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Fuzzy Time Series Analysis for Stock Sales Forecasting

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ABSTRACT

Investing is often considered one of the ways to generate profits by allocating funds to a place or company with the aim of gaining profits and avoiding inflation in the future. Among the many types of investments, investing in stocks is one of the popular ones. However, investing in the stock market is not easy because it is considered very risky due to the fluctuating prices of shares. The unstable movement of share prices is an important indicator for investors in determining whether they will sell, hold, or buy certain shares. Therefore, a method is needed to forecast the movement of share prices. This research aims to implement the fuzzy time series method for forecasting stock sales to support efficient decision-making. Using historical data on stock sales at PT. Bank Mandiri (Persero) from January 2, 2024, to October 4, 2024. The results of the study show that the application of the fuzzy time series method produces a forecast of stock price sales with a fairly high accuracy, with an accuracy of 98.7261%, and an MAPE error rate of only 1.2739% of the 180 data tested. This study shows that the forecasting model applied is able to provide an optimal picture of the relevant trends in the movement of stock sales, so it can be used to help make strategic decisions, thus it can be a reference for investors, especially in the stock field, to minimize risk in making decisions before investing.

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1. INTRODUCTION

Investment is the allocation of a certain amount of funds or resources at present with the aim of gaining profits in the future for investors, as well as protecting the value of assets from the effects of inflation. Investments can be divided into two main categories: real assets, such as property, land, and precious metals, and securities, including bonds, mutual funds, stocks, and other financial instruments regulated by supervisory authorities. One of the popular types of investment is stock investment [1].

According to the Indonesia Stock Exchange (IDX), stocks represent an individual's or entity's capital ownership in a company or limited liability corporation. By owning stocks, the party has rights to the company's income and assets and the right to attend the General Meeting of Shareholders (GMS). As shareholders, investors become part of the company [2].

Since stock prices can fluctuate daily, many consider them a high-risk investment. The volatility of stock prices reflects market conditions at any given time, providing crucial insights for investors in deciding whether to sell, hold, or purchase certain stocks. Therefore, methods to forecast stock price movements are necessary. Stock price data is typically presented in the form of time series, making time series methods commonly used in stock price forecasting [3][4].

A previous study conducted by Andres and Erlin in 2022, successfully implemented Fuzzy Time Series (FTS) to predict flour sales at UD. Citra Pekanbaru. Using sample data obtained from the research object

and the FTS Chen method for forecasting, the study concluded that the accuracy rate reached 88.4%, which is considered good for forecasting purposes [5]. Study conducted by Kumar and Kumar in 2022. This research focused on developing a hybrid FTS model that utilized modified clustering techniques to enhance the accuracy of COVID-19 case and death predictions in India. The study found that the proposed model achieved an accuracy rate of 92.5%, demonstrating its effectiveness in forecasting complex time series data during the pandemic [6].

Pant and Kumar in 2022 explored in a study aimed to improve the forecasting accuracy of time series data by integrating particle swarm optimization with intuitionistic fuzzy sets. The researchers reported that their proposed method achieved an accuracy rate of 90.3%, indicating a significant enhancement over traditional FTS methods [7]. Dixit and Jain in 2023 presented an article titled "Intuitionistic FTS forecasting method for non-stationary time series data with suitable number of clusters and different window size for fuzzy rule generation." This research focused on developing a forecasting method tailored for non-stationary time series data. The findings revealed that their method achieved an accuracy of 89.7%, showcasing its applicability in handling varying data patterns effectively [8]. Hariyanto in 2023 published a study called "Average-Based FTS Markov Chain Based on Frequency Density Partitioning." This research investigated the application of a fuzzy time series Markov chain model to forecast time series data. The study concluded that the model attained an accuracy of 91.2%, highlighting its robustness in predicting future values based on historical data [9].

This study aims to replicate the previous research by employing the FTS method but with different research objects and calculation variables. In this research, the object is stock trading at PT Bank Mandiri (Persero), and the variables used include the daily closing price of stock sales and the stock trading volume on the respective days. PT Bank Mandiri (Persero) Tbk is an Indonesia-based company primarily engaged in the banking sector. The company operates under the name Bank Mandiri. Its products include savings, checking accounts, and deposits. The company also offers various loans, such as mortgage loans, working capital loans, and investment loans.

This research is expected to make a significant contribution, particularly in developing an effective forecasting method with better accuracy. The results of this study are also expected to serve as a valuable tool that can be used by stakeholders in the investment field, particularly in stocks, as a reference or basis for making accurate and wise decisions to avoid future losses [10].

2. RESEARCH METHOD

Research methods are a conceptual framework serves as the foundation for designing, implementing, and evaluating research. It helps researchers formulate research questions, identify relevant variables, design research methodologies, and map out the flow of data analysis. In this study, the researcher uses the following research framework:

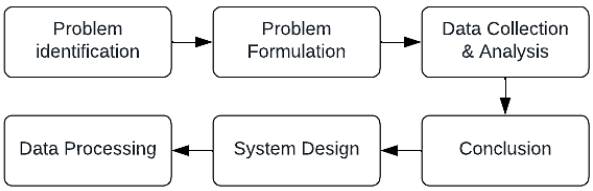

Figure 1. Research Framework

From Figure 1, we can observe several steps in the research process, starting with the first step, which is problem identification, the process of problem identification involves recognizing and understanding the challenges faced in a given situation, which is crucial for determining the root causes and establishing steps to address them. In the case of stock sales at PT. Bank Mandiri (Persero), the identified issue is the instability and fluctuations in stock prices, posing significant risks to investors. Forecasting can serve as a critical guide for investors in deciding whether to sell, hold, or buy specific stocks. The next step is problem formulation, which helps structure the identified issues to facilitate finding solutions. Data on stock sales were obtained from Google's Kaggle database and analyzed to identify relevant variables for data processing. After analysis, the data was processed and tested using the FTS method to forecast future stock price movements at PT. Bank Mandiri (Persero), utilizing Matlab for processing. System design was carried out prior to problem-solving, involving the development of a flowchart to guide the system built for data processing and forecasting.

Conclusions were drawn based on the test results, with the expectation that the study could serve as a valuable reference for future research and as guidance for individuals interested in investing in PT. Bank Mandiri (Persero).

2.1. Stock

According to the journal article by Anisa Putri and Budi Hartono in 2020, stocks are defined as financial instruments representing an individual's or entity's ownership of a portion of a company's assets and profits. Shareholders have the right to receive dividends and participate in the General Meeting of Shareholders (GMS). The value of stocks can be influenced by various factors, such as the company's financial performance, economic conditions, and market sentiment [11]. Stocks is securities representing ownership of a portion of a company. Shareholders are entitled to a share of the company's profits and can enjoy capital gains if stock prices increase. Stock prices tend to fluctuate based on company performance, economic news, and changes in government policies [12].

Stocks defined as units of ownership in a company that grant their holders the right to receive a portion of the company's profits in the form of dividends and voting rights in strategic decision-making processes. Stock prices are influenced by various factors, including corporate governance, financial performance, and both domestic and international market conditions [13].

2.2. Investment

Investment defined as the process of allocating resources, particularly money, into various instruments or assets with the expectation of generating future returns. In the context of the stock market, investment involves purchasing company shares with the anticipation of stock value appreciation and dividend income [14]. Investment is the activity of capital allocation in the form of physical or financial assets aimed at increasing production capacity and generating future returns. Investment plays a crucial role in economic growth by enhancing capital accumulation and productivity. Investment is defined as any form of capital allocation aimed at generating future profits. This includes foreign direct investment (FDI), where foreign investors bring capital, technology, and managerial expertise into local economies, as well as domestic investment by local entities[15].

2.3. Fuzzy Logic

Fuzzy Logic is a field of study that deals with uncertainty. Without disregarding existing factors, Fuzzy Logic is considered capable of mapping an input into an output. It is regarded as highly flexible and tolerant of the available data. Fuzzy Logic is an enhancement of Boolean logic that addresses the concept of partial truth. While classical logic asserts that everything can be defined in binary terms (0 or 1, black or white, yes or no), Fuzzy Logic replaces Boolean truth values with degrees of truth [16].

Fuzzy logic is a mathematical framework for dealing with uncertainty and imprecision, extending classical binary logic to handle the concept of partial truth. Introduced by Lotfi Zadeh in 1965, fuzzy logic allows for reasoning that is not strictly true or false but can take on a continuum of values between these extremes. This capability makes fuzzy logic particularly valuable in applications where human reasoning and decision-making processes are involved, such as control systems, artificial intelligence, and data analysis. In recent years, fuzzy logic has been increasingly applied in various domains, including engineering, economics, and environmental science, due to its ability to model complex systems and manage imprecise information. For instance, a study by Castillo et al. (2022) highlights the use of interval type-3 fuzzy logic in forecasting COVID-19 cases, demonstrating the framework's adaptability and effectiveness in handling real-world uncertainties [17]. Furthermore, Pant and Kumar (2021) explored the integration of particle swarm optimization with intuitionistic fuzzy sets to enhance forecasting accuracy, showcasing the ongoing evolution of fuzzy logic applications in predictive analytics [7]. The versatility of fuzzy logic continues to inspire innovative methodologies across diverse fields, making it an essential tool for researchers and practitioners alike.

2.4. Fuzzy Time Series

Fuzzy Time Series is a method used to predict time series data by applying fuzzy logic theory. This method is particularly useful when the data to be predicted lacks a clear pattern and contains uncertainty or vagueness. Fuzzy theory enables the representation of uncertain data in the form of fuzzy sets, which can handle both qualitative and quantitative data effectively[18][19].

Fuzzy time series is an extension of fuzzy logic that specifically addresses the challenges of forecasting in time series data. This approach incorporates fuzzy logic principles to manage uncertainty in temporal data, allowing for more accurate predictions in scenarios where traditional statistical methods may be inadequate. The foundational work on fuzzy time series was established by Song and Chissom, who introduced a framework that utilizes fuzzy sets to represent and analyze time series data. Recent advancements in this field have led to the development of novel methodologies that enhance the forecasting capabilities of fuzzy time series models. For example, Kumar and Kumar (2022) proposed a hybrid fuzzy time series model that employs modified clustering techniques to predict COVID-19 cases and deaths in India, demonstrating the model's

effectiveness in complex forecasting scenarios [6]. Additionally, research by Dixit and Jain (2023) introduced an intuitionistic fuzzy time series forecasting method tailored for non-stationary data, further illustrating the adaptability of fuzzy time series approaches (Bas, 2024). The integration of fuzzy logic with other techniques, such as Markov chains and clustering algorithms, continues to advance the field, enabling more robust and accurate forecasting solutions across various domains, including economics and environmental monitoring [17][18].

The sales forecasting system developed in this study utilizes the Fuzzy Time Series method combined with data visualization to calculate forecast values. The process begins with historical data from previous periods, which serves as the basis for predicting the sales price for the following day. This involves determining the number and length of intervals. Once the interval lengths are calculated, the process moves to the Fuzzification stage. At this stage, fuzzy logical relationships are identified and grouped to derive forecast data. Finally, the process concludes with Defuzzification to produce the final forecast results [21]. Fuzzy Time Series Flowchart is shown in Figure 2.

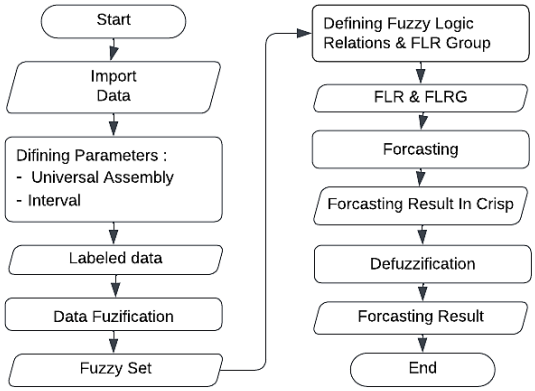

Figure 2. Fuzzy Time Series Flowchart

Based on Figure 2, we can see that fuzzy time series consists of several stages, namely:

1. Define Universal set

   Determining the universal set is carried out for all variables to be used. The universal set can be determined using the formula 1.

$$U\ Price = [\min price \max price] \tag{1}$$

   Where the max and min values can be found using the formula 2.

$$\min price = \min(open) - 1 \tag{2}$$
$$\max price = \max(open) + 1 \tag{3}$$

2. Define Intervals

   Defining the intervals is carried out for all variables to be used. The data will be divided into 15 intervals, with the length of each interval calculated using the following formula 3.

$$Interval\ Length\ (Price) = \frac{\max price - \min price}{Number\ of\ Interval} \tag{4}$$

3. Define a Fuzzy Set

   At this stage, after the data is divided into several intervals, each interval is defined with its fuzzy set.

4. Fuzzification

   This process involves assigning each data point to a fuzzy set according to its interval.

5. Forming Fuzzy Logic Relationship

   After defining the fuzzy sets, the next step is to establish relationships between the fuzzy sets.

6. Forming Fuzzy Logic Relationsip Group

   After determining the relationships between variables, the next step is to group these relationships into several groups, where the number of groups depends on the number of intervals created for the data.

7. Forcasting and Defuzzification

   The next step is forecasting and defuzzification, which is the process in a fuzzy logic system used to convert fuzzy values (produced by the fuzzy system) into comprehensible values. In this process, the midpoint interval method is used, which can be calculated using the following formula 5.

$$\frac{Upper\ limit + lower\ limit}{2} \tag{5}$$

3. RESULTS AND ANALYSIS

The data used in this study consists of stock sales data covering 180 days dataset of stock transactions at PT Bank Mandiri (Persero), spanning from January 2, 2024, to October 4, 2024. This data was retrieved on October 5, 2025, from the Kaggle platform. The dataset includes three variables: Date, Daily Opening Price, and Sales Volume. This data was analyzed using the Fuzzy Time Series Algorithm to forecast stock sales at PT Bank Mandiri (Persero). The analysis aims to understand the key factors influencing stock sales and provide valuable insights as a reference for investors before making investment decisions.

The implementation of the Fuzzy Time Series (FTS) method in this research will be described in the form of manual calculations. The manual calculation process using the FTS method in this research will use data on 60 day dataset of sale from September to Oktober 2024, namely as presented in Table 1.

Table 1. Bank Mandiri Stock Sales Data from September to October 2024

No.	Date	Open Price	Volume	No.	Date	Open Price	Volume
1	12/07/2024	6450	136132200	31	23/08/2024	7000	111752100
2	15/07/2024	6450	66071800	32	26/08/2024	7050	78515400
3	16/07/2024	6400	64687900	33	27/08/2024	7025	91686700
4	17/07/2024	6450	109729800	34	28/08/2024	7025	114606200
5	18/07/2024	6550	132532000	35	29/08/2024	7300	94475900
6	19/07/2024	6500	63165500	36	30/08/2024	7100	153760500
7	22/07/2024	6575	110467000	37	02/09/2024	7200.0	82176000
8	23/07/2024	6750	77861700	38	03/09/2024	7200.0	75100800
9	24/07/2024	6500	63940900	39	04/09/2024	7000.0	78789800
10	25/07/2024	6450	66655400	40	05/09/2024	7125.0	59432000
11	26/07/2024	6575	76519500	41	06/09/2024	7175.0	63619300
12	29/07/2024	6550	54435300	42	09/09/2024	7250.0	71430300
13	30/07/2024	6475	86701400	43	10/09/2024	7250.0	73515700
14	31/07/2024	6400	99004100	44	11/09/2024	7300.0	91822300
15	01/08/2024	6550	163086200	45	12/09/2024	7375.0	68254300
16	02/08/2024	6700	167892400	46	13/09/2024	7300.0	45854000
17	05/08/2024	6700	184384000	47	17/09/2024	7325.0	96428000
18	06/08/2024	6650	95785000	48	18/09/2024	7375.0	47279200
19	07/08/2024	6725	84582200	49	19/09/2024	7450.0	1,24E+08
20	08/08/2024	6800	81408500	50	20/09/2024	7400.0	97901700
21	09/08/2024	6825	79710700	51	23/09/2024	7325.0	79675600
22	12/08/2024	6875	50756000	52	24/09/2024	7400.0	81817100
23	13/08/2024	6850	68666000	53	25/09/2024	7350.0	1,92E+08
24	14/08/2024	7075	97695100	54	26/09/2024	7175.0	1,73E+08
25	15/08/2024	7075	75955500	55	27/09/2024	7025.0	1,61E+08
26	16/08/2024	7075	64266400	56	30/09/2024	7000.0	1,66E+08
27	19/08/2024	7075	50246100	57	01/10/2024	7000.0	82690100
28	20/08/2024	7200	102615900	58	02/10/2024	7025.0	91076400
29	21/08/2024	7300	88487800	59	03/10/2024	7000.0	86264900
30	22/08/2024	7150	157323000	60	04/10/2024	7025.0	79485300

3.1. Define Universal set

Determining the universal set is carried out for all variables to be used. In this study, two variables are utilized, namely, open price and volume. Based on the formula explained above, the universal set for the variable open price is [6399 7451], and for the variable volume is [45853999 770252401].

3.2. Define Intervals

The next step is to define the intervals for each variable. After calculating using the formula explained earlier, the interval length for the variable open price is 70,133, and for the variable volume, it is 9,756,206.8.

3.3. Define a Fuzzy Set

After the data is divided into several intervals, in this case into 15 intervals, each interval is then defined with its fuzzy set, and the upper and lower bounds of each interval are displayed, as shown in Table 2.

Table 2. Interval Definition Results

Interval		Fuzzy Set	Interval		Fuzzy Set
Upper limit	Lower limit		Upper limit	Lower limit	
6399	6469.1	P1	45854000	55610000	V1
6469.1	6539.3	P2	55610000	65366000	V2
6539.3	6609.4	P3	65366000	75123000	V3
6609.4	6679.5	P4	75123000	84879000	V4
6679.5	6749.7	P5	84879000	94635000	V5
6749.7	6819.8	P6	94635000	104390000	V6
6819.8	6889.9	P7	104390000	114150000	V7
6889.9	6960.1	P8	114150000	123900000	V8
6960.1	7030.2	P9	123900000	133660000	V9
7030.2	7100.3	P10	133660000	143420000	V10
7100.3	7170.5	P11	143420000	153170000	V11
7170.5	7240.6	P12	153170000	162930000	V12
7240.6	7310.7	P13	162930000	172680000	V13
7310.7	7380.9	P14	172680000	182440000	V14
7380.9	7451	P15	182440000	192200000	V15

3.4. Fuzzification

After defining the fuzzy sets, the next step is the fuzzification process, which involves assigning each data point to its corresponding fuzzy set based on the defined intervals for each variable, as shown in Table 3.

Table 3. Fuzzification Results

No.	Date	Open Price	Volume	No.	Date	Open Price	Volume
1	12/07/2024	P1	V10	31	23/08/2024	P9	V7
2	15/07/2024	P1	V3	32	26/08/2024	P10	V4
3	16/07/2024	P1	V2	33	27/08/2024	P9	V5
4	17/07/2024	P1	V7	34	28/08/2024	P9	V8
5	18/07/2024	P3	V9	35	29/08/2024	P13	V5
6	19/07/2024	P2	V2	36	30/08/2024	P10	V12
7	22/07/2024	P3	V7	37	02/09/2024	P12	V4
8	23/07/2024	P6	V4	38	03/09/2024	P12	V3
9	24/07/2024	P2	V2	39	04/09/2024	P9	V4
10	25/07/2024	P1	V3	40	05/09/2024	P11	V2
11	26/07/2024	P3	V4	41	06/09/2024	P12	V2
12	29/07/2024	P3	V1	42	09/09/2024	P13	V3
13	30/07/2024	P2	V5	43	10/09/2024	P13	V3
14	31/07/2024	P1	V6	44	11/09/2024	P13	V5
15	01/08/2024	P3	V13	45	12/09/2024	P14	V3
16	02/08/2024	P5	V13	46	13/09/2024	P13	V1
17	05/08/2024	P5	V15	47	17/09/2024	P14	V6
18	06/08/2024	P4	V6	48	18/09/2024	P14	V1
19	07/08/2024	P5	V4	49	19/09/2024	P15	V9
20	08/08/2024	P6	V4	50	20/09/2024	P15	V6
21	09/08/2024	P7	V4	51	23/09/2024	P14	V4
22	12/08/2024	P7	V1	52	24/09/2024	P15	V4
23	13/08/2024	P7	V3	53	25/09/2024	P14	V15
24	14/08/2024	P10	V6	54	26/09/2024	P12	V14
25	15/08/2024	P10	V4	55	27/09/2024	P9	V12
26	16/08/2024	P10	V2	56	30/09/2024	P9	V13
27	19/08/2024	P10	V1	57	01/10/2024	P9	V4
28	20/08/2024	P12	V6	58	02/10/2024	P9	V5
29	21/08/2024	P13	V5	59	03/10/2024	P9	V5
30	22/08/2024	P11	V12	60	04/10/2024	P9	V4

3.5. Forming Fuzzy Logic Relationship

After defining the fuzzy sets, the next step is to establish relationships between these fuzzy sets, commonly referred to as Fuzzy Logical Relationships (FLR). By connecting the fuzzy sets of adjacent data or dates, as shown in Table 4.

Table 4. Fuzzy Logical Relationships (FLR)

Date	FLR (price)	FLR (volume)	Date	FLR (price)	FLR (volume)
12/07/2024 → 15/07/2024	P1 → P1	V10 → V3	23/08/2024 → 26/08/2024	P10 → P9	V4 → V5

Date	FLR (price)	FLR (volume)	Date	FLR (price)	FLR (volume)
15/07/2024 → 16/07/2024	P1 → P1	V3 → V2	26/08/2024 → 27/08/2024	P9 → P9	V5 → V8
16/07/2024 → 17/07/2024	P1 → P1	V2 → V7	27/08/2024 → 28/08/2024	P9 → P13	V8 → V5
17/07/2024 → 18/07/2024	P1 → P3	V7 → V9	28/08/2024 → 29/08/2024	P13 → P10	V5 → V12
18/07/2024 → 19/07/2024	P3 → P2	V9 → V2	29/08/2024 → 30/08/2024	P10 → P12	V12 → V4
19/07/2024 → 22/07/2024	P2 → P3	V2 → V7	30/08/2024 → 02/09/2024	P12 → P12	V4 → V3
22/07/2024 → 23/07/2024	P3 → P6	V7 → V4	02/09/2024 → 03/09/2024	P12 → P9	V3 → V4
23/07/2024 → 24/07/2024	P6 → P2	V4 → V2	03/09/2024 → 04/09/2024	P9 → P11	V4 → V2
24/07/2024 → 25/07/2024	P2 → P1	V2 → V3	04/09/2024 → 05/09/2024	P11 → P12	V2 → V2
25/07/2024 → 26/07/2024	P1 → P3	V3 → V4	05/09/2024 → 06/09/2024	P12 → P13	V2 → V3
26/07/2024 → 29/07/2024	P3 → P3	V4 → V1	06/09/2024 → 09/09/2024	P13 → P13	V3 → V3
29/07/2024 → 30/07/2024	P3 → P2	V1 → V5	09/09/2024 → 10/09/2024	P13 → P13	V3 → V5
30/07/2024 → 31/07/2024	P2 → P1	V5 → V6	10/09/2024 → 11/09/2024	P13 → P14	V5 → V3
31/07/2024 → 01/08/2024	P1 → P3	V6 → V13	11/09/2024 → 12/09/2024	P14 → P13	V3 → V1
01/08/2024 → 02/08/2024	P3 → P5	V13 → V13	12/09/2024 → 13/09/2024	P13 → P14	V1 → V6
02/08/2024 → 05/08/2024	P5 → P5	V13 → V15	13/09/2024 → 17/09/2024	P14 → P14	V6 → V1
05/08/2024 → 06/08/2024	P5 → P4	V15 → V6	17/09/2024 → 18/09/2024	P14 → P15	V1 → V9
06/08/2024 → 07/08/2024	P4 → P5	V6 → V4	18/09/2024 → 19/09/2024	P15 → P15	V9 → V6
07/08/2024 → 08/08/2024	P5 → P6	V4 → V4	19/09/2024 → 20/09/2024	P15 → P14	V6 → V4
08/08/2024 → 09/08/2024	P6 → P7	V4 → V1	20/09/2024 → 23/09/2024	P14 → P15	V4 → V4
09/08/2024 → 12/08/2024	P7 → P7	V1 → V3	23/09/2024 → 24/09/2024	P15 → P14	V4 → V15
12/08/2024 → 13/08/2024	P7 → P7	V3 → V6	24/09/2024 → 25/09/2024	P14 → P12	V15 → V14
13/08/2024 → 14/08/2024	P7 → P10	V6 → V4	25/09/2024 → 26/09/2024	P12 → P9	V14 → V12
14/08/2024 → 15/08/2024	P10 → P10	V4 → V2	26/09/2024 → 27/09/2024	P9 → P9	V12 → V13
15/08/2024 → 16/08/2024	P10 → P10	V2 → V1	27/09/2024 → 30/09/2024	P9 → P9	V13 → V4
16/08/2024 → 19/08/2024	P10 → P12	V1 → V6	30/09/2024 → 01/10/2024	P9 → P9	V4 → V5
19/08/2024 → 20/08/2024	P12 → P13	V6 → V5	01/10/2024 → 02/10/2024	P9 → P9	V5 → V5
20/08/2024 → 21/08/2024	P13 → P11	V5 → V12	02/10/2024 → 03/10/2024	P1 → P1	V5 → V4
21/08/2024 → 22/08/2024	P11 → P9	V12 → V7	03/10/2024 → 04/10/2024	P1 → P1	V10 → V3
22/08/2024 → 23/08/2024	P9 → P10	V7 → V4	-	-	-

3.6. Forming Fuzzy Logic Relationsip Group

After identifying the relationships between variables, the next step is to group these relationships into several groups. The number of groups depends on the number of intervals created for the data. Each group contains or indicates the possible connections between the fuzzy sets, as shown in Table 5.

Table 5. FLRG

Group	FLR	Group	FLR
1	P1 → 1,1,1,3,3,3	9	P9 → 10,9,13,11,9,9,9,9,9
2	P2 → 3,1,1	10	P10 → 10,10,10,12,9,12
3	P3 → 2,6,3,2,5	11	P11 → 9,12
4	P4 → 5	12	P12 → 13,12,9,13,9
5	P5 → 5,4,6	13	P13 → 11,10,13,13,14,14
6	P6 → 2,7	14	P14 → 13,14,15,15,12
7	P7 → 7,7,10	15	P15 → 15,14,14
8	P8 →	-	-

3.7. Forcasting and Defuzzification

The next step is to perform forecasting and the defuzzification process. By finding the midpoint of each fuzzy set interval within the FLRG, then summing these midpoints and dividing by the number of fuzzy sets in the FLRG. In the defuzzification process, the forecast results are obtained by finding the midpoint of the interval in each FLRG, calculated using the formula explained earlier, the results of the forecasting can be seen in the table 6.

Table 6. Defuzzification and Forcasting Result

Date	Actual Price	FLR	Upper limit	Lower limit	Predicted Price
12/07/2024	6450	P1 → 1,1,1,3,3,3	-	-	-
15/07/2024	6450	P1 → 1,1,1,3,3,3	6399.00	6469.13	6434.07
16/07/2024	6400	P1 → 1,1,1,3,3,3	6399.00	6469.13	6434.07
17/07/2024	6450	P1 → 1,1,1,3,3,3	6399.00	6469.13	6434.07
18/07/2024	6550	P3 → 2,6,3,2,5	6399.00	6469.13	6434.07
19/07/2024	6500	P2 → 3,1,1	6469.13	6539.27	6504.20
22/07/2024	6575	P3 → 2,6,3,2,5	6539.27	6609.40	6574.33
23/07/2024	6750	P6 → 2,7	6469.13	6539.27	6504.20
24/07/2024	6500	P2 → 3,1,1	6469.13	6539.27	6504.20
25/07/2024	6450	P1 → 1,1,1,3,3,3	6539.27	6609.40	6574.33
26/07/2024	6575	P3 → 2,6,3,2,5	6399.00	6469.13	6434.07
29/07/2024	6550	P3 → 2,6,3,2,5	6469.13	6539.27	6504.20
30/07/2024	6475	P2 → 3,1,1	6469.13	6539.27	6504.20
31/07/2024	6400	P1 → 1,1,1,3,3,3	6539.27	6609.40	6574.33
01/08/2024	6550	P3 → 2,6,3,2,5	6399.00	6469.13	6434.07

Date	Actual Price	FLR	Upper limit	Lower limit	Predicted Price
02/08/2024	6700	P5 → 5,4,6	6469.13	6539.27	6504.20
05/08/2024	6700	P5 → 5,4,6	6679.53	6749.67	6714.60
06/08/2024	6650	P4 → 5	6679.53	6749.67	6714.60
07/08/2024	6725	P5 → 5,4,6	6679.53	6749.67	6714.60
08/08/2024	6800	P6 → 2,7	6679.53	6749.67	6714.60
09/08/2024	6825	P7 → 7,7,10	6469.13	6539.27	6504.20
12/08/2024	6875	P7 → 7,7,10	6819.80	6889.93	6854.87
13/08/2024	6850	P7 → 7,7,10	6819.80	6889.93	6854.87
14/08/2024	7075	P10 → 10,10,10,12,9,12	6819.80	6889.93	6854.87
15/08/2024	7075	P10 → 10,10,10,12,9,12	7030.20	7100.33	7065.27
16/08/2024	7075	P10 → 10,10,10,12,9,12	7030.20	7100.33	7065.27
19/08/2024	7075	P10 → 10,10,10,12,9,12	7030.20	7100.33	7065.27
20/08/2024	7200	P12 → 13,12,9,13,9	7030.20	7100.33	7065.27
21/08/2024	7300	P13 → 11,10,13,13,14,14	7240.60	7310.73	7275.67
22/08/2024	7150	P11 → 9,12	7100.33	7170.47	7135.40
23/08/2024	7000	P9 → 10,9,13,11,9,9,9,9,9	6960.07	7030.20	6995.13
26/08/2024	7050	P10 → 10,10,10,12,9,12	7030.20	7100.33	7065.27
27/08/2024	7025	P9 → 10,9,13,11,9,9,9,9,9	7030.20	7100.33	7065.27
28/08/2024	7025	P9 → 10,9,13,11,9,9,9,9,9	7030.20	7100.33	7065.27
29/08/2024	7300	P13 → 11,10,13,13,14,14	7030.20	7100.33	7065.27
30/08/2024	7100	P10 → 10,10,10,12,9,12	7100.33	7170.47	7135.40
02/09/2024	7200.0	P12 → 13,12,9,13,9	7030.20	7100.33	7065.27
03/09/2024	7200.0	P12 → 13,12,9,13,9	7240.60	7310.73	7275.67
04/09/2024	7000.0	P13 → 11,10,13,13,14,14	7240.60	7310.73	7275.67
05/09/2024	7125.0	P13 → 11,10,13,13,14,14	7030.20	7100.33	7065.27
06/09/2024	7175.0	P13 → 11,10,13,13,14,14	6960.07	7030.20	6995.13
09/09/2024	7250.0	P14 → 13,14,15,15,12	7240.60	7310.73	7275.67
10/09/2024	7250.0	P13 → 11,10,13,13,14,14	7100.33	7170.47	7135.40
11/09/2024	7300.0	P14 → 13,14,15,15,12	7100.33	7170.47	7135.40
12/09/2024	7375.0	P14 → 13,14,15,15,12	7100.33	7170.47	7135.40
13/09/2024	7300.0	P15 → 15,14,14	7240.60	7310.73	7275.67
17/09/2024	7325.0	P15 → 15,14,14	7100.33	7170.47	7135.40
18/09/2024	7375.0	P14 → 13,14,15,15,12	7240.60	7310.73	7275.67
19/09/2024	7450.0	P15 → 15,14,14	7240.60	7310.73	7275.67
20/09/2024	7400.0	P14 → 13,14,15,15,12	7380.87	7451.00	7415.93
23/09/2024	7325.0	P12 → 13,12,9,13,9	7380.87	7451.00	7415.93
24/09/2024	7400.0	P9 → 10,9,13,11,9,9,9,9,9	7240.60	7310.73	7275.67
25/09/2024	7350.0	P9 → 10,9,13,11,9,9,9,9,9	7380.87	7451.00	7415.93
26/09/2024	7175.0	P9 → 10,9,13,11,9,9,9,9,9	7240.60	7310.73	7275.67
27/09/2024	7025.0	P9 → 10,9,13,11,9,9,9,9,9	7240.60	7310.73	7275.67
30/09/2024	7000.0	P9 → 10,9,13,11,9,9,9,9,9	7030.20	7100.33	7065.27
01/10/2024	7000.0	P9 → 10,9,13,11,9,9,9,9,9	7030.20	7100.33	7065.27
02/10/2024	7025.0	P1 → 1,1,1,3,3,3	7030.20	7100.33	7065.27
03/10/2024	7000.0	P1 → 1,1,1,3,3,3	7030.20	7100.33	7065.27
04/10/2024	7025.0	P1 → 1,1,1,3,3,3	7030.20	7100.33	7065.27

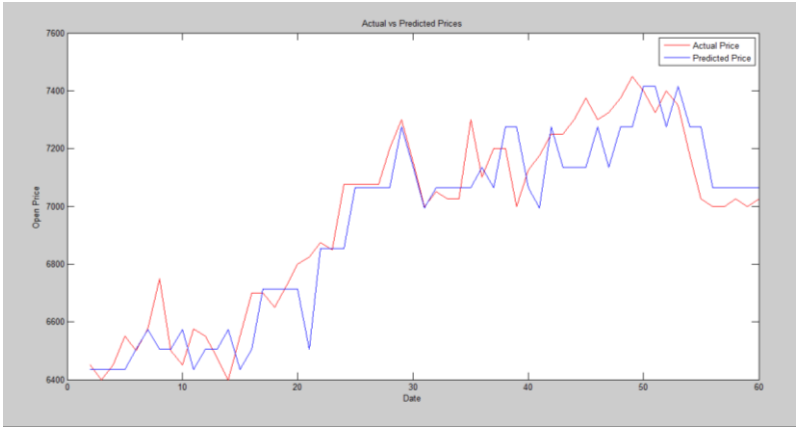

Figure 3. Comparison graph of actual data and forecasted results from the sample data.

In Figure 3, the comparison between the actual data and the predicted results from the sample data can be seen. The red line represents the actual data, while the blue line represents the predicted data.

3.8. Testing with actual data

After completing all testing processes with the sample data, the next step is testing with the actual data, consisting of 180 datasets spanning from January 2, 2024, to October 4, 2024. The results of this testing can be seen in Table 7.

Table 7. Forcasting Result with Actual Data

Date	Actual Price	Predicted Price	Date	Actual Price	Predicted Price
02/01/2024	6050.0	-	30/05/2024	5775.0	5829.90
03/01/2024	6100.0	6053.50	31/05/2024	6000.0	5829.90
04/01/2024	6125.0	6053.50	03/06/2024	6075.0	6053.50
05/01/2024	6400.0	6388.90	04/06/2024	6150.0	6053.50
08/01/2024	6500.0	6500.70	05/06/2024	6125.0	6388.90
09/01/2024	6425.0	6388.90	06/06/2024	6125.0	6388.90
10/01/2024	6375.0	6500.70	07/06/2024	6250.0	6388.90
11/01/2024	6425.0	6500.70	10/06/2024	6275.0	6277.10
12/01/2024	6575.0	6500.70	11/06/2024	6200.0	6277.10
15/01/2024	6575.0	6612.50	12/06/2024	6050.0	6388.90
16/01/2024	6525.0	6612.50	13/06/2024	5975.0	6053.50
17/01/2024	6525.0	6388.90	14/06/2024	5850.0	5829.90
18/01/2024	6525.0	6388.90	19/06/2024	5775.0	5829.90
19/01/2024	6500.0	6388.90	20/06/2024	5825.0	5829.90
22/01/2024	6500.0	6388.90	21/06/2024	6050.0	5829.90
23/01/2024	6525.0	6388.90	24/06/2024	6075.0	6053.50
24/01/2024	6450.0	6388.90	25/06/2024	5925.0	6053.50
25/01/2024	6325.0	6388.90	26/06/2024	5950.0	5829.90
26/01/2024	6250.0	6277.10	27/06/2024	5900.0	5829.90
29/01/2024	6350.0	6277.10	28/06/2024	6000.0	5829.90
30/01/2024	6475.0	6500.70	01/07/2024	6175.0	6053.50
31/01/2024	6650.0	6388.90	02/07/2024	6275.0	6388.90
01/02/2024	6575.0	6612.50	03/07/2024	6275.0	6277.10
02/02/2024	6625.0	6612.50	04/07/2024	6250.0	6277.10
05/02/2024	6700.0	6612.50	05/07/2024	6325.0	6277.10
06/02/2024	6825.0	6836.10	08/07/2024	6400.0	6277.10
07/02/2024	6875.0	6836.10	09/07/2024	6225.0	6500.70
12/02/2024	7150.0	6836.10	10/07/2024	6375.0	6277.10
13/02/2024	7100.0	7059.70	11/07/2024	6400.0	6500.70
15/02/2024	7300.0	7283.30	12/07/2024	6450.0	6500.70
16/02/2024	7375.0	7395.10	15/07/2024	6450.0	6388.90
19/02/2024	7150.0	7171.50	16/07/2024	6400.0	6388.90
20/02/2024	7250.0	7059.70	17/07/2024	6450.0	6500.70
21/02/2024	7125.0	7395.10	18/07/2024	6550.0	6388.90
22/02/2024	7175.0	7059.70	19/07/2024	6500.0	6388.90
23/02/2024	7050.0	7059.70	22/07/2024	6575.0	6388.90
26/02/2024	6950.0	7283.30	23/07/2024	6750.0	6612.50
27/02/2024	6975.0	6947.90	24/07/2024	6500.0	6836.10
28/02/2024	7025.0	6947.90	25/07/2024	6450.0	6388.90
29/02/2024	7125.0	7283.30	26/07/2024	6575.0	6388.90
01/03/2024	7050.0	7059.70	29/07/2024	6550.0	6612.50
04/03/2024	7000.0	7283.30	30/07/2024	6475.0	6388.90
05/03/2024	7075.0	6947.90	31/07/2024	6400.0	6388.90
06/03/2024	7000.0	7283.30	01/08/2024	6550.0	6500.70
07/03/2024	7075.0	6947.90	02/08/2024	6700.0	6388.90
08/03/2024	7150.0	7283.30	05/08/2024	6700.0	6836.10
13/03/2024	7250.0	7059.70	06/08/2024	6650.0	6836.10
14/03/2024	7250.0	7395.10	07/08/2024	6725.0	6612.50
15/03/2024	7450.0	7395.10	08/08/2024	6800.0	6836.10
18/03/2024	7425.0	7171.50	09/08/2024	6825.0	6836.10
19/03/2024	7250.0	7171.50	12/08/2024	6875.0	6836.10
20/03/2024	7050.0	7395.10	13/08/2024	6850.0	6836.10
21/03/2024	7100.0	7283.30	14/08/2024	7075.0	6836.10
22/03/2024	7000.0	7283.30	15/08/2024	7075.0	7283.30
25/03/2024	7250.0	6947.90	16/08/2024	7075.0	7283.30
26/03/2024	7225.0	7395.10	19/08/2024	7075.0	7283.30
27/03/2024	7200.0	7059.70	20/08/2024	7200.0	7283.30
28/03/2024	7150.0	7059.70	21/08/2024	7300.0	7059.70
01/04/2024	7250.0	7059.70	22/08/2024	7150.0	7395.10
02/04/2024	6900.0	7395.10	23/08/2024	7000.0	7059.70
03/04/2024	6950.0	6947.90	26/08/2024	7050.0	6947.90
04/04/2024	6750.0	6947.90	27/08/2024	7025.0	7283.30
05/04/2024	6825.0	6836.10	28/08/2024	7025.0	7283.30
16/04/2024	6350.0	6836.10	29/08/2024	7300.0	7283.30
17/04/2024	6700.0	6500.70	30/08/2024	7100.0	7395.10
18/04/2024	6800.0	6836.10	02/09/2024	7200.0	7283.30

Date	Actual Price	Predicted Price	Date	Actual Price	Predicted Price
19/04/2024	6725.0	6836.10	03/09/2024	7200.0	7059.70
22/04/2024	6875.0	6836.10	04/09/2024	7000.0	7059.70
23/04/2024	6850.0	6836.10	05/09/2024	7125.0	6947.90
24/04/2024	6925.0	6836.10	06/09/2024	7175.0	7059.70
25/04/2024	7050.0	6947.90	09/09/2024	7250.0	7059.70
26/04/2024	7000.0	7283.30	10/09/2024	7250.0	7395.10
29/04/2024	6650.0	6947.90	11/09/2024	7300.0	7395.10
30/04/2024	6800.0	6612.50	12/09/2024	7375.0	7395.10
02/05/2024	6800.0	6836.10	13/09/2024	7300.0	7171.50
03/05/2024	6300.0	6836.10	17/09/2024	7325.0	7395.10
06/05/2024	6250.0	6277.10	18/09/2024	7375.0	7395.10
07/05/2024	6325.0	6277.10	19/09/2024	7450.0	7171.50
08/05/2024	6325.0	6277.10	20/09/2024	7400.0	7171.50
13/05/2024	6200.0	6277.10	23/09/2024	7325.0	7171.50
14/05/2024	6175.0	6388.90	24/09/2024	7400.0	7395.10
15/05/2024	6200.0	6388.90	25/09/2024	7350.0	7171.50
16/05/2024	6450.0	6388.90	26/09/2024	7175.0	7171.50
17/05/2024	6350.0	6388.90	27/09/2024	7025.0	7059.70
20/05/2024	6550.0	6500.70	30/09/2024	7000.0	7283.30
21/05/2024	6225.0	6388.90	01/10/2024	7000.0	6947.90
22/05/2024	6000.0	6277.10	02/10/2024	7025.0	6947.90
27/05/2024	6025.0	6053.50	03/10/2024	7000.0	7283.30
28/05/2024	5850.0	6053.50	04/10/2024	7025.0	6947.90
29/05/2024	5825.0	5829.90	-	-	-

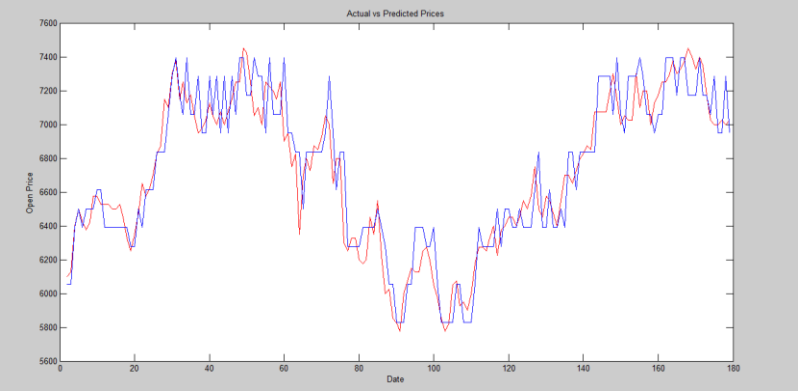

Figure 4. Comparison graph of actual data and forecasted results from the actual data.

In Figure 4, the comparison between the actual data and the predicted results from the actual data can be seen. The red line represents the actual data, while the blue line represents the predicted data.

3.9. Finding the MAPE Value

After conducting the testing, the next step is to calculate the error rate of the tested data. By calculating the absolute value of the difference between the predicted data and the actual data, then dividing it by the value of the actual data and multiplying it by one hundred percent. The results can be seen in the table 8.

Table 8. MAPE Result

Data point	Actual Price (Ap)	Predicted Price (Pp)	$\left\|\frac{(Pp-Ap)}{(Ap)}\right\|.100\%$	Data point	Actual Price (Ap)	Predicted Price (Pp)	$\left\|\frac{(Pp-Ap)}{(Ap)}\right\|.100\%$
0	6050.0	-	-	90	5775.0	5829.90	0.950649%
1	6100.0	6053.50	0.762295%	91	6000.0	5829.90	2.835000%
2	6125.0	6053.50	1.167347%	92	6075.0	6053.50	0.353909%
3	6400.0	6388.90	0.173438%	93	6150.0	6053.50	1.569106%
4	6500.0	6500.70	0.010769%	94	6125.0	6388.90	4.308571%
5	6425.0	6388.90	0.561868%	95	6125.0	6388.90	4.308571%
6	6375.0	6500.70	1.971765%	96	6250.0	6388.90	2.222400%
7	6425.0	6500.70	1.178210%	97	6275.0	6277.10	0.033466%
8	6575.0	6500.70	1.130038%	98	6200.0	6277.10	1.243548%
9	6575.0	6612.50	0.570342%	99	6050.0	6388.90	5.601653%
10	6525.0	6612.50	1.340996%	100	5975.0	6053.50	1.313808%
11	6525.0	6388.90	2.085824%	101	5850.0	5829.90	0.343590%
12	6525.0	6388.90	2.085824%	102	5775.0	5829.90	0.950649%
13	6500.0	6388.90	1.709231%	103	5825.0	5829.90	0.084120%

Data point	Actual Price (Ap)	Predicted Price (Pp)	$\left\|\frac{(Pp-Ap)}{(Ap)}\right\|.100\%$	Data point	Actual Price (Ap)	Predicted Price (Pp)	$\left\|\frac{(Pp-Ap)}{(Ap)}\right\|.100\%$
14	6500.0	6388.90	1.709231%	104	6050.0	5829.90	3.638017%
15	6525.0	6388.90	2.085824%	105	6075.0	6053.50	0.353909%
16	6450.0	6388.90	0.947287%	106	5925.0	6053.50	2.168776%
17	6325.0	6388.90	1.010277%	107	5950.0	5829.90	2.018487%
18	6250.0	6277.10	0.433600%	108	5900.0	5829.90	1.188136%
19	6350.0	6277.10	1.148031%	109	6000.0	5829.90	2.835000%
20	6475.0	6500.70	0.396911%	110	6175.0	6053.50	1.967611%
21	6650.0	6388.90	3.926316%	111	6275.0	6388.90	1.815139%
22	6575.0	6612.50	0.570342%	112	6275.0	6277.10	0.033466%
23	6625.0	6612.50	0.188679%	113	6250.0	6277.10	0.433600%
24	6700.0	6612.50	1.305970%	114	6325.0	6277.10	0.757312%
25	6825.0	6836.10	0.162637%	115	6400.0	6277.10	1.920312%
26	6875.0	6836.10	0.565818%	116	6225.0	6500.70	4.428916%
27	7150.0	6836.10	4.390210%	117	6375.0	6277.10	1.535686%
28	7100.0	7059.70	0.567606%	118	6400.0	6500.70	1.573437%
29	7300.0	7283.30	0.228767%	119	6450.0	6500.70	0.786047%
30	7375.0	7395.10	0.272542%	120	6450.0	6388.90	0.947287%
31	7150.0	7171.50	0.300699%	121	6400.0	6388.90	0.173438%
32	7250.0	7059.70	2.624828%	122	6450.0	6500.70	0.786047%
33	7125.0	7395.10	3.790877%	123	6550.0	6388.90	2.459542%
34	7175.0	7059.70	1.606969%	124	6500.0	6388.90	1.709231%
35	7050.0	7059.70	0.137589%	125	6575.0	6388.90	2.830418%
36	6950.0	7283.30	4.795683%	126	6750.0	6612.50	2.037037%
37	6975.0	6947.90	0.388530%	127	6500.0	6836.10	5.170769%
38	7025.0	6947.90	1.097509%	128	6450.0	6388.90	0.947287%
39	7125.0	7283.30	2.221754%	129	6575.0	6388.90	2.830418%
40	7050.0	7059.70	0.137589%	130	6550.0	6612.50	0.954198%
41	7000.0	7283.30	4.047143%	131	6475.0	6388.90	1.329730%
42	7075.0	6947.90	1.796466%	132	6400.0	6388.90	0.173438%
43	7000.0	7283.30	4.047143%	133	6550.0	6500.70	0.752672%
44	7075.0	6947.90	1.796466%	134	6700.0	6388.90	4.643284%
45	7150.0	7283.30	1.864336%	135	6700.0	6836.10	2.031343%
46	7250.0	7059.70	2.624828%	136	6650.0	6836.10	2.798496%
47	7250.0	7395.10	2.001379%	137	6725.0	6612.50	1.672862%
48	7450.0	7395.10	0.736913%	138	6800.0	6836.10	0.530882%
49	7425.0	7171.50	3.414141%	139	6825.0	6836.10	0.162637%
50	7250.0	7171.50	1.082759%	140	6875.0	6836.10	0.565818%
51	7050.0	7395.10	4.895035%	141	6850.0	6836.10	0.202920%
52	7100.0	7283.30	2.581690%	142	7075.0	6836.10	3.376678%
53	7000.0	7283.30	4.047143%	143	7075.0	7283.30	2.944170%
54	7250.0	6947.90	4.166897%	144	7075.0	7283.30	2.944170%
55	7225.0	7395.10	2.354325%	145	7075.0	7283.30	2.944170%
56	7200.0	7059.70	1.948611%	146	7200.0	7283.30	1.156944%
57	7150.0	7059.70	1.262937%	147	7300.0	7059.70	3.291781%
58	7250.0	7059.70	2.624828%	148	7150.0	7395.10	3.427972%
59	6900.0	7395.10	7.175362%	149	7000.0	7059.70	0.852857%
60	6950.0	6947.90	0.030216%	150	7050.0	6947.90	1.448227%
61	6750.0	6947.90	2.931852%	151	7025.0	7283.30	3.676868%
62	6825.0	6836.10	0.162637%	152	7025.0	7283.30	3.676868%
63	6350.0	6836.10	7.655118%	153	7300.0	7283.30	0.228767%
64	6700.0	6500.70	2.974627%	154	7100.0	7395.10	4.156338%
65	6800.0	6836.10	0.530882%	155	7200.0	7283.30	1.156944%
66	6725.0	6836.10	1.652045%	156	7200.0	7059.70	1.948611%
67	6875.0	6836.10	0.565818%	157	7000.0	7059.70	0.852857%
68	6850.0	6836.10	0.202920%	158	7125.0	6947.90	2.485614%
69	6925.0	6836.10	1.283755%	159	7175.0	7059.70	1.606969%
70	7050.0	6947.90	1.448227%	160	7250.0	7059.70	2.624828%
71	7000.0	7283.30	4.047143%	161	7250.0	7395.10	2.001379%
72	6650.0	6947.90	4.479699%	162	7300.0	7395.10	1.302740%
73	6800.0	6612.50	2.757353%	163	7375.0	7395.10	0.272542%
74	6800.0	6836.10	0.530882%	164	7300.0	7171.50	1.760274%
75	6300.0	6836.10	8.509524%	165	7325.0	7395.10	0.956997%
76	6250.0	6277.10	0.433600%	166	7375.0	7395.10	0.272542%
77	6325.0	6277.10	0.757312%	167	7450.0	7171.50	3.738255%
78	6325.0	6277.10	0.757312%	168	7400.0	7171.50	3.087838%
79	6200.0	6277.10	1.243548%	169	7325.0	7171.50	2.095563%
80	6175.0	6388.90	3.463968%	170	7400.0	7395.10	0.066216%
81	6200.0	6388.90	3.046774%	171	7350.0	7171.50	2.428571%
82	6450.0	6388.90	0.947287%	172	7175.0	7171.50	0.048780%
83	6350.0	6388.90	0.612598%	173	7025.0	7059.70	0.493950%
84	6550.0	6500.70	0.752672%	174	7000.0	7283.30	4.047143%

Data point	Actual Price (Ap)	Predicted Price (Pp)	$\left\|\frac{(Pp-Ap)}{(Ap)}\right\|.100\%$	Data point	Actual Price (Ap)	Predicted Price (Pp)	$\left\|\frac{(Pp-Ap)}{(Ap)}\right\|.100\%$
85	6225.0	6388.90	2.632932%	175	7000.0	6947.90	0.744286%
86	6000.0	6277.10	4.618333%	176	7025.0	6947.90	1.097509%
87	6025.0	6053.50	0.473029%	177	7000.0	7283.30	4.047143%
88	5850.0	6053.50	3.478632%	178	7025.0	6947.90	1.097509%
89	5825.0	5829.90	0.084120%	Mean			1.8826%

From Table 8 above, after calculating the MAPE value for each data point, the next step is to find the mean of all the MAPE values. As shown in Table 8 above, the average MAPE value is 1.8826%.

3.10. Discussion

Fuzzy time series has demonstrated its effectiveness in forecasting stock sales using time series datasets. The results of this study reflect an overall accuracy of 98.7261%, highlighting the superiority of fuzzy time series in stock forecasting. Fuzzy time series offers several advantages in forecasting stock sales compared to other fuzzy methods. It effectively handles fluctuating and uncertain time series data commonly found in stock movements. Its flexible fuzzy intervals allow for better adaptation to data patterns, while dynamic fuzzy rules enhance accuracy in predicting future values based on historical trends. Additionally, Fuzzy time series is computationally efficient and simpler to implement without sacrificing precision, making it a robust choice for stock sales forecasting.

This study are important as a potential method to reduce risks for investors when considering investments in a company. However, to optimize the Fuzzy time series, efforts are needed to address challenges related to parameter adjustments and data quality. Future research should test this model on specific stock sectors to observe performance variations across industries. Combining the forecasting results with fundamental analysis is recommended to achieve a more comprehensive perspective.

4. CONCLUSION

The results of the analysis indicate that the fuzzy time series method demonstrates a high level of accuracy in forecasting stock sales, achieving an accuracy rate of 98.7261% with a MAPE error rate of only 1.2739% from the 180 tested data points. The study reveals that the applied forecasting model provides an optimal representation of relevant stock sales trends, making it a valuable tool for supporting strategic decision-making. By utilizing this model, stock market participants can minimize risks when making investment decisions.

The researchers acknowledge several limitations of this study, such as the lack of industry variation in the stock data used for testing, the forecasting focus being limited to a specific model, and the absence of a more user-friendly and real-time implementable system. Therefore future research should test this model on specific stock sectors to observe performance variations across industries. Combining the forecasting results with fundamental analysis is recommended to achieve a more comprehensive perspective. Additionally, further development is needed to transform this model into a web or mobile application, enabling real-time use and improving accessibility.

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