# COMPARISON OF WEIGHTED MOVING AVERAGE AND PROPHET METHOD IN PREDICTING STOCK PRICES

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## ABSTRACT

*Stocks are one of the favorite investment methods of Indonesian people. This is because stocks are "high risk high return" investments. That is an investment that provides high returns even though it has a high risk as well. To find a good stock, we can do technical analysis. But doing technical analysis is not easy because it takes time and enough experience to be able to do the right technical analysis. To overcome difficulties in conducting technical analysis. An appropriate algorithm is needed to predict stock prices. And a program that can work automatically in running the algorithm. So that's why I created a program that can run Weighted Moving Average and Prophet automatically. Later these two algorithms will be compared for their accuracy in predicting stock prices. The final result of this study is the performance of the Weighted Moving Average and Prophet in predicting stock prices. With this research, readers can understand how the Weighted Moving Average and Prophet work. And it is easier to predict stock prices because it can be done automatically.*

**Keywords:** stock, wma, prophet

## BACKGROUND

Stocks are one of the favorite investment methods of Indonesian people. This is because stocks are "high risk high return" investments. That is an investment that provides high returns even though it has a high risk as well. To find a good stock, we can do fundamental analysis and technical analysis. Fundamental analysis is an analysis of the condition of the company whose shares are traded. The way of analysis we can see the total amount of company income, the amount of expenses, the amount of company debt, and the amount of profit distributed to shareholders. We can see all of that on the Indonesia Stock Exchange website. In addition we can also perform technical analysis. Technical analysis aimed at observing patterns in stock prices. The use of technical analysis is that we can find the best momentum when to buy or sell. But doing technical analysis is not easy because it takes time and enough experience to be able to do the right technical analysis.

To overcome difficulties in conducting technical analysis, therefore the research is conducted. The research will predict future stock prices using the Weighted Moving Average algorithm and the Prophet. Weighted Moving Average is one part of the Moving Average method. This method was chosen because the Weighted Moving Average method is more responsive to

price changes compared to similar methods, namely the Simple Moving Average and the Exponential Moving Average. The Weighted Moving Average works by giving weight to each existing data, but the weight given to the latest data is greater than the old data. Other methods used to predict stocks are RSI, Bollinger Band, and Prophet. Prophet is an open source library created by Facebook's Core Data Science team. The advantage of Prophet is in its accuracy and speed in processing existing data. In addition, the Prophet is also prepared to handle missing data and outliers. Prophet predicts stock prices by studying trends from historical stock price data. For this reason, the Prophet needs to be "trained" by entering the historical stock price data.

This research will explain the performance comparison between the Weighted Moving Average and the Prophet. In addition, readers will understand how to use the Weighted Moving Average and Prophet in predicting. This research can also be used as a reference to determine the most effective algorithm in predicting stock prices. Programs that have been created can also be used to predict future stock prices.

Formulation of the problem to be discussed in this research is:

1. Can the Weighted Moving Average and Prophet be used to predict stocks?
2. How does the accuracy compare between the Weighted Moving Average algorithm and the Prophet?

The data to be used is taken from yahoo.finance.com. The data is historical data on stock prices. Later the data will be used to make predictions using Weighted Moving Average and Prophet models. The accuracy of the two models will be compared to find the most effective model in predicting stock prices.

The purpose of this study is to predict stock prices using the WMA and Prophet methods. Another goal is to know the accuracy of WMA and Prophet in predicting stock prices. The prediction accuracy values of these two methods will be compared later. So it can be found which method has the best accuracy in predicting stock prices.

## LITERATURE STUDY

From the past until now, a lot of research has focused on finding algorithms that are able to predict stock prices accurately. One of the author is Hilhami[1]. Hilhami tried to compare the Simple Moving Average and Weighted Moving Average methods in predicting stocks. Simple Moving Average method works by calculating the average value of the data to predict future data. While the Weighted Moving Average method works by calculating the average value and giving a heavier weight to the most recent data and reducing the weighting to the old data. The author uses historical stock price data to predict future stock prices. The steps taken by author in conducting research are author collecting stock price data from www.investing.id. Then the author determines the time to be predicted. Then the stock price data will be used to calculate the predicted value

using the Simple Moving Average and Weighted Moving Average methods. After that, the prediction results will be checked for accuracy using Mean Absolute Percentage Error. The purpose of this study is that the author wants to know which method has better performance in predicting stock prices. The conclusion obtained by the author is that the Weighted Moving Average algorithm is more responsive to stock price movements than the Simple Moving Average. And the Weighted Moving Average has higher accuracy in predicting stock prices than the Simple Moving Average. This is evidenced by the MAPE value of the Simple Moving Average algorithm of 4.34% while the MAPE value of the Weighted Moving Average algorithm is 3.64%.

Besides Hilhami, Purba et al. [2] also conducts research on Moving Averages. Purba compares the performance of Moving Average (MA) and Neural Network Algorithm in stock price prediction. Moving Average is a forecasting method that works by calculating the average value of a data in a certain period. Backpropagation is an algorithm with a multi-layer network that can minimize errors in the network. The steps taken by the author in making a Neural Network are initialization, namely determining the network architecture, the MSE value as a stop condition, and the learning rate and setting the weight value. As long as the stop is worth the condition, the feedforward and backpropagation processes will be carried out. If the termination conditions are met, the network training can be stopped. The author uses stock price history as a dataset to predict future stock prices. The purpose of this study is that the author wants to compare the performance of the Backpropagation-based Neural Network algorithm and the Moving Average algorithm in predicting stock prices. The conclusion obtained by the author is that the Backpropagation-based Neural Network algorithm and the Moving Average algorithm are effective in predicting stocks. In terms of accuracy, the Moving Average algorithm is more accurate than the Backpropagation-based Neural Network algorithm, namely the Moving Average accuracy is 80.11% and the Backpropagation-based Neural Network is 78.91%.

In addition to the Weighted Moving Average and the Simple Moving Average, another forecasting method that is often used in predicting stocks is the Exponential Moving Average. Suarsa [3] conducted research on the performance of the Simple Moving Average, Weighted Moving Average, and also the Exponential Moving Average in predicting stocks in the telecommunications sub-sector. The steps taken by author in conducting research are firstly author prepare stock price historical data. Then the author will predict stock prices using the SMA, WMA, and EMA methods. After that the accuracy of the SMA,WMA,EMA will be tested using the MAPE method. The aim of the author in this research is to find out which method between the Simple Moving Average, Weighted Moving Average, and Exponential Moving Average has the highest accuracy in predicting stocks. In finding the level of accuracy, author used the MAPE method. After calculating the prediction accuracy using the MAPE method, the author found that the Weighted Moving Average had the smallest MAPE value of 3.10%. While the Exponential Moving Average has a MAPE value of 3.52% and the Simple Moving Average has a MAPE value of 4.19%. The author concludes that the Weighted Moving Average method has the best accuracy in

predicting stocks compared to the Simple Moving Average and Exponential Moving Average. In addition to comparing the Weighted Moving Average with other algorithms, author are also interested in combining the Weighted Moving Average with other algorithms to increase the effectiveness of predictions. Putri et al. [4] tried to use Brown's Weighted Exponential Moving Average Method. This method is a combination of Weighted Moving Average and Brown's Double Exponential Smoothing. To get more accurate prediction results, the method was combined with the Levenberg-Marquadt algorithm. The steps taken by the author in conducting the research were collecting data on closing price shares with a total of 258 data used for predictions using the B-WEMA method. Then the author predict stock prices using the B-WEMA method. After that, the author tested the accuracy of the B-WEMA prediction results with the MAPE method. Then the author searched for the alpha optimization value using the LM algorithm with the help of a library. After that, the author tested the accuracy of the prediction results of B-WEMA with Levenberg-Marquardt Optimization using the MAPE method. The purpose of this study is to determine the performance of Brown's Weighted Exponential Moving Average with Levenberg-Marquardt Optimization and to determine whether Levenberg-Marquardt Optimization has a positive effect on accuracy in predicting stock prices. The conclusion obtained by the author is that the Brown's Weighted Exponential Moving Average algorithm with Levenberg-Marquardt Optimization is effective in predicting stocks. And Levenberg-Marquadt optimization has a positive impact in terms of prediction accuracy. The proof is that the accuracy of the Brown's Weighted Exponential Moving Average method if calculated based on the MSE is 7,271.63 and the MAPE is 3.028%. However, if you use the Brown's Weighted Exponential Moving Average algorithm with Levenberg-Marquardt Optimization, then the MSE value is 3,619.98 and the MAPE is 1.99%.

## RESEARCH METHODOLOGY

### *Literature Study*

Journals and literature related to the topic were studied to get to know the method better. The journals and literature that were collected and studied amounted to 10. There were 5 journals each related to the Weighted Moving Average and Prophet methods. Journals and literature collected are used to enrich insights and provide different perspectives in conducting research.

### *Data Collection*

This study will predict the stock price of Bank Central Asia (BCA). BCA was chosen because it is a Go-Public company with the largest capitalization in Indonesia. The author took stock price data from yahoo.finance.com. This is stock price data from November 20, 2019 to February 16, 2021.The data used amounted to 300 data.

### *Weighted Moving Average Implementation*

The Weighted Moving Average works by calculating a moving average on the data and assigning a weight that is adjusted according to the order. The workflow is, first the program will determine the amount of load that will be given to the data. So for example there are three data,

the first data will have a smaller weight than the second data weight. And the second data will have a smaller weight than the third data weight. The load is adjusted according to the order of the data, the newer the data the bigger the load. Then the data will be multiplied by the load and the result will be divided by the total of all existing loads.

### *Prophet Implementation*

Prophet predicts future values by calculating trend values and seasonal values. To find trend values, change points are created. Changepoint is the time when the data is measured the amount of change. After making a changepoint, the existing data is calculated using a formula to find the trend value. After finding the trend value, the existing data is calculated with a formula to find the seasonal value. After finding the trend value and seasonal value, the two values are added to find the predicted result.

### *Result Analysis*

At this stage the prediction results of the two algorithms will be tested for accuracy using the Mean Absolute Error Percentage method. Then the MAPE values of the two algorithms will be compared. The smaller the MAPE value, the higher the prediction accuracy.

## ANALYSIS

The purpose of this project is to analyze and compare the performance of the Prophet algorithm and the Weighted Moving Average algorithm in predicting stocks. Prophet is a library created by the Facebook Core Data Science team. This research does not use Facebook's library but uses a method created by Facebook. The two methods that will be compared are written in Python. Stock price data obtained from yahoo.finance.com. This data amounted to as much as 300 data. This is stock price data from November 20, 2019 to February 16, 2021. To calculate accuracy, the stock price data is divided into 3 parts namely train, validation, and test. The train part will be used to train the algorithm. The validation and test sections will be used to check the accuracy of the algorithm in predicting stocks.

$$\mathbf{F} = \frac{W1.D1 + W2.D2}{TW} \quad (1)$$

W1 = First data weight

W2 = Second data weight

D1 = First data

D2 = Second data

TW = Total data weight

The Weighted Moving Average works by calculating a moving average on the data and assigning a weight that is adjusted according to the order. The workflow is, first the program will determine the amount of load that will be given to the data. So for example there are three data, the first data will have a smaller weight than the second data weight. And the second data will have a smaller weight than the third data weight. The load is adjusted according to the order of the data, the newer the data the bigger the load. Then the data will be multiplied by the load and the result will be divided by the total of all existing loads.

## PROPHET

In making predictions, the Prophet uses the Generalized Additive Model (GAM) technique. Prophet works by dividing the time series into 3 components: trend, seasonality, and holidays. A trend is a time series pattern that indicates growth or shrinkage. Seasonality is a cycle that repeats itself over a specific period of time. Holiday is the effect of a holiday at a certain time. Holiday is an additional feature that can be activated if you want to use it. However, because the stock market does not operate during holidays, the holiday feature is not used.

### *Create Changepoint*

The changepoint is the time when a change in trend occurs. A total of 25 changepoints were installed within the predicted timeframe. How big the change in changepoint will be determined by the size of the delta.

*Trend Formula*

$$g(t) = (k + a(t) \mid \delta)t + (m + a(t) \mid \gamma) \quad (2)$$

$k$ = growth rate

$\delta$ = rate adjustments

$m$ = offset parameter

$a$ = changepoint location

$\gamma$ = continous parameter

$t$ = time

In calculating the trend value, what is done is to add the value of the growth rate and a multiplied by delta (matrix multiplication). A is a matrix containing the time of the changepoint change. Delta is the trend rate adjustment parameter. The purpose of the delta is to control how

much the trend changes. The delta value can be changed. The greater the delta value, the greater the trend change.

*Seasonality Formula*

$$X = \cos\frac{(2piNt)}{P} + \sin\frac{(2piNt)}{P} \quad (3)$$

$$s(t) = X(t)\beta \quad (4)$$

In calculating the seasonality value, the program will detect the amount of prediction time. If the prediction time is 30 days or less then N is 3 and P is 7. If the prediction time is less than 365 days then N is 10 and P is 365.25. After that the program will calculate the value of seasonality. After getting the seasonality value, the seasonality value will be multiplied by beta. Beta is the seasonality adjustment parameter. The use of beta is as a controller of how much change in seasonality. After that the trend values and seasonality values will be added, the results are predictions.

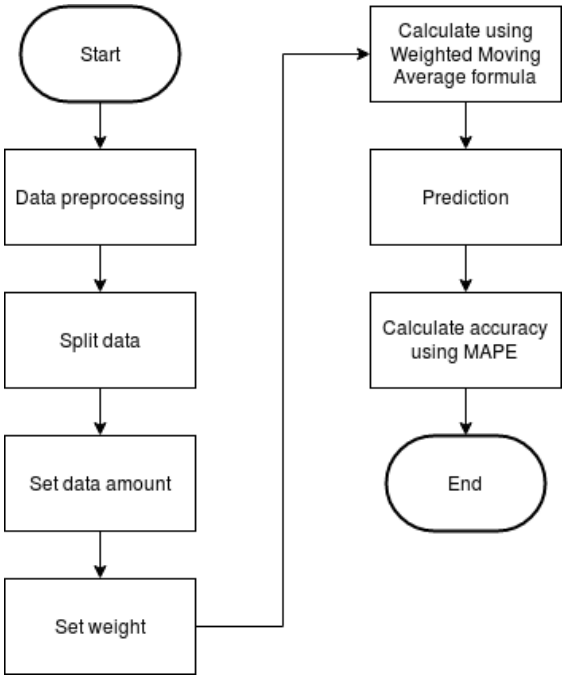
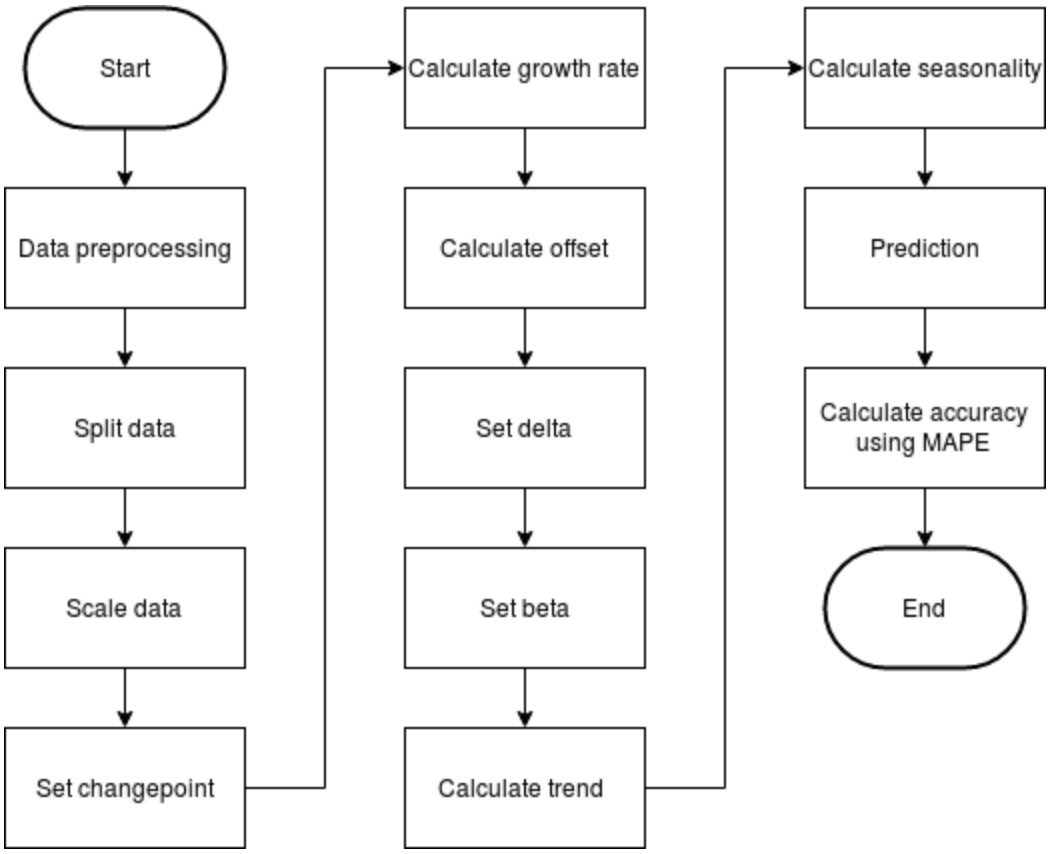



**Figure 1** : Weighted Moving Average Flowchart

The flowchart diagram above tells the stages in implementing WMA. The first step is to do data preprocessing.The first step is to do data preprocessing. What is done in the preprocessing data is the historical stock price data that has been downloaded, cleaned of empty data. In addition, historical stock price data also contains unnecessary data such as Volume, Open. The unnecessary




data is deleted. After preprocessing the data, the next step is splitting the data. What is done in the data split is the historical stock price data is divided into 3, namely train, validation, and test. Train is data that will be used to train the method. Validation and test are data that will be used to calculate the accuracy value.

After splitting the data, the next step is to determine the amount of data to be used in training the WMA method. After that the program will determine the amount of load that will be given to the data. So for example there are three data, the first data will have a smaller weight than the second data weight. And the second data will have a smaller weight than the third data weight. The load is adjusted according to the order of the data, the newer the data the bigger the load. After carrying out the weighting process, the next step is to make predictions using the WMA formula. The data will be multiplied by the load and the result will be divided by the total of all existing loads. After finding the prediction results, the prediction accuracy will be calculated using the MAPE method.

**Figure 2**. Prophet Flowchart

The flowchart diagram above tells the stages in implementing the Prophet. The first step is to do data preprocessing. What is done in the preprocessing data is the historical stock price data that has been downloaded, cleaned of empty data. In addition, historical stock price data also

contains unnecessary data such as Volume, Open. The unnecessary data is deleted. After preprocessing the data, the next step is splitting the data. What is done in the data split is the historical stock price data is divided into 3, namely train, validation, and test. Train is data that will be used to train the method. Validation and test are data that will be used to calculate the accuracy value. After splitting the data, the next step is scaling the data. So the stock price data will be scaled with the absolute maximum method. And the time data will be scaled with the min max method. After scaling the data, the next step is to install a changepoint. The changepoint is the time when a change in trend occurs. A total of 25 changepoints were installed within the predicted timeframe.

After installing the changepoint, the next step is to calculate the growth rate. After calculating the growth rate, the next step is to calculate the offset. The growth rate and offset values need to be calculated because they will later be needed in calculating the trend value. After calculating the offset value, the next step is to set the delta value. Delta is the trend rate adjustment parameter. The purpose of the delta is to control how much the trend changes. The delta value can be changed. The greater the delta value, the greater the trend change. After setting the delta value, the next step is to set the beta value. Beta is the seasonality adjustment parameter. The use of beta is as a controller of how much change in seasonality. The beta value can be changed. The greater the beta value, the greater the seasonality change. After setting the beta value, the next step is to calculate the trend value. In calculating the trend value, what is done is to add the value of the growth rate and a multiplied by delta (matrix multiplication). A is a matrix containing the time of the changepoint change. Delta is the trend rate adjustment parameter. The purpose of the delta is to control how much the trend changes. The delta value can be changed. The greater the delta value, the greater the trend change. After calculating the trend value, the next step is to calculate the seasonality value. In calculating the seasonality value, the program will detect the amount of prediction time. If the prediction time is 30 days or less then N is 3 and P is 7. If the prediction time is less than 365 days then N is 10 and P is 365.25. After that the program will calculate the value of seasonality. After getting the seasonality value, the seasonality value will be multiplied by beta. Beta is the seasonality adjustment parameter. The use of beta is as a controller of how much change in seasonality. After calculating the seasonality value, the next step is trend values and seasonality values will be added, the results are predictions. After finding the prediction results, the prediction accuracy will be calculated using the MAPE method.

## IMPLEMENTATION

This research uses the python programming language. The stock price data that has been collected will later be used by Prophet and WMA methods to predict future stock prices. The steps taken in implementing Prophet and WMA methods will be explained below.

### *Prophet Implementation*

```
1  df['y_scaled'] = df['y'] / df['y'].max()
2  t_scale = df['ds'].max() - df['ds'].min()
```

```
3  df['t'] = (df['ds'] - df['ds'].min()) / t_scale
4  future['t'] = (future['ds'] - future['ds'].min()) / t_scale
```

Line 5 is used to get the y_scaled value by using the max absolute scaler method. The value of y_scaled is the value of the stock price that has been scaled. Then in lines 6 to 7 is used to scaled the time data with the min max scaler. Line 8 is used for is scaling the future time data, which is the predicted time period with the min max scaler.

```
5  stop = len(t)
6  start = len(t) - check
7  changepoints = np.linspace(start, stop, 25)
```

Line 9 is used to be the stop requirements, namely the condition of the stop point for the changepoint installation. Line 10 is used to be the start requirements, namely the initial location conditions for the changepoint installation. The purpose of this design is to be able to install the changepoint correctly. Line 11 is used to install changepoints with the same distance from each other according to the designed start and stop points as many as 25.

```
8  deltas = np.random.laplace(0, 0.01, 25)
9  beta = np.random.normal(0, 10)
10 a = (t[:, None] > changepoints) * 1
```

Line 12 is used to make arrangements about how much the trend will change. Line 13 is used to make arrangements about how much seasonality will change. Line 14 is used to make a matrix. This matrix will be useful for recording the point of change in the value of growth due to passing through the changepoint. Later this matrix will be used in calculating the trend value.

```
11 trend = k + a @ deltas
12 trend = trend * t
13 trend = trend + m + a @ gamma
14 trend = trend * df['y'].max()
```

Line 15 to 18 is used to calculate the trend value based on the Prophet method. Line 15, is used to perform matrix multiplication, which is between a and deltas. Then the results will be added to the value of k. The goal is that every time a changepoint is passed, the value of k will be added to the value of deltas. Line 16 is used to multiplied the matrix between the total growth and the value of t. Line 17 is used to add the result of multiplying the total growth matrix and the t value with the total offset value. The total offset value is obtained by multiplying the matrix between a and gamma. Then the result will be added with the value of m. The goal is that when every changepoint is passed, the value of m will be added to the value of gamma. In line 18, the results of the previous calculation will be multiplied by the maximum share price. This is done to restore the scaled stock price data to normal.

```
15 if check == 7 or check <= 30:
16     n = 3
```

```
17      p = 7
18  elif check >= 365:
19      n = 10
20      p = 365.25
21  s =  2 * np.pi * n * t / p
22  seasonality = np.cos(s) + np.sin(s)
23  seasonality = seasonality * beta
24  df2 = np.array(1)
25  df2 = trend + seasonality
```

Line 19 to 27 is used to calculate the seasonality value using the Prophet method. On line 19 to 24 there will be a check for the amount of time that will be predicted. If the number is 7 days or less than 30 days then n will be worth 3 and p will be worth 7. But if the amount of time to be predicted is more or equal to 365 days then n will be worth 10 and p will be worth 365.25. On line 25-26 there will be a process of calculating the seasonality formula. In line 27 the result of calculating the seasonality formula will be multiplied by beta. Line 28 is used to create a new array to store the predicted results. In line 29, the trend values and seasonality values will be added to get the prediction results.

### *WMA Implementation*

```
26  alldata= df['y']
27  weightamount = 30
28  weight = np.array((15))
29  nextweight = np.sum(weight)
```

Line 30 is used to enter all stock price data into the array. Later alldata will be used to store the results of stock price predictions. Line 31 is the place to set the amount of data that will be used to train the WMA method. Line 32 is used to enter the first weight of 15. Line 33 is used to enter the number of weights into the next weight.

```
30  for i in check:
31      wma = data * weight
32      wma = wma / totalweight
33      wma = np.sum(wma)
34      alldata = np.append(alldata,wma)
```

In line 34-37 there is a process of calculating the prediction results using the WMA method. On line 35, there is a multiplication process between stock price data and weight. The latest stock data will be multiplied by the largest weight. In line 36, the result of multiplying stock price data with weight will be divided by the total of all weight. In line 37 all the data in the wma array will be added up to get the prediction result. In line 38 the prediction results will be stored in the alldata array.

## RESULT

**Table 1.** Prediction Result

| Method | Validation | Test |
|---|---|---|
| Prophet | 2.73 | 6.92 |
| Weighted Moving Average | 10.47 | 14.87 |

The table above is the accuracy value of the WMA and Prophet methods calculated by the MAPE method. Testing is carried out in 2 stages, namely validation and test. After being calculated using the MAPE method, it was found that, Prophet prediction accuracy value in the validation stage was 2.73 and in the test stage was 6.92. And WMA prediction accuracy value in the validation stage was 10.47 and in the test stage was 14.87.

## CONCLUSION

From this research, it can be concluded that Prophet has higher accuracy in predicting stock prices compared to the Weighted Moving Average. This is evidenced by the Prophet Mean Absolute Percentage Error value of 2,73. While Weighted Moving Average has MAPE value of 10,47. The smaller the MAPE value, the more accurate the prediction results. Although even not as accurate as the Prophet, the Weighted Moving Average also remains reliable in predicting stock prices. This is evidenced by the small Mean Absolute Percentage Error value.

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