

## Analysis of Moving Average, Weight Moving Average, Exponential Smoothing in predicting shoe prices

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### ABSTRACT

Research related to forecasting is growing, starting with simple forecasting based on time or forecasting with certain criteria. Forecasting methods continue to be developed with the reason to produce good models and can predict with high accuracy. The simplest forecasting method is the statistical value of the data, namely the average value or what is often called the moving average. Referring to the existing forecasting methods, we try to propose research related to the analysis of the MA, WMA, and Exponential Smoothing (ES) methods in forecasting shoe prices. The purpose of this study is to analyze the three methods in predicting the price of Adidas brand shoes. The data is taken from the Kaggle dataset and the analysis of the three methods uses the MSE (Mean Squared Error) value. Forecasting analysis process using the statsmodels library in Jupyter Notebooks. The MSE values of the three methods are MA with 2 times of 15484.68, MA with 3 times of 24829.42, WMA 3 times of 14239.74, WMA 4 times of 18386.77, and ES 3 times of 38349.34, ES 4 times of 43102.42. This study concludes that the lowest MSE value is the best predictive method, namely WMA with 2 times MSE 7268.3.

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## 1. INTRODUCTION

The Moving Average (MA) method predicts the next time data based on historical data from the past. The MA model assumes that what happened in the future is what happened in the past. The MA model recognizes and analyzes what data happened in the past to make forecasts[1][2][3][4][5][6]. The step to forecasting is to determine the purpose of forecasting or what is expected, determine the variables or items to be forecasted, determine the data used based on the desired time, for example, 1 month or several months, 1 year, 2 years. Creating a forecasting model, choosing the best model with a low error value. Make a forecasting system by looking at the results of its accuracy. How to determine the model is effective or good by calculating the value of MAD

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(Mean Absolute Deviation) or by MSE (Mean Squared Error). The forecasting model is said to be good if the difference between the forecast and the actual data is very small.

Forecasting using the MA method estimates data based on moving time [1][2][3][4][5][6][7][8][9][10][11][12][13]. For example, predicting the price of shoes in March based on 3 months, then it will add up the price of shoes in January, February, and March, then the average is calculated. Meanwhile, the WMA method adds up the shoe prices in January, February, and March multiplied by the weight and divided by the total weight. Forecasting models using the MA, WMA, or ES methods will forecast shoe price data in motion based on the specified time. ES forecasting method also predicts in motion from the previous time data [14][15][16][17]. The three methods of MA, WMA, ES movingly predict future data based on the average value of past data.

Research that does forecasting using MA, WMA and ES methods is how to test its effectiveness with MAPE (Mean Absolute Percentage Error) [1], MSE [5][6], MAD [17]. Research related to forecasting using the MA and WMA methods shows that the results of prediction of monthly production using the WMA method are better with the MAPE 12.53% [1]. Other forecasting related to predicting the amount of inventory with WMA and Double ES. The results of forecasting both methods are analyzed using MSE. The smallest MSE result is the WMA method with a value of 0.114 [5]. Related research predicts the number of UPN Veteran Yogyakarta students using the MA method. The prediction results are analyzed for the error value with Mean Square Error (MSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE). The results of the forecasting show that the WMA method has the lowest MSE, MAE, MAPE values, with consecutive values of 5807.96, 55.89, 5.24% [6]. Other studies predict rice yields using the ES method. The accuracy of the predicted values was measured using MAD, MSE, and MAPE. The accuracy values of MAD MSE and MAPE, respectively, were 44.39, 18.29, and 16.68% [17].

From several previous studies, it was explained that the MA, WMA, and ES methods can be used for forecasting. We propose forecasting shoe prices using these three methods. Research objectives We analyze the effectiveness of these three methods in forecasting shoe prices. The effectiveness of a forecasting method is if the accuracy of the forecasting approaches the actual data, and the error difference is very small [1][5][6][17].

## 2. RESEARCH METHOD

The data used in this research were taken from the Kaggle dataset [18]. The data consists of several types of shoe brands from one year and processed only by the Adidas brand. The research process is in Figure 1.

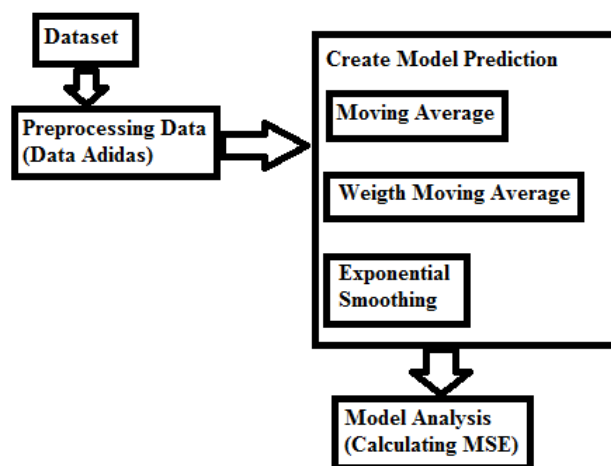


Figure 1. Research Process Diagram

Figure 1 illustrates that a dataset consisting of several lines of shoe brands is processed first. The data is only taken by the Adidas brand so that it becomes 229 rows of data. Price data for Adidas shoes are predicted using the MA, WMA, and ES methods. The prediction results are analyzed by calculating the MSE as in Equation 1.

$$MSE = \frac{\sum (T - F)^2}{n} \quad (1)$$

Explanation of Equation 1, T is the actual data on the price of Adidas shoes, and F is the result of the shoe price prediction from the three methods, and n is the number of data, n is 229.

This research, in predicting the price of Adidas shoes, uses Python in Jupyter Notebooks with the statsmodels library. This research will predict data based on references 2 previous times and 3 previous times.

The MA algorithm is an algorithm that predicts future data based on past data. The MA algorithm will add and divide data several times. Equation 2 is the process of calculating price predictions using MA. Equation 2 is  $F_t$  the predictive value of a certain time.  $Y_t, Y_{t-1}$  is the actual data from any given time.

$$F_t = \frac{Y_t + Y_{t-1} + Y_{t-n+1}}{n} \quad (2)$$

The WMA algorithm is almost the same as MA, but each data will be multiplied by the weight and divided by the number of weights. Equation 3 is a price prediction formula using WMA.

$$F_t = \frac{w_1 Y_t + w_2 Y_{t-1} + w_3 Y_{t-n+1}}{\sum w} \quad (3)$$

Equations 1 to 4, the symbol F is the predicted value, and the symbol T is the actual data. All Equations 2 to 4 explain that the prediction is based on time. The explanation of Equation 3 is almost the same as Equation 2 but only differs in the denominator. The sum of the actual data each time is multiplied by the weight divided by the total weight.

MA, WMA, and ES methods will predict data in motion over time based on the past time [1][5][6][17]. The process of the ES method in predicting in Equation 4.

$$F_t = F_{t-1} + (\alpha(Y_{t-1} - F_{t-1})) \quad (4)$$

As an explanation of Equation 4, the predicted data is symbolized by  $F_t$ . The prediction result data refers to the predictive data the previous time is symbolized  $F_{t-1}$  and the previous time actual data is symbolized  $Y_{t-1}$ .

**Table 1.** Price Prediction Process for Shoes 2 Time with MA

Time	Price of		2 Time Shoe Price Prediction
	Adidas Shoes		
1	399		0
2	375		$=(399+375)/2$ 258.00
3	89		$=(375+89)/2$ 154.67
4	99		$=(89+99)/2$ 62.67
5	275		$=(99+275)/2$ 124.67
6	899		$=(275+899)/2$ 391.33
7	275		$=(899+275)/2$ 391.33
8	189		$=(275+189)/2$ 154.67
9	300		$=(189+300)/2$ 163.00
10	115		$=(300+115)/2$ 138.33
11	399		$=(115+399)/2$ 171.33
12	249		$=(399+249)/2$ 216.00

**Table 2.** Price Prediction Process for Shoes 3 Time with MA

Time	Price of		3 Time Shoe Price Prediction
	Adidas Shoes		
1	399		0
2	375		0 0.00
3	89		$=(399+375+89)/3$ 215.75
4	99		$=(375+89+99)/3$ 140.75
5	275		$=(89+99+275)/3$ 115.75
6	899		$=(99+275+899)/3$ 318.25
7	275		$=(275+899+275)/3$ 362.25
8	189		$=(899+275+189)/3$ 340.75
9	300		$=(275+189+300)/3$ 191
10	115		$=(189+300+115)/3$ 151
11	399		$=(300+115+399)/3$ 203.5
12	249		$=(115+399+249)/3$ 190.75

**Table 3.** Price Prediction Process for Shoes 3 Time with WMA

Time	Price of		3 Time Shoe Price Prediction
	Adidas Shoes		
1	399		0
2	375		0 0.00
3	89		$=((399*1)+(375*2)+(89*3))/6$ 236.00

4	99	$=((375*1)+(89*2)+(99*3))/6$	141.67
5	275	$=((89*1)+(99*2)+(275*3))/6$	185.33
6	899	$=((99*1)+(275*2)+(899*3))/6$	557.67
7	275	$=((275*1)+(899*2)+(275*3))/6$	483.00
8	189	$=((899*1)+(275*2)+(189*3))/6$	336.00
9	300	$=((275*1)+(189*2)+(300*3))/6$	258.83
10	115	$=((189*1)+(300*2)+(115*3))/6$	189.00
11	399	$=((300*1)+(115*2)+(399*3))/6$	287.83
12	249	$=((115*1)+(399*2)+(249*3))/6$	276.67

### 3. RESULTS AND DISCUSSION

Table 1 describes an example of calculating the price prediction for Adidas shoes with MA 2 time. The prediction calculation process refers to Equation 2. For example, to predict the price of shoes for the 2nd time, it will add up the prices of the shoes at the 2nd and 1st time and then divide by 2. While Table 2 describes an example of calculating the prediction of Adidas shoe prices with MA 3 times. For example, if you predict the price of shoes for the 3rd time, you will add up the actual data for the 1st, 2nd, and 3rd time and then divide by 3.

Table 3 is an example of calculating shoe price predictions using the WMA method 3 times. The weights used are [1, 2, 3]. The actual data from each time is multiplied by the weight and divided by the total weight. For example, predicting the price of Adidas shoes for the 3rd time, then the 1st data multiplied by 1 is added to the 2nd data is multiplied by 2, and the sum of the 3rd data multiplied by 3 is all totaled and divided by the total weight equals 6.

Table 4 is an example of calculating shoe price predictions using the WMA method with 4 times. The weights used are [1, 2, 3, 4], the illustration of the calculation is as in Table 4. Table 5 is the result of predicting the price of Adidas shoes with the ES method. The second column is the actual price, and the last column is the ES prediction result. Table 6 describes the evaluation results of the three methods by calculating the MSE value. Each MSE of the three methods was used 2 times and 3 times. Table 7 is the actual data interface for the price of Adidas shoes and the prediction results using the MA method with 2 times, and 3 times and WMA with 3 times in a row for 13 times.

**Table 4.** Price Prediction Process for Shoes 4 Time with WMA

Price of Adidas Shoes	4 Time Shoe Price Prediction	
399	0	0
375	0	0
89	0	0
99	$=((399*1)+(375*2)+(89*3)+(99*4))/10$	181.20
275	$=((375*1)+(89*2)+(99*3)+(275*4))/10$	195.00
899	$=((89*1)+(99*2)+(275*3)+(899*4))/10$	470.80
275	$=((99*1)+(275*2)+(899*3)+(275*4))/10$	444.60
189	$=((275*1)+(899*2)+(275*3)+(189*4))/10$	365.40
300	$=((899*1)+(275*2)+(189*3)+(300*4))/10$	321.60
115	$=((275*1)+(189*2)+(300*3)+(115*4))/10$	201.30
399	$=((189*1)+(300*2)+(115*3)+(399*4))/10$	273.00

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249	$=((300*1)+(115*2)+(399*3)+(249*4))/10$	272.30
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The Graph of Prediction Results from the MA method with 2 times is as shown in Figure 2. Figure 2 describes the actual data in the red dot and the prediction results in the form of a blue line. Figure 3 is a graph of the prediction results with WMA 3 times. The actual data is in the form of a red dot and the prediction result is in the form of a blue line. Figure 4 is a graph of the prediction results of the ES method 3 times.

**Table 5.** Price Prediction Process for Shoes 3 Time with ES

	Price	Forecasting
0	399	394.628793
1	375	393.781057
2	89	365.659964
3	99	395.365656
4	275	394.517919
5	899	366.396826
6	275	396.102518
7	189	395.254782
8	300	367.133689
9	115	396.839380
10	399	395.991644
11	249	367.870551
12	115	397.576243

**Tabel 6.** MSE Value from the MA Method, WMA ES

Method	2nd Time	3rd Time	4th Time
MA	15484.68	24829.4	28099.41
WMA	7268.3	14239.7	18386.77
ES	-	38349.3	43102.42

**Table 7.** View of Jupyter Notebooks on Shoe Price Prediction Results with MA and WMA

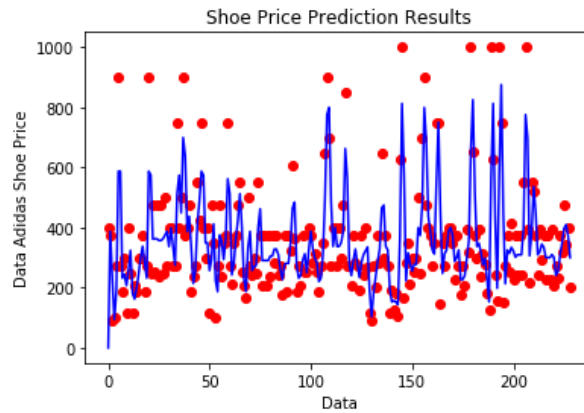
No	Price	MA 2	MA 3	WMA
1	399	0	0	0
2	375	387	0	0
3	89	232	287.67	0
4	99	94	187.67	181.2
5	275	187	154.33	195
6	899	587	424.33	470.8
7	275	587	483	444.6
8	189	232	454.33	365.4

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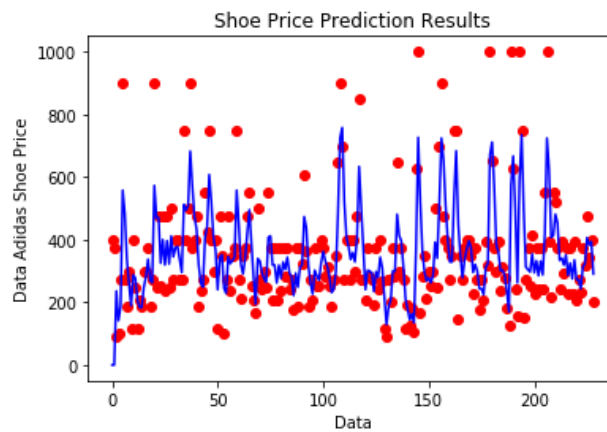
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9	300	244.5	254.67	321.6
10	115	207.5	201.33	201.3
11	399	257	271.33	273
12	249	324	254.33	272.3
13	115	182	254.33	212

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**Figure 2.** Graph of MA Method Prediction Results with 2 Times



**Figure 3.** Graph of WMA Method Prediction Results with 3 Times

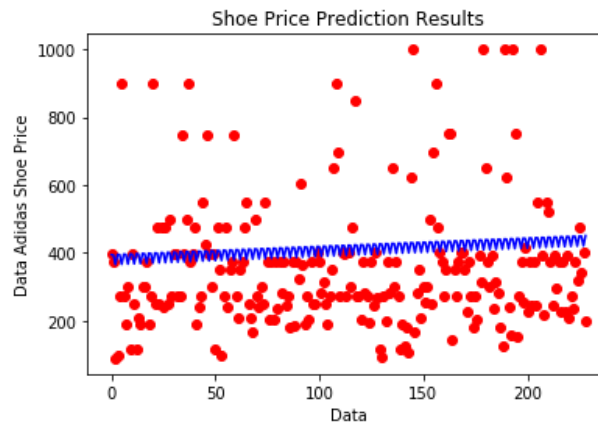


Figure 4. Graph of ES Method Prediction Results with 3 Times

#### 4. CONCLUSION

This research analyzes three forecasting methods, namely MA, WMA, ES. These three methods are used to predict shoe price data taken from the Kaggle dataset. This research calculates the average value of the data 2 times before and 3 times before. The analysis process of the performance of the three methods uses MSE. The MSE value of the three methods is MA with 2 times 15484.68, with 3 times 24829.42. The MSE value of the WMA method with 2 times is 7268.3 and 3 times is 14239.74. The MSE value of the ES method with 3 times is 38349.34, and 4 times is 43102.42. It is concluded that the lowest MSE value is the most effective method, the lowest MSE value in the WMA method with 2 times is 7268.3. So the most effective method of the three methods of MA, WMA, and ES is WMA 2 time.

It is expected that further research, in predicting data using the WMA method by analyzing some of the most effective times.

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