint A_{11}: 4487
      U_{12}: 4621 - 4890 midpoint A_{12}: 4756

3. The fuzzification for each A_i is given as follow:

Table 1. Fuzzification Data

Date	Data	Fuzzification
2 Jan 2015	2330	A3
5 Jan 2015	2320	A3
6 Jan 2015	2305	A3
7 Jan 2015	2355	A3
8 Jan 2015	2395	A3
9 Jan 2015	2405	A3
12 Jan 2015	2350	A3
13 Jan 2015	2365	A3
14 Jan 2015	2350	A3
⋮	⋮	⋮
⋮	⋮	⋮
28 Des 2021	4090	A10
29 Des 2021	4080	A9
30 Des 2021	4110	A10

4. The table of Fuzzy Logic Relationship (FLR) is given as follow:

Table 2. Fuzzy of Logic Relationship (FLR)

Date	Data	Fuzzy Logic Relationship
2 Jan 2015	2330	A3 → A3
5 Jan 2015	2320	A3 → A3
6 Jan 2015	2305	A3 → A3
7 Jan 2015	2355	A3 → A3
8 Jan 2015	2395	A3 → A3
9 Jan 2015	2405	A3 → A3
12 Jan 2015	2350	A3 → A3
13 Jan 2015	2365	A3 → A3
14 Jan 2015	2350	A3 → A3
⋮	⋮	
28 Des 2021	4090	A10 → A9
29 Des 2021	4080	A9 → A10
30 Des 2021	4110	

5. Fuzzy Logic Relationship Group (FLRG) is given as follow:

Table 3. Fuzzy Logic Relationship Group (FLRG)

Current State	Next State			
A1	A1	A2		
A2	A1	A2	A3	
A3	A2	A3	A4	A5
A4	A3	A4	A5	
A5	A4	A5	A6	
A6	A5	A6	A7	
A7	A6	A7	A8	
A8	A7	A8	A9	
A9	A7	A8	A9	A10
A10	A9	A10	A11	
A11	A10	A11	A12	
A12	A11	A12		

6. The prediction of BBRI Stock Price
   The prediction of BBRI stock price is calculated using the formulas as follow:

Table 4. Prediction of BBRI stock price

Prediction of BBRI stock price	
F_1	1929
F_2	2063.66
F_3	2468
F_4	2602.66
F_5	2872
F_6	3141
F_7	3410
F_8	3679
F_9	3813.75
F_{10}	4217.66
F_{11}	4487
F_{12}	4621.5

7. Prediction of BBRI stock price for the 1753rd data is 4217.667

The prediction and the actual data of BBRI stock price for Jan 2015 – Dec 2021 is shown as follow:
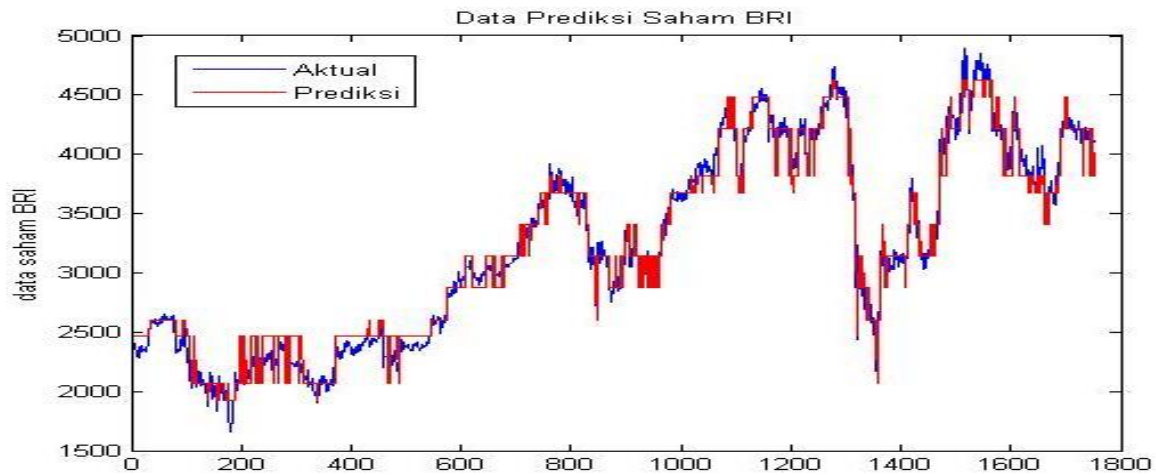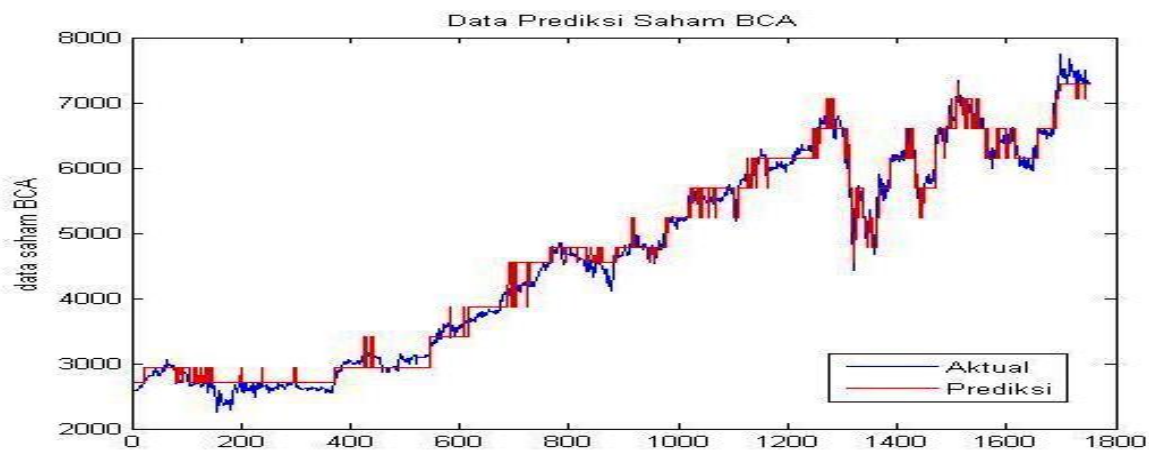

Figure 2: The prediction of Stock price of BBRI

The following is calculation of the value of Mean Absolute Percentage Error (MAPE) of BBRI stock price:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{D_i - F_i}{D_i}\right| \times 100\% = 3.2197\%$$

Thus, the prediction of BBRI stock price using Chen Fuzzy Time series produces an accuracy of 96.7%.

The seven steps above is repeated for prediction of stock price of BBCA, BMRI, TLKM and BBNI. The prediction of the stock price is given as follow:

The prediction of BCA stock price using the Fuzzy Time Series Chen method for Jan 2015 – Dec 2021 is given as follow:

Figure 3: Prediction Stock Price of BBCA

The following is calculation of the value of Mean Absolute Percentage Error (MAPE) of BCA stock price:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{D_i - F_i}{D_i}\right| \times 100\% = 3.1983\%$$

Thus, the prediction of BCA stock price using Chen Fuzzy Time series produces an accuracy of 96.8%.

The prediction of BMRI stock price using the Fuzzy Time Series Chen method for Jan 2015 – Dec 2021 is given as follow:
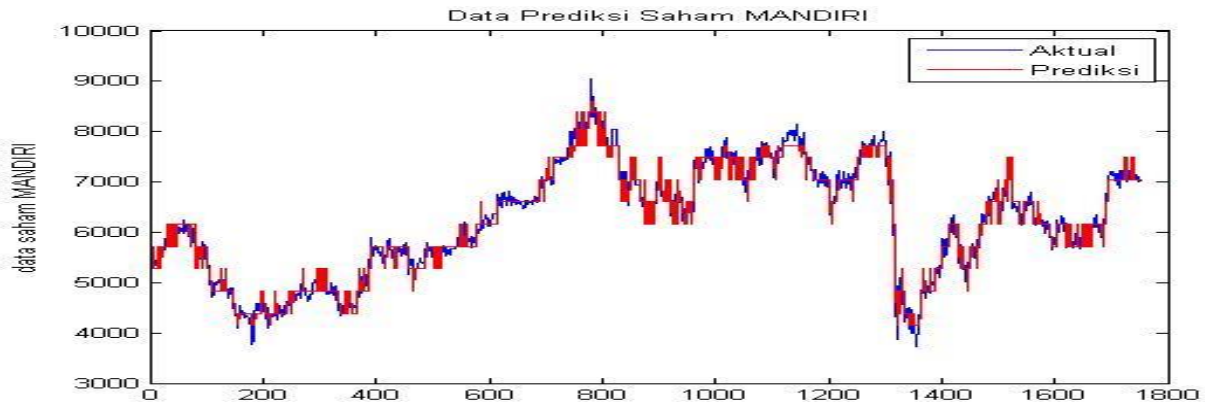

Figure 4: Prediction Stock Price of BMRI

The following is calculation of the value of Mean Absolute Percentage Error (MAPE) of BMRI stock price:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{D_i - F_i}{D_i}\right| \times 100\% = 2.3894\%$$

Thus, the prediction of BMRI stock price using Chen Fuzzy Time series produces an accuracy of 97.7%.

The prediction of Telkom Indonesia stock price using the Fuzzy Time Series Chen method for Jan 2015 – Dec 2021 is given as follow:
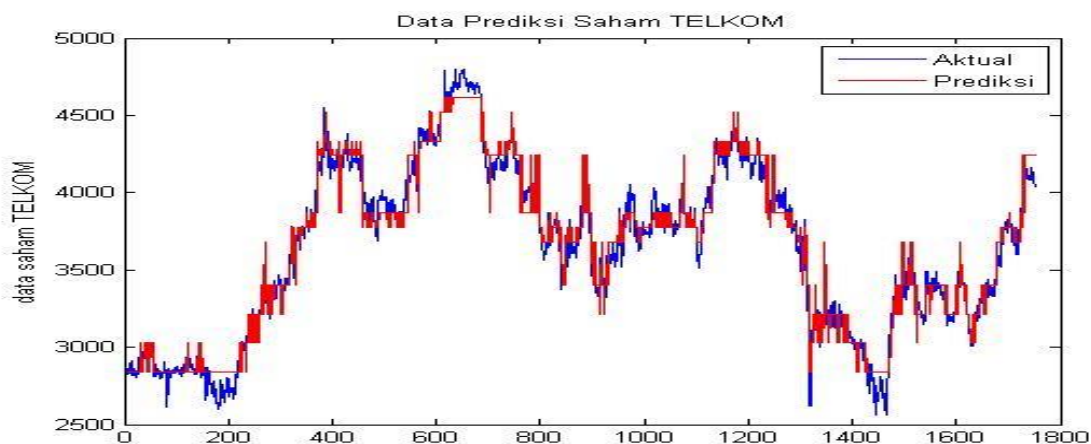

Figure 5: Prediction Stock Price of TLKM

The following is calculation of the value of Mean Absolute Percentage Error (MAPE) of TLKM stock price:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{D_i - F_i}{D_i}\right| \times 100\% = 2.2243\%$$

Thus, the prediction of TLKM stock price using Chen Fuzzy Time series produces an accuracy of 97.8%.

The prediction of BBNI stock price using the Fuzzy Time Series Chen method for Jan 2015 – Dec 2021 is given as follow:
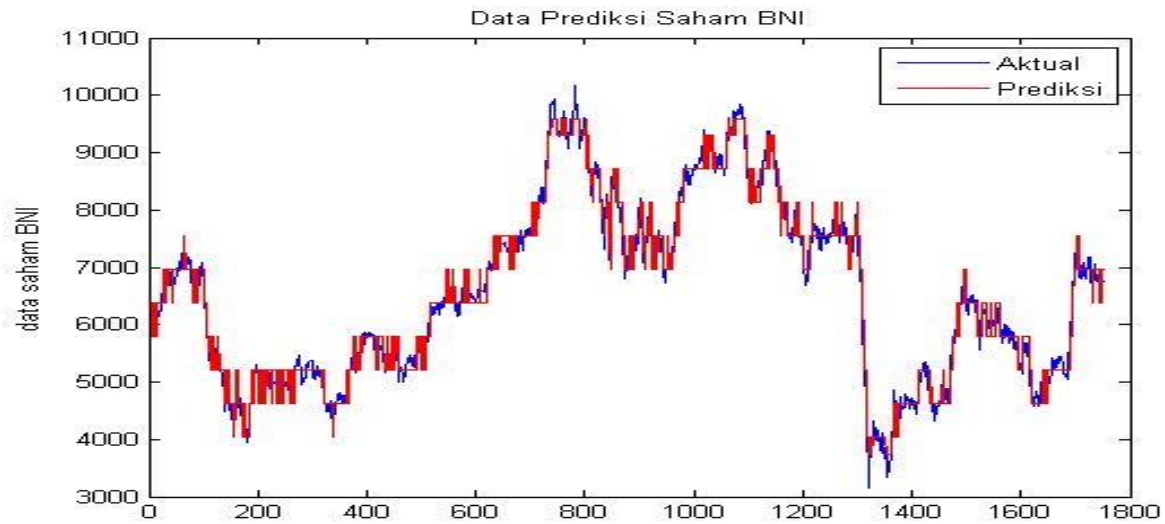

Figure 6: Prediction Stock Price of BNI

The following is calculation of the value of Mean Absolute Percentage Error (MAPE) of BBNI stock price:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{D_i - F_i}{D_i}\right| \times 100\% = 2.8066\%$$

Thus, the prediction of BBNI stock price using Chen Fuzzy Time series produces an accuracy of 97.2%.

5. Conclusions

Based on the valued of MAPE, the Chen's Fuzzy Time Series produce a good prediction for stock price of BRI, BCA, Mandiri, Telkom Indonesia, and BNI with the number of accuracy is 96.7%, 96.8%, 97.7%, 97.8%, and 97.2% respectively. Chen's Fuzzy time series can be used to predict the stock price for the future.

Acknowledgements

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