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Comparison of Double Exponential Smoothing Method with Weighted Moving Average in Forecasting UD Sales. Setya Abadi D. M as Financial Literacy

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Abstract:

Purpose:
UD. Setya Abadi D. M is a business unit focusing on the food industry, such as making frozen food (Maryam, churros, tortillas). In carrying out its production activities, this company certainly needs a strategy to compete with other competitors, one of which is forecasting. In this research, the data used is past product sales data from July 2021 to June 2023. This research aims to forecast sales in the future period in order to meet customer needs.

Methodology:
This data processing uses the weighted moving average and double exponential smoothing methods, which are then tested with the Mean Absolute Percent Error value. Forecasting with the lowest MAPE value is an effective method. The α value used in the double exponential smoothing method from 0.1 to 0.9 is chosen to have the lowest MAPE level: α = 0.6 and α = 0.7. Meanwhile, the weighted moving average method uses three months and four months.

Findings:
In the MAPE calculation, the results obtained for double exponential smoothing α = 0.6 are 6.45%, and α = 0.7 are 7.14%, while the moving average n = 3 is 13.59%, and n = 4 is 13, 48 %.

Implication:
It can be concluded that the lowest MAPE value was produced using the DES (Double Exponential Smoothing) method with $\boldsymbol{\alpha}$ = 0.6 with a MAPE value of 6.45%. This value is lower than DES $\boldsymbol{\alpha}$ = 0.7, 3-month WMA, and 4-month WMA with weights of 0.4, 0.3, 0.2, 0.1.

INTRODUCTION

Forecasting is an essential component of a business process system, from determining what products will be made, where they will be stored, and what quantities will be made. It depends on estimates of future demand, both from the size of production targets and labor scheduling (Aziza, 2022).

The main problem faced by business people is determining/forecasting the number of sales of goods in the future referring to previous sales data. According to Aziza (2022), the forecasting process influences business actors in deciding business steps by determining the quantity of goods produced that the company must prepare.

Referring to the SIINAS (National Industrial Information System) report launched by the Ministry of Industry as a forum for granting industrial permits such as IUI, IUP, and development reports (Destyarini & Tanaamah, 2021), Ud. Setya Abadi D. M reported a consistent sales escalation from semester 2 of 2021 to semester 1 of 2023. An increase also followed this in the number of raw materials, employees, and various types of products.

If you estimate naively (layman's approach), sales will increase from semester to semester in the following few semesters. However, remember that the products sold are frozen food such as kebabs, churros, and Maryam bread. So, a systematic forecasting method will determine sales quantity figures, influencing the number of products and how storage is prepared.

It is necessary to start considering sales forecasting to solve this issue. Sales forecasting predicts future buyer demand by applying several appropriate methods (Alfarisi, 2017).

Based on the problems above, find a suitable forecasting model for UD's business. Setya Abadi, using data from 4 consecutive semesters, this research implemented the Weighted Moving Average and Double Exponential Smoothing forecasting methods. According to Heizer Render (2020), this type of time series method assumes the

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data relationship occasionally. Then, the historical data will be projected for the future through a mathematical model (Sofiati et al., 2022).

According to Aprilyanta et al. (2022), a weighted moving average is a forecasting method that uses weights to estimate historical data for each data point. Double Exponential Smoothing uses small data with a constant smoothing factor chosen randomly.

Using these two methods, we can decide on the most appropriate forecasting method and have values close to reality (Atmaja et al., 2021) because inaccurate forecasting techniques will result in inaccurate predictions and bad decisions (Dwi et al., 2021). It will later be seen in an error level indicator in the form of MAPE (Mean Absolute Percent Error). The smaller the value of the MAPE indicator, the more efficient and precise the process of forecasting product sales UD, Setya Abadi, D. M.

Literature Review, Weighted Moving Average. Heizer (2020) said that forecasting using the moving average method will involve several actual data values to create a forecast. When data has a trend or pattern, weights are applied to confirm the actual value. It makes the moving average forecasting method more sensitive to changes or Blips because new data has a greater or weighted probability. However, the selection of weights is random because there is no formula for determining them.

The binding rule is that the weighting value must be higher for the latest data than for previous data (Aprilyanta et al., 2022).

Apart from that, it should be noted (Awaluddin et al., 2021) that when applying this method, it is recommended to use a short period to reduce inaccuracy in the forecasting.

The weighted average movement, according to Heizer and Render (2020), can be formulated as;

$$\text{Weighted Average Movement} = \frac{\sum(\text{Period weight n})(\text{Period request n})}{\sum \text{weight}}$$

Double Exponential Smoothing. The Double Exponential Smoothing method is a moving average forecasting method involving a minimum of data and a constant smoothing that the company manager decides (Heizer & Render, 2020). This method maintains previous data and is easy to use without requiring much data. Based on the journal from Kurniawan and Herwanto (2021), the Double Exponential Smoothing formula is shown with several of the following equations.

a. Determination of the first smoothing value (S't)

$$S'_t = a(X_t) + (1 - a)(S'_{t-1})$$

b. Determination of the first smoothing value (S"t)

$$S"_t = a(S'_t) + (1 - a)(S"_{t-1})$$

c. Determination of the constant (αt)

$$a_t = 2S't - S"t$$

d. Determining the amount of slope (bt)

$$b_t = \frac{\propto}{1 - \propto}(S't - S"t)$$

e. Determining the forecast value (F_7+m)

$$F_7 + m = a_t + b_t(m)$$

Constant Smoothing. Constant smoothing (α), according to Heizer & Render (2020), is a variable or weight determined by a forecaster with a value of more than or equal to 0 and less than or equal to 1. For business

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applications, it usually ranges between 0.05 and 0.50. It can be changed to place a higher load on new data or a lower load on previous data.

Average Absolute Percentage Error (MAPE). The use of MAD and MSE raises a problem: the forecasting value is based on how large the item is calculated and predicted. The MAD and MSE values will be enormous if forecasting goods are measured in thousands. Therefore, Heizer and Render (2020) applied the mean absolute percentage error (MAPE). According to Nabillah and Ranggadara (2020), MAPE is the average value of the absolute difference between the actual and forecast figures. Apart from that, it is also commonly known as the percentage value of the actual number.

Absolute Percentage Error (MAPE) calculations must be performed by identifying the absolute error for each data period used, dividing by the observed value during that period, and then finding the average of this absolute percentage. (Nabillah & Ranggadara, 2020), If the period is assumed to be n, MAPE is formulated as follows;

$$\text{MAPE} = \frac{\sum_{i=1}^{n} 100\ x \frac{|Aktual_i - Peramalan_i|}{Aktual_i}}{n}$$

METHODS

The data source used is overall sales data from UD, Setya Abadi D.m, from July 2021 to June 2023. The research method used by the author is a series of main steps in analyzing sales data using the Weighted Moving Average method, and Double Exponential Smoothing is written in the following image.

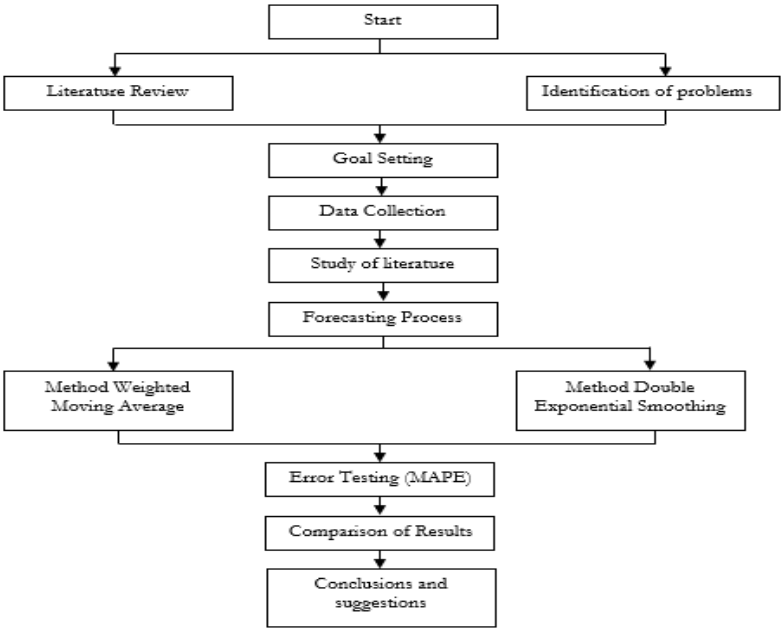

Figure 1. Weighted Moving Average and Double Exponential Smoothing stages

In making sales forecasting decisions from UD. Setya Abadi D.N. uses descriptive analysis by creating systematic descriptions or presentations related to UD sales forecasting. Setya Abadi D.M. is supported by related mathematical models that will be used to make optimal company decisions.

RESULTS AND DISCUSSION

Direct interviews with company owners Ud obtained research data. Setya Abadi D. M refers to the company report on the SIINAS (National Information System) website from July 2021 to June 2023.

Table 1. Sales Data

Period	Month	Amount	Period	Month	Amount

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1	2021 July	1.787	13	2022 August	4.158
2	2021 September	2.314	14	2022 September	3.367
3	2021 October	2.086	15	2022 October	3.523
4	2021 November	2.446	16	2022 November	3.081
5	2021 December	2.560	17	2022 December	3.675
6	2022 January	3.600	18	2023 January	3.890
7	2022 February	3.543	19	2023 February	3.564
8	2022 March	3.120	20	2023 March	4.286
9	2022 April	3.592	21	2023 April	3.219
10	2022 May	4.087	22	2023 May	2.966
11	2022 June	4.210	23	2023 June	3.447
12	2022 July	3.256			

After obtaining the required data, the forecasting process is carried out using these two methods. However, forecasting will be carried out for the first time using the 3-month weighted moving average method with a constant of 0.3, 0.2, 0.1, and 4 monthly with a constant of 0.4, 0.3, 0.2, and 0.1.

Calculate the 3-month Weighted Moving Average.

$$MA_4 = \frac{(0,3)(A_3)+(0,2)(A_2)+(0,1)(A_1)}{0,6} = \frac{(0,3)(2086)+(0,2)(2314)+(0,1)(1787)}{0,6} = 2112$$

$$MA_5 = \frac{(0,3)(A_4)+(0,2)(A_3)+(0,1)(A_2)}{0,6} = \frac{(0,3)(A_4)+(0,2)(A_3)+(0,1)(A_2)}{0,6} = 2304$$

Table 2. 3 Month WMA Forecast

Period	Month	Actual Value	3-Month Forecasting Value
1	2021 July	1.787	
2	2021 September	2.314	
3	2021 October	2.086	
4	2021 November	2.446	2.112
5	2021 December	2.560	2.304
6	2022 January	3.600	2.443
7	2022 February	3.543	3.061
8	2022 March	3.120	3.398
9	2022 April	3.592	3.341
…	….	…..	……
20	2023 March	4.286	3.691
21	2023 April	3.219	3.979
22	2023 May	2.966	3.632
23	2023 June	3.447	3.270

Calculate the 4-month Weighted Moving Average.

$$MA_5 = \frac{(0,4)(A_4)+(0,3)(A_3)+(0,2)(A_2)+(0,1)(A_1)}{1,0} = \frac{(0,4)(2446)+(0,3)(2086)+(0,2)(2314)+(0,1)(1787)}{1,0} = 2246$$

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$$MA_6 = \frac{(0,4)(A_5)+(0,3)(A_4)+(0,2)(A_3)+(0,1)(A_2)}{1,0} = \frac{(0,4)(2560)+(0,3)(2446)+(0,2)(2086)+(0,1)(2314)}{1,0} = 2406$$

Table 3. 4 Monthly WMA Forecast

Period	Month	Actual Value	4 Month Forecasting Value
1	2021 July	1.787	
2	2021 September	2.314	
3	2021 October	2.086	
4	2021 November	2.446	
5	2021 December	2.560	2.246
6	2022 January	3.600	2.406
7	2022 February	3.543	2.906
8	2022 March	3.120	3.254
9	2022 April	3.592	3.287
…	….	…..	……
20	2023 March	4.286	3.636
21	2023 April	3.219	3.929
22	2023 May	2.966	3.675
23	2023 June	3.447	3.366

Calculate the Error Indicator with the MAPE Value. After the data is processed, a hardness test will be carried out using the MAPE indicator.

Table 4. MAPE Test from WMA Forecasting

Period	3 Monthly WMA		WMA 4 Monthly	
	(At-Ft)/At*100	[(At-Ft)/At*100]	(At-Ft)/At*100	[(At-Ft)/At*100]
1				
2				
3				
4	13,65	13,65		
5	10,00	10,00	12,28	12,28
6	32,14	32,14	33,16	33,16
7	13,60	13,60	17,98	17,98
8	-8,92	8,92	-4,29	4,29
9	6,99	6,99	8,49	8,49
…	…	…	…	…
20	13,88	13,88	15,17	15,17
21	-23,62	23,62	-22,06	22,06
22	-22,46	22,46	-23,91	23,91
23	5,13	5,13	2,36	2,36
	MAPE	**13,59**	**MAPE**	**13,48**

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Determine the Alpha Value. After the data is collected, the next step is processing the data using the double exponential smoothing method and the moving average method. The α value taken from Brown's double exponential smoothing method is the α value with the lowest two error values from 0.1 to 0.1. 0.9 is obtained for the α value, which has the lowest error value: α = 0.6 and α = 0.7.

Table 5. Alpha Test with MAPE

No.	Alpha	MAPE	No.	Alpha	MAPE
1	0,1	21,46	6	0,6	13,28
2	0,2	16,05	7	0,7	13,38
3	0,3	14,65	8	0,8	13,56
4	0,4	13,73	9	0,9	13,81
5	0,5	13,46			

Calculating double Exponential Smoothing with $\alpha = 0.6$.

1) Determination of the first Smoothing value (S't)

$$S'3 = (0{,}6 \times 2086) + (1\text{-}0{,}6)\ (2314) = 2177$$

2) Determination of the second Smoothing value (S't)

$$S''3 = (0{,}6 \times 2177) + (1\text{-}0{,}6)\ (1787) = 2021$$

3) Determination of constant quantities (a)

$$A_3 = (2 \times 2177)\text{-}2177 = 2333$$

4) Determination of slope quantity (b)

$$B3 = \frac{0{,}6}{1-0{,}6}\ (2177 - 2021) = 234$$

5) Determination of the forecast quantity (Ft + m)
For t = 3 and m = 1

$$F3+1 = 2333 + 234(1) = 2567$$

Table 6. Forecasting DES Method 0.6

Period	Month	Actual Value	S't	S''t	A	b	Ft
1	2021 July	1.787					
2	2021 September	2.314	1.787	1.787	1787	0	1.787
3	2021 October	2.086	2.177	2.021	2.333	234	2.567
4	2021 November	2.446	2.302	2.252	2351,92	74,88	2.427
5	2021 December	2.560	2.514	2.429	2599,36	127,44	2.727
6	2022 January	3.600	3.184	2.916	3451,84	401,76	3.854
7	2022 February	3.543	3.566	3.413	3718,52	229,08	3.948
8	2022 March	3.120	3.289	3.400	3178,56	-165,96	3.013

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9	2022 April	3.592	3.403	3.358	3448,8	68,4	3.517
..	…..	…..	…..	…..	….	….	…..
20	2023 March	4.286	3.997	3.876	4118,32	181,68	4.300
21	2023 April	3.219	3.646	3.786	3505,24	-210,84	3.294
22	2023 May	2.966	3.067	3.299	2835,76	-347,16	2.489
23	2023 June	3.447	3.255	3.180	3329,56	112,44	3.442

Calculating Double Exponential Smoothing with $\alpha = 0.7$.

1) Determination of the first Smoothing value (S't)

$$S'3 = (0,7 \times 2086) + (1-0,7)\ (2314) = 2154$$

2) Determination of the second Smoothing value (S't)

$$S''3 = (0,7 \times 2154) + (1-0,7)\ (1787) = 2044$$

3) Determination of constant quantities (a)

$$A3 = (2 \times 2154) - 2044 = 2264,02$$

4) Determination of slope quantity (b)

$$B3 = \frac{0,7}{1-0,7}\ (2154 - 2044) = 257,18$$

5) Determination of the forecast quantity (Ft + m)
For t = 3 and m = 1

$$F3+1 = 2264,02 + 257,18(1) = 2522$$

Table 7. Forecasting DES 0.7

Period	Month	Actual Value	S't	S"t	a	b	Ft
1	2021 July	1.787					
2	2021 September	2.314	1.787	1.787	1.787,00	-	1.787
3	2021 October	2.086	2.154	2.044	2.264,62	257,18	2.522
4	2021 November	2.446	2.338	2.283	2.393,08	128,52	2.522
5	2021 December	2.560	2.526	2.469	2.582,14	131,46	2.714
6	2022 January	3.600	3.288	3.059	3.516,66	533,54	4.050
7	2022 February	3.543	3.560	3.478	3.641,73	190,47	3.832
8	2022 March	3.120	3.247	3.341	3.152,94	- 219,24	2.934
9	2022 April	3.592	3.450	3.389	3.511,45	142,45	3.654
..	…..	…..	….	…..	….	….	…..
20	2023 March	4.286	4.069	3.947	4.191,68	285,32	4.477
21	2023 April	3.219	3.539	3.698	3.380,01	- 371,21	3.009
22	2023 May	2.966	3.042	3.191	2.892,74	- 348,04	2.545
23	2023 June	3.447	3.303	3.224	3.380,94	182,56	3.564

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Calculate the Error Indicator with the MAPE Value. After the data is processed, a hardness test will be carried out using the MAPE indicator.

Table 8. MAPE Test from DES Forecasting

Period	DES 0,6		DES 0,7	
	(At-Ft)/At*100	[(At-Ft)/At*100]	(At-Ft)/At*100	[(At-Ft)/At*100]
1				
2	22,77	22,77	22,77	22,77
3	-23,08	23,08	-20,89	20,89
4	0,78	0,78	-3,09	3,09
5	-6,52	6,52	-6,00	6,00
6	-7,04	7,04	-12,51	12,51
7	-11,42	11,42	-8,16	8,16
8	3,44	3,44	5,97	5,97
9	2,08	2,08	-1,72	1,72
…	…	…	…	…
20	-0,33	0,33	-4,46	4,46
21	-2,34	2,34	6,53	6,53
22	16,10	16,10	14,20	14,20
23	0,15	0,15	-3,38	3,38
	MAPE	**6,45**	**MAPE**	**7,14**

Recapitulation of MAPE Values.

Table 9. Recapitulation of MAPE Values

No.	Method	MAPE
1	WMA 3 Monthly	13,59
2	WMA 4 Monthly	13,48
3	DES 0,6	6,45
4	DES 0,7	7,14

Based on Table 1, product sales from Ud. Setya Abadi D. M has a trend data pattern because of sales of Ud products. Setya Abadi D. M has an increase in certain months and a decrease in certain months. If you look at the table, the number of product sales per semester from Ud. Setya Abadi D. M has increased from each semester to the next, with sales decreasing each semester in the third or fourth month since the 2021 period.

1. Forecasting Weighted Moving Average method. The recapitulation results were obtained from the 3-month and 4-month weighted moving average calculations in Table 2 and Table 3, and then these results were continued to obtain the error values for each period. In Table 4, error values are obtained from the 3-month weighted moving average calculation results with a constant of 0.1, 0.2, 0.3, and the 4-month weighted moving average calculation with a constant of 0.1, 0.2, 0.3, 0.4 each period. Then, this error value can produce MAPE values of 13.59% and 13.48%, respectively, in the recapitulation, seen in Table 9.
2. Forecasting using the Double Exponential Smoothing method. The recapitulation results obtained from the double exponential smoothing calculation α = 0.6 and α = 0.7 in Table 6 and Table 7. Then, these results are used to calculate the error value for each period. Table 8 is the error value obtained from the calculation results

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of double exponential smoothing α = 0.6 and α = 0.7 in each period. Then, this error value can produce MAPE values of 6.45% and 7.14%, respectively. This value can be seen in the recapitulation in Table 9.

A comparison of the MAPE values of the two methods for future forecasting can be seen at the smallest MAPE value. The MAPE value is obtained from the 3-month and 4-month weighted moving average forecast with values of 13.59% and 13.48%, respectively. Meanwhile, the MAPE value for the double exponential smoothing method with α = 0.6 and α = 0.7 is 6.45% and 7.14%, respectively. Based on a comparative analysis of the two methods, the appropriate method for forecasting product sales at Ud. Setya Abadi D. M is Double Exponential Smoothing α = 0.6 with a MAPE value of 6.45% because from this type of data, sales data is Ud. Setya Abadi D. M has a trend type of data. It is because the data has increased and decreased in certain months.

CONCLUSION

In knowing the sales figures for Ud products. Setya Abadi D. M, a forecast must be carried out to see how much the company's product sales will be in the future. Based on the calculation results above, it can be concluded that the lowest MAPE value was produced using the DES (Double Exponential Smoothing) method with α = 0.6 with a MAPE value of 6.45%. This value is lower than DES α = 0.7, 3-month WMA, and 4-month WMA with weights of 0.4, 0.3, 0.2, 0.1.

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