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APPLICATION OF FUZZY TIME SERIES WITH FIBONACCI RETRACEMENT FOR FORECASTING STOCK PRICE PT. BANK RAKYAT INDONESIA

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ABSTRACT

Stock can be defined as securities that indicate the ownership of a person or legal entity to the company issuing the shares. Good stocks for long-term investment are stocks that have good fundamentals and large market capitalization. The purpose of investing is to make a profit. In investing in stocks, investors need to know the risk management that can affect the ups and downs of a stock. Forecasting or forecasting is an analysis to predict everything related to the production, supply, demand, and use of technology in an industry or business. One of the forecasting methods is using fuzzy time series. The primary purpose of fuzzy time series is to predict time series data that can widely use on any real-time data, including capital market data. In this study, we will discuss the evolution of the time series model in overcoming fluctuations that often occur in stock prices by using a fuzzy time series that combines a stock analysis approach, namely Fibonacci retracement. The stock data used in this study is the close price of BBRI for October 2021 to March 2022. Forecasting result for 1 April 2022 is IDR 4660.49 with a Mean Absolute Percentage forecasting accuracy value of 1.034%.

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1. INTRODUCTION

Stock is one of the long-term financial instruments traded on the Indonesian capital market. Stock can be defined as securities that indicate the ownership of a person or legal entity to the company issuing the shares. Good stocks for long-term investment are stocks that have good fundamentals and large market capitalization. Data from the Indonesia Stock Exchange (IDX) shows that the banking sector is one of the sectors experiencing very significant growth. The banking sector has an essential role in mediating the economy between those who have excess funds and those who need funds. [1]

PT Bank Rakyat Indonesia is one of the largest state-owned banks in Indonesia, which is listed on the Indonesia Stock Exchange (IDX) and continuously records a profit every year. Bank BRI is a state-owned bank (State-Owned Enterprise) that consistently focuses on funding the MSME sector (Micro, Small, and Medium Enterprises). [2].

In investing in stocks, investors need to know the risk management that can affect the ups and downs of a stock. Forecasting is an analysis to predict everything related to the production, supply, demand, and use of technology in an industry or business. The usefulness of forecasting is making decisions based on considerations of what will happen when the decision is implemented. [3]

One of the forecasting methods for time series data is fuzzy time series. Fuzzy time series is one of the soft computing methods that has been used and applied in time series data analysis. The primary purpose of fuzzy time series is to predict time series data that can be widely used on any real-time data, including capital market data [4-7].

Fuzzy time series method has been implemented to predict TSMC and TAIEX stock prices by applying stock analysis theory to improve forecasting accuracy. Stock analysis theory is divided into two, namely fundamental analysis and technical analysis. Fundamental analysis is an analysis that includes how the company's performance and the condition of macroeconomic variables both at home and abroad. In comparison, technical analysis tries to predict future stock prices by utilizing historical stock data in the past.[8-10]

One method of technical analysis is using Fibonacci retracement. A Fibonacci retracement is an analytical tool used by stock and forex traders to approach technical analysis. This indicator is the result of the development of the ratio comparison on the Fibonacci number series. The results can be used to consider buying and selling shares. This analysis technique is used by taking a line to unite the two extreme points (highest point and lowest point) contained on the price chart. Then, the trader can divide the vertical distance between the two points based on the Fibonacci comparison. The comparisons used are 23.6%, 38.2%, 61.8%, and also 100%[11-13]

2. RESEARCH METHODS

Fuzzy time series is a development model of the Song and Chissom models by examining the distribution of data in linguistic values and applying stock analysis theory to the fuzzy time series model. Fuzzy time series with stock analysis theory improves forecasting accuracy, and the predicted target is the stock price [14-15]

There are several forecasting steps using the fuzzy time series method, namely:
Step one: Dividing the set of universes $U = [D_{min}, D_{max}]$.

Table 1. Interval base

Interval	Base
0.1-1.0	0.1
1.1-10	1
11-100	10
101-1000	100

One method of determining the effective interval length is the average-based method, the basis for the length of the interval, as evidenced in **Table 1.**

The second step: Making $L_1, L_2, \ldots, L_k$ a fuzzy set where the linguistic variables are determined by the state of the universe. The definition of a fuzzy set for the universe is:

$$\begin{aligned} L_1 &= {}^{a_{11}}/_{u_1} + {}^{a_{12}}/_{u_2} + \ldots + {}^{a_{1m}}/_{u_m} \\ L_2 &= {}^{a_{21}}/_{u_1} + {}^{a_{22}}/_{u_2} + \ldots + {}^{a_{2m}}/_{u_m} \\ &\vdots \\ L_k &= {}^{a_{k1}}/_{u_1} + {}^{a_{k2}}/_{u_2} + \ldots + {}^{a_{km}}/_{u_m} \end{aligned} \quad (1)$$

The value of a_{ij}indicates the degree of membership of the $u_j$fuzzy L_i set where $a_{ij} \in [0,1]$, $1 \leq i \leq k$, and $1 \leq j \leq m$. The value of the degree of membership of a_{ij} is determined based on the rules as below:
Rule 1: If historical data is P_t included u_i, then the membership degree value for $u_i$is 1, $u_{i+1}$is 0.5 and if not $u_i$and u_{i+1}, it is declared zero.
Rule 2: If historical data is P_t included inu_i, $1 \leq i \leq k$ then the value of the degree of membership for u_i is 1, $u_{i-1}$and $u_{i+1}$is 0.5 and if not u_i, u_{i-1} and u_{i+1}, then it is declared zero.
Rule 3: If historical data is P_t included u_i,then the membership degree value for $u_i$is 1, u_{i-1} is 0.5 and if not $u_i$and u_{i-1}, it is declared zero.
Suppose there is a $u_1$finite u_7 interval for the stock price interval, so that the defined L_1 fuzzy set is finite L_7. So, the linguistic variables are L_1(very low price), L_2(low price), L_3(low enough price), L_4(normal price), L_5 (high enough price), L_6(high price), L_6(high price), and L_7(very high price). The fuzzy set equation formed is as follows:

$$\begin{aligned} L_1 &= {}^{1}/_{u_1} + {}^{0.5}/_{u_2} + {}^{0}/_{u_3} + {}^{0}/_{u_4} + {}^{0}/_{u_5} + {}^{0}/_{u_6} + {}^{0}/_{u_7} \\ L_2 &= {}^{0.5}/_{u_1} + {}^{1}/_{u_2} + {}^{0.5}/_{u_3} + {}^{0}/_{u_4} + {}^{0}/_{u_5} + {}^{0}/_{u_6} + {}^{0}/_{u_7} \\ L_3 &= {}^{0}/_{u_1} + {}^{0.5}/_{u_2} + {}^{1}/_{u_3} + {}^{0.5}/_{u_4} + {}^{0}/_{u_5} + {}^{0}/_{u_6} + {}^{0}/_{u_7} \\ L_4 &= {}^{0}/_{u_1} + {}^{0}/_{u_2} + {}^{0.5}/_{u_3} + {}^{1}/_{u_4} + {}^{0.5}/_{u_5} + {}^{0}/_{u_6} + {}^{0}/_{u_7} \\ L_5 &= {}^{0}/_{u_1} + {}^{0}/_{u_2} + {}^{0}/_{u_3} + {}^{0.5}/_{u_4} + {}^{1}/_{u_5} + {}^{0.5}/_{u_6} + {}^{0}/_{u_7} \\ L_6 &= {}^{0}/_{u_1} + {}^{0}/_{u_2} + {}^{0}/_{u_3} + {}^{0}/_{u_4} + {}^{0.5}/_{u_5} + {}^{1}/_{u_6} + {}^{0.5}/_{u_7} \\ L_7 &= {}^{0}/_{u_1} + {}^{0}/_{u_2} + {}^{0}/_{u_3} + {}^{0}/_{u_4} + {}^{0}/_{u_5} + {}^{0.5}/_{u_6} + {}^{1}/_{u_7} \end{aligned} \quad (2)$$

Fuzzy logic relation is based on the fuzzification of historical data. If the fuzzification of stock prices builds a fuzzy logical relation $L_i \rightarrow L_j$ with $L_i$and $L_j$are called the current state and the following state, respectively, of fuzzy logic relations.

The third step: Forming a group of FLR (Fuzzy Logical Relationship) so that the multiplication between the vectors of each observation is obtained. FLR can be divided into groups, where the FLR which has the current state (current state) the same is inserted into the same FLR.
As an example:

$$L_i \rightarrow L_j$$
$$L_i \rightarrow L_k$$

L_i as the current state, $L_j$and $L_k$as the current state. So, $L_j$and $L_k$are in a group FLR.

Table 2. Fuzzy logical relationship

$L_1 \rightarrow L_1$	$L_1 \rightarrow L_2$	$L_2 \rightarrow L_3$	$L_3 \rightarrow L_3$
$L_3 \rightarrow L_4$	$L_4 \rightarrow L_4$	$L_4 \rightarrow L_3$	$L_4 \rightarrow L_6$
$L_6 \rightarrow L_6$	$L_6 \rightarrow L_7$	$L_7 \rightarrow L_7$	$L_7 \rightarrow L_6$

Table 2 shows the Fuzzy Logical Relationship formed.

Table 3. Fuzzy logical relationship groups

Group 1	$L_1 \rightarrow L_1$	$L_1 \rightarrow L_2$	
Group 2	$L_2 \rightarrow L_3$		
Group 3	$L_3 \rightarrow L_3$	$L_3 \rightarrow L_4$	$L_4 \rightarrow L_6$
Group 4	$L_4 \rightarrow L_4$	$L_4 \rightarrow L_3$	
Group 5	$L_6 \rightarrow L_5$	$L_6 \rightarrow L_7$	
Group 6	$L_7 \rightarrow L_7$	$L_7 \rightarrow L_6$	

Table 3. shows the Fuzzy Logical Relationship Groups formed.

Fourth step: Determining the weight of fluctuations for each FLR in the FLR group with the equation:

$$w_{L_i \rightarrow L_j} = \sum_{i=0}^{f(L_i \rightarrow L_j)} i \quad (3)$$

Information:

$w_{L_i \rightarrow L_j}$: weight vector element for FLR

$f(L_i \rightarrow L_j)$: frequency of occurrence $L_i \rightarrow L_j$

i : order of occurrence$L_i \rightarrow L_j$

The sum of the weights of each FLR must be standardized to obtain a column vector.

$$\left[\frac{W_1}{\sum_{i=1}^{k} W_i}, \frac{W_2}{\sum_{i=1}^{k} W_i}, \dots, \frac{W_k}{\sum_{i=1}^{k} W_i}\right] = [W_1^*, W_2^*, \dots, W_k^*] = \boldsymbol{w_t} \quad (4)$$

where:

t : $1, \dots, n \; dan \; i = 1, \dots, k$

$\boldsymbol{w_t}$: size weight vector (1 x k) for L_i at time t

The fifth step: Calculating the center of the distribution of linguistic values, with the equation:

$$\boldsymbol{v_t} = [v_1, v_{2,} \dots, v_k] \text{ dengan } v_i = \frac{\sum_{t=1}^{n} u_{it} x_t}{\sum_{t=1} u_{it}} \quad (5)$$

where:

$\boldsymbol{v_t}$: vector size $(1 \times k)$ at time t

v_i : center of distribution of linguistic values L_i

u_{it} : linguistic value membership function L_i

x_t : observation value

The linguistic distribution center vector is v_t, generated by each linguist.

Sixth step: After that, it goes into the defuzzification process, were in the fourth and fifth steps that, the weighted vector and the center vector of the distribution of linguistic values are obtained, and the two vectors are multiplied to get the initial estimate. The defuzzification process is defined by the equation:

$$Forecast_{t+1} = \boldsymbol{v_t w'_t}, \qquad t = 1, \dots, n \quad (6)$$

where:

$Forecast_{t+1}$: forecasting at time $t+1$

$\boldsymbol{v_t}$: vector row $(1 \times k)$ at time t

$\boldsymbol{w'_t}$: column vector $(k \times 1)$ at time t

The seventh step: Using the Fibonacci equation to obtain a conclusive forecasting result using two linear parameters and, the Fibonacci forecasting equation is

$$Fibonacci_{forecast_{t+1}} = P_t + \alpha(Forecast_{t+1} - P_t) + \beta(Forecast_t - P_{t-1}) \quad (7)$$

[16]

where:

P_t : t -th actual value

P_{t-1} : actual value to-$(t-1)$

$Forecast_t$: t -th forecast

$Forecast_{t+1}$: forecast-$(t+1)$

Forecasting Model Accuracy Measure

The assessment of the accuracy of the forecasting results in this study uses the Mean Absolute Percentage Error (MAPE).

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{X_t - \bar{X}_t}{X_t}\right| x\ 100\% \quad (8)$$

where:
n : many observations
X_t : t-th actual value
$\bar{X}_t$: t-th forecasting value

3. RESULTS AND DISCUSSION

Data Description

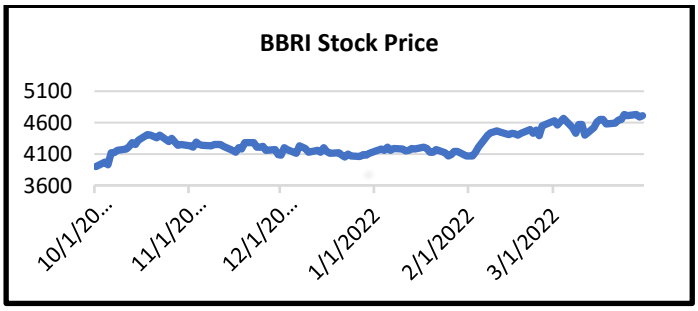

Figure 1. BBRI stock price chart

The graph in Figure 1 is the stock price graph of PT. Bank Rakyat Indonesia Tbk (BBRI) in the period from October 1, 2021 to March 31, 2022 as for the complete data can be seen in Appendix 1. Based on the graph data, it can be known that the lowest share price is Rp. 3900 and the highest share price is Rp. 4730. From the pattern of the chart, BBRI stock price data tend to have data that is horizontal or trend with a distance or range of 830 and an average or mean value of Rp. 4285.76.

Chart Analysis with *Fibonacci Retracement*

Figure 2. *Fibonacci retracement* levels of BBRI stock chart

Figure 2 shows the *retracement level* of BBRI stock is 23.6%, then 38.2%, 50%, and then followed by 61.8%.

Formation of the universe of *discourse*

It is obtained from the data that $D_{min} = 3900$and $D_{max} = 4730$ then the set of universes formed

$$U = [D_{min}\,; D_{max}]$$
$$= [3900\,;\ 4730]$$

Formation of the effective interval using the average basis

The formation of the active interval is calculated by finding the average difference in the data. That is equal to 45.85 ($n = 125$). Then the number of intervals obtained is 41 with an interval length equal to 20.

Table 4. Effective interval formed

Interval(u_i)	Linguistics(L_i)
u_1	$[3900, 3920]$
u_2	$[3920, 3940]$
u_3	$[3940, 3960]$
⋮	⋮
u_{39}	$[4680, 4700]$
u_{40}	$[4700, 4720]$
u_{41}	$[4720, 4740]$

Table 4 shows that the formation of the active interval calculated by finding the average difference of the data, which is 45.85 (n=125). The value of 45.88 is divided by two to get 22.94, based on Table 1, then the interval base used is 20. Then the value of 22.94 is rounded based on the base so that the value of 20 is obtained as the effective interval length, then determine the number of intervals by calculating the result of dividing the range by the interval. The value of 4730 (maximum value) minus 3900 (minimum value) is 830. After that, 830 is divided by 20 and the value is 41.5. The number of intervals must be an odd number, so it is rounded to 41.

Fuzzification process

The fuzzification stage based on the effective interval obtained can be determined by the linguistic value with the number of intervals formed. From each of these interval classes, a fuzzy linguistic set will be defined L_i, with $1 \leq i \leq 41$. The results of the fuzzification of BBRI shares are presented in Table 5.

Table 5. BBRI Stock Fuzzification

No	Date	Stock price	FZ
1	01/10/2021	3900	L_1
2	04/10/2021	3970	L_4
3	05/10/2021	3930	L_2
⋮	⋮	⋮	⋮
123	29/03/2022	4690	L_{40}
124	30/03/2022	4720	L_{41}
125	31/03/2022	4660	L_{38}

The results of the fuzzification of BBRI stock for 01/10/2021 is defined to L_1 because data will enter into a linguistic value that has a membership degree value equal to 1 which indicates the true value.

Formation of fuzzy logic relationship

The formation of fuzzy logic relationship (FLR) and FLR Group is identified based on fuzzified historical data previously.

Table 6. FLR

No	Date	FLR
1	01/10/2021	-
2	04/10/2021	$L_1 \rightarrow L_4$
3	05/10/2021	$L_4 \rightarrow L_2$
⋮	⋮	⋮
123	29/03/2022	$L_{41} \rightarrow L_{40}$
124	30/03/2022	$L_{40} \rightarrow L_{41}$
125	31/03/2022	$L_{41} \rightarrow L_{38}$

In Table 6, fuzzy logic relationship or FLR is formed based on present historical data $F(t-1)$ with historical data of the present $F(t)$.

Forming FLRG and weighting

FLRG is done by fuzzy grouping sets that have the same current state and then grouping them into one group in the next state.

Table 7. FLRG and weighting

Linguistics	FLRG		Frequency	Weight	$\sum_{i=1}^{k} w_i$
	Current State	*Next State*			
L_1	L_1	L_4	1	1	1
L_2	L_2	L_{11}	1	1	1
L_4	L_4	L_2	1	1	1
⋮	⋮	⋮	⋮	⋮	⋮
L_{39}	L_{39}	L_{31}	1	1	1
L_{40}	L_{40}	L_{41}	1	1	1
L_{41}	L_{41}	L_{40}	1	1	5
	L_{41}	L_{41}	2	3	
	L_{41}	L_{38}	1	1	

Table 7 presents all FLR groups forming a vector generated FLRG of dimension 41 for each linguistic. Each FLR in the same FLRG must be given a weight, and the weighting can increase the accuracy of the forecast.

Table 8. Vector weighted each linguistic

w_t for	L_1	$w_1 = 1, w_2 = 0, w_3 = 0, \ldots, w_{41} = 0$
	L_2	$w_1 = 0, \ldots, w_{10} = 0, w_{11} = 1, w_{12} = 0, \ldots, w_{41} = 0$
	L_3	$w_1 = 0, w_2 = 0, w_3 = 0, \ldots, w_{41} = 0$
	⋮	⋮
	L_{40}	$w_1 = 0, w_2 = 0, w_3 = 0, \ldots, w_{40} = 0, w_{41} = 1$
	L_{41}	$w_1 = 0, \ldots, w_{37} = 0, w_{38} = \frac{1}{5}, w_{39} = 0, w_{40} = \frac{1}{5}, w_{41} = \frac{3}{5}$

The sum of the weights of each FLR must be standardized to obtain a weighted vector. In summary, the weighted vectors are presented in **Table 8**.

In the next step, after the weighted vector is formed for each linguistic value from the observations, the linguistic distribution center value is calculated.

Table 9. Calculation of linguistic distribution center

Linguistics	t	Data	v_i
L_1	1	3900	$v_1 = 3900$
L_2	3	3930	$v_2 = 3930$
⋮	⋮	⋮	⋮
Linguistics	t	**Data**	v_i
	120	4730	
	121	4710	
L_{41}	122	4730	$v_{41} = 4708$
	124	4710	
	125	4660	

The central vector of linguistic distribution v_t can be generated by any linguistic value. In **Table 9**, it can be seen that the observation value of the linguistic value membership function L_i divided by the number of observations, then the center of the distribution of L_i with $1 \leq i \leq 41$ will be obtained.

Defuzzification of BRI's stock price

Defuzzification serves to change the fuzzy output into a firm value based on a representatively determined membership function. The result of defuzzification is obtained by multiplying the weighted vector with the center vector of the linguistic distribution. The formation of the active interval is calculated by finding the average of the data differences. The number of intervals must be an odd number, then rounded to 41. **Table 10** shows the intervals formed on observations with interval lengths equal to 20.

Table 10. FLRG defuzzification results of BBRI stock data

Current State	Forecasted
L_1	3900
L_2	4115.71
L_3	-
L_4	3930
⋮	⋮
L_{39}	4520
L_{40}	4720
L_{41}	4692.8

After getting the results of the defuzzification fuzzy time series forecasting value, calculated Fibonacci forecast value using equation $Fibonacci_{forecast_{t+1}} = P_t + \alpha(Forecast_{t+1} - P_t) + \beta(Forecast_t - P_{t-1})$ with two linear parameters, $\alpha = 0.1$ and $\beta = -0.1$, as the proposed model can adjust the forecasting result by allowing minimum error. The results of *forecasting fuzzy time series and Fibonacci are* presented in **Table 11.**

Table 11. BBRI stock price forecasting results

Date	FTS	FTS *Trends*	Fibo	Fibo *Trends*
01/10/2021	-	-	-	-
04/10/2021	3900	-	-	-
05/10/2021	3930	go on	3966	-

Date	FTS	FTS *Trends*	Fibo	Fibo *Trends*
06/10/2021	4115.71	go on	3952.57	down
⋮	⋮	⋮	⋮	⋮
30/03/2022	4720	go on	4694.75	down
31/03/2022	4692.8	down	4705,28	go on
01/04/2022	4647.77	down	4660.49	down

Table 11 shows the results of forecasting using fuzzy time series and Fibonacci forecast of BBRI's stock price. After going through the process of FLRG and weighting and obtained the result of forecasting the price of BBRI shares for the next period, which is the period of April 1, 2022 amounting to 4660.46 in Rupiah exchange rate. As for the actual price of BBRI shares in the period of April 1, it is Rp. 4730.

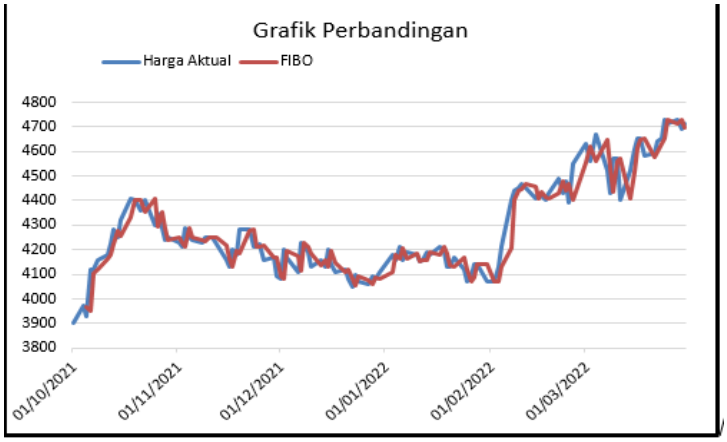

Figure 3. Comparison graph of actual and forecasting value

Furthermore, from the prediction, a comparison chart was obtained between the BBRI stock price data or the actual data with the data of the prediction using the Fibonacci method. In **Figure 3**, it can be seen that the forecasting data pattern fluctuates following the actual data pattern.

Calculating MAPE

The purpose of calculating the MAPE value (mean absolute percentage) is to determine the level of accuracy in forecasting by measuring the accuracy of forecasting results. The level of accuracy of forecasting results against actual data is presented in **Table 12.**

Table 12. MAPE value of BBRI stock forecasting results

Date	Actual Price	FTS	Fibo	Absolute Error Percentage (Fibo)
01/10/2021	3900	-	-	-
04/10/2021	3970	3900	-	-
05/10/2021	3930	3930	3966	0.916030534
⋮	⋮	⋮	⋮	⋮
30/03/2022	4710	4720	4694.75	0.323779193
31/03/2022	4660	4692.8	4705.28	0.97167382
MAPE				1.034146099

In principle, forecasting is done by comparing the results of forecasting with the reality that happened. In the forecasting process with the level of forecasting, there is an error size that indicates the accuracy of the model. One of the most commonly used error measures is MAPE. Then, based on the data in **Table 12**, the MAPE value for Fibonacci is 1.034%.

4. CONCLUSIONS

Based on the results of the analysis and discussion of the research that has been done, several conclusions were obtained. The following are some conclusions from this study.

1. BBRI stock price analysis using Fibonacci retracement results in support levels at 23.6% and 38.2%, and if the 100% or 78.6% level can be passed, the stock has the potential to trend.
2. From the results of forecasting using fuzzy time series with Fibonacci forecasts in BBRI stock price research for the period October 1, 2021, to March 31, 2022, the result of the forecasting value on April 1, 2022 is Rp. 4660.49. This forecasting has a Mean Absolute Percentage Error or MAPE forecasting accuracy of 1.034%.

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