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Forescating the Amount of Corn Production in North Sumatra Based on 2017 – 2021 Data Using The Single and Double Exponential Smoothing Method (Case Study of Central Bureau of Statistics of North Sumatra)

Syaiful Amri Saragih[1], Asritanarni Munar[2], Wilda Rina Hasibuan[3*]

[1,2]Department of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Sumatera Utara, Medan, Indonesia

[3]Department of Computer Science, Faculty of Computer Science and Information Technology, Universitas Muhammadiyah Sumatera Utara, Medan, Indonesia

[*]wildarinahasibuan77@gmail.com

Abstract

North Sumatra Province has high potential in the management and marketing of corn (Zae Mays) crops. Cultivation of corn plants is a superior product where the largest income is obtained from the sale of commodities and their processing so that they can assist the government in improving the economy. This study aims to determine the yield of corn in North Sumatra Province in the coming year. Data collection for this study uses secondary data, namely primary data obtained from other parties which are generally made in the form of tables and diagrams. Data obtained from the Central Bureau of Statistics of North Sumatra for corn production in 2017 was 1,741,257 tons, corn production in 2018 was 1,710,784 tons, corn production in 2019 was 1,960,424 tons, corn production in 2020 was 1,965. 444 tons, corn production in 2021 is 1,724,398 tons. To find out the increase in corn production, the consideration and comparison of the forecasting methods needed to minimize forecast errors that aim to approach reality are the single and double exponential smoothing methods with one parameter from Brown.

Keywords: *Corn Production, North Sumatra Province, Single Exponential Smoothing, Double Exponential Smoothing*

1. Introduction

Inventory control is a technique related to determining the amount of material inventory that must be procured to ensure smooth operation of production activities, as well as determining procurement schedules and the number of orders for goods that should be made by the company [1] Single Exponential Smoothing The forecasting method used in this study is the single exponential smoothing method. Methods the moving-average method which gives stronger weight on recent data than the initial data. Single exponential smoothing will always follow every trend in real data [2], because they can do no more than regulate the upcoming forecast by a percentage of the last error. Past forecast errors are used to correct for the next forecast in the opposite direction to the error [3] This approach is subject to large forecasting errors because the errors are squared. MSE provides better accuracy than MAD so it is widely used in weighting optimization [4] discusses the Double Exponential Smoothing method, Weighted Moving Average, Moving Average, Time Series, and trend projections. Error calculations in this research use MAE, MAPE, and MSE. The conclusion of this research is that the Double Exponential Smoothing method is considered better because it has the smallest MSE, MAE and MAPE values compared to the other two methods with MSE values of 968877.92, MAPE of 1.3% and MAE of 14372.35 [5].

As the second most produced food after rice, corn's high demand as animal feed and for industrial purposes poses challenges such as depletion of natural resources and the impact of climate change. Cooperation and collaboration are required to support the development of sustainable corn commodities [4]. However, the problem of land-carrying capacity is a constraint for Indonesian agriculture. As the population increases, more land is needed to meet housing demands, leading to the conversion of agricultural land and affecting corn productivity in the country. Despite a fluctuating rise in production in Indonesia between 1980 and 2019, the overall increase was only 3.98 tons/ha/year or 0.102% per year [6]

Thirty years ago, maize was primarily consumed as food. However, with the development of the poultry industry in the early 1970s, corn began to be used as an energy source for modern poultry feed [7] Before 1990, it was shown that 86% of this crop in Indonesia was consumed directly, and only about 6% was used in the feed industry. Despite this, the adoption of maize in the food industry remains low, accounting for only 7.5% [8]. The availability of this commodity is wider in the rainy than dry season [9]. This research aims to see the

development of corn yields using a forecasting method, namely using past data to predict the future. In this research, the data used is secondary data obtained from the North Sumatra Central Statistics Agency for corn production in 2017 – 2021.

2. Research Methods

2.1. Data collection

The literature study method is a series of activities to obtain data/information by gathering information from reference books, journals, and so on.

A. Single Exponential Smoothing Method

The Single Exponential Smoothing method explains that the data experiences instability around a stable average value, without a growth pattern or trend. The predicted value can be searched using Equation 1 [10].
Single Exponential Smoothing Formula:
$Ft=\alpha Xt-1+(1-\alpha)Ft-1(1)$
Where:
α = Parameter value of $0<\alpha<1$
$Xt-1$= Actual value at time (t-1)
$Ft-1$= Predicted value at time (t-1)
Ft = Predicted value at time t

B. Double Exponential Smoothing Method

The Double Exponential Smoothing method is used for data that shows trends. The initialization process uses Equation 2-3 and the predicted value can be found using Equation 4-8 [10].
Double Exponential Smoothing Formula:
$S't=\alpha Xt+(1-\alpha)S't-1(4)$
$S''t=\alpha S't+(1-\alpha)S''t-1(5)$
$aT=2S't-S''(6)$
$bT=\alpha 1-\alpha(S't-S''t)(7)$
$Ft=aTt-1+bTt-1(8)$

2.2. Secondary Data Method

Secondary data is primary data obtained by other parties which are generally presented in the form of tables or diagrams.

3. Data Analysis Method

Making a Scatter Diagram Before forecasting, the first step in analyzing the data is to make a scatter diagram. Making a scatter diagram with the help of Microsoft Excel with the base year as the abscissa axis and sales volume as the ordinate axis.

Choose a suitable Exponential Smoothing Method. The exponential smoothing method used is the Single Exponential Smoothing and Double Exponential Smoothing Methods. Where the data used is data that uses an upward trend.

Determine the forecasting equation using the Single Exponential Smoothing and Double Exponential Smoothing formulas.

Design Accuracy of Forecasting Method Accuracy in the forecasting process is fundamental to forecasting, namely by measuring the degree of suitability of a particular forecasting method for a collection of data. In time series modeling, it is possible to determine the past to predict/forecast situations that will occur in the future. Several criteria for testing the accuracy of forecasting are:

a. Mean Error (ME) / Middle Value Error
b. Mean Square Error (MSE) / Middle Value of Squared Error
c. Mean Absolute Error (MAE) / Middle Value of Absolute Error
d. Mean Percentage Error (MPE) / Middle Value of Percentage Error
e. Mean Absolute Percentage Error (MAPE)
f. Sum Square Error (SSE) / Sum of Squared Errors

Significance level At this significance level, alpha $0<\alpha<1$ is used. This is done to produce the smallest MSE value of the alpha tested, because the smaller the error value, the better the forecast.

4. Results And Discussion

Calculation of Goods Forecasting Using the Single Exponential Smoothing Method The process of calculating goods forecasting data Corn Production Data for North Sumatra Province in 2017 - 2021 can be seen in the Table. 1. By obtaining actual values for the period 2017-2021, production data can be predicted for 2022. Forecasting in this study uses the values $\alpha = 0.1$, $\alpha = 0.2$, $\alpha = 0.3$, $\alpha = 0.4$ and $\alpha = 0.5$. To get the best alpha value, you have to find the error value by calculating or measuring the error, mean absolute error, mean squared error. Later α which has the smallest error value will be chosen. Forecasting accuracy results with $\alpha = 0.1$ can be seen in Table 2. Forecasting accuracy results with $\alpha = 0.2$ can be seen in Table 3. Forecasting accuracy results with $\alpha = 0.3$ can be seen in Table 4. Forecasting accuracy

results with α = 0.4 can be seen in Table 5. The results of forecasting accuracy with α = 0.5 can be seen in Table 6. The following is the single exponential smoothing formula.

Table 1: Data on corn production for the province of North Sumatra 2017 - 2021

Periode (t)	Year	Production (ton)
1	Year 2017	1.741.257
2	Year 2018	1.710.784
3	Year 2019	1.960.424
4	Year 2020	1.965. 444
5	Year 2021	1.724.398

Table 2: Forescating accuracy results α = 0.1

Year	Produktion $A_{(t-1)}$	Forecast (α = 0.1)	*Error*	*Mean Absolute Error*	*Mean Squared Error (MSE)*
Year 2017	1.741.257	1,741,257	0	0	0
Year 2018	1.710.784	1,741,257	-30473	30473	928603729
Year 2019	1.960.424	1,738,210	222214	222214	49379195124
Year 2020	1.965. 444	1,760,431	205013	205013	42030276866
Year 2021	1.724.398	1,780,932	-56534	56534	3196140306
Total			340220	514235	95534216025
Average			28352	42853	7961184669

Table 3: Forescating accuracy results α = 0.2

Year	Produktion $A_{(t-1)}$	Forecast (α = 0.)	*Error*	*Mean Absolute Error*	*Mean Squared Error (MSE)*
Year 2017	1.741.257	1,741,257	0	0	0
Year 2018	1.710.784	1,741,257	-30473	30473	928603729
Year 2019	1.960.424	1,735,162	225262	225262	50742788435
Year 2020	1.965. 444	1,782,653	182791	182791	33412710537
Year 2021	1.724.398	1,801,434	-77036	77036	5934499691
Total			300544	515562	91018602392
Average			25045	42963	7584883533

Table 4: Forescating accuracy results α = 0.3

Year	Produktion $A_{(t-1)}$	Forecast (α = 0.)	*Error*	*Mean Absolute Error*	*Mean Squared Error (MSE)*
Year 2017	1.741.257	1,741,257	0	0	0
Year 2018	1.710.784	1,741,257	-30473	30473	928603729
Year 2019	1.960.424	1,732,115	228309	228309	52124953819
Year 2020	1.965. 444	1,804,874	160570	160570	25782728111
Year 2021	1.724.398	1,821,935	-97537	97537	9513464613
Total			260869	516889	88349750273
Average			21739	43074	7362479189

Table 5: Forescating accuracy results α = 0.4

Year	Produktion $A_{(t-1)}$	Forecast (α = 0.)	*Error*	*Mean Absolute Error*	*Mean Squared Error (MSE)*
Year 2017	1.741.257	1,741,257	0	0	0
Year 2018	1.710.784	1,741,257	-30473	30473	928603729
Year 2019	1.960.424	1,729,068	231356	231356	53525691278
Year 2020	1.965. 444	1,821,610	143834	143834	20688139009
Year 2021	1.724.398	1,879,144	-154746	154746	23946252714
Total			189971	560409	99088686730
Average			15831	46701	8257390561

Table 6: Forescating accuracy results α = 0.5

Year	Production $A_{(t-1)}$	Forecast (α = 0.)	*Error*	*Mean Absolute Error*	*Mean Squared Error (MSE)*
Year 2017	1.741.257	1,741,257	0	0	0
Year 2018	1.710.784	1,741,257	-30473	30473	928603729
Year 2019	1.960.424	1,726,021	234404	234404	54945000812
Year 2020	1.965. 444	1,843,222	122222	122222	14938156173
Year 2021	1.724.398	1,904,333	-179935	179935	32376649209
Total			146217	567033	103188409923
Average			12185	47253	8599034160

Actual value of time series ‘t − 1 :
Forecast at time t−1 (previous time).

1. Determine the value of Double Exponential Smoothing (*S*"t) *S*"t = α *S* 't + (1−α)*S*"t − 1 (2)
   Where, the following description:
   S"t : Double Exponential Smoothing
   α : Alpha (parameter between 0 and 1)
   *X*t + (1−α) : Actual value of time series
   S"t − 1 : Forecasting at time t−1 (previous time)
2. Determine the value of αt αt = 2
   S' t − *S*"t (3) Where, the description is as follows: αt : Constant *S* 't : Single Exponential Smoothing *S*"t : Double Exponential Smoothing
3. Determine the value of βt βt = *S*'t − *S*"t (4)
   Where, the description is as follows: βt : Constant α : Alpha (parameter between 0 and 1)
   't : Single Exponential Smoothing *S*"t : Double Exponential Smoothing
4. Determine Forecasting Results *S*t + m = αt βt (5)
   Where, the description is as follows: *S*t + m : Result of forecasting – m m : Number of future periods to be forecast αt : Constant βt : Coefficient of trend
5. Determining the Mean Absolute Percentage Error (MAPE) Mean Absolute Percentage Error (MAPE) is an evaluation calculation , MAPE is used to measure how precise or accurate a prediction is used. The following is the MAPE calculation formula and the MAPE criteria are in Table 2. MAPE = ∑ |ˆ| (6) Where, information as follows: ŷ : Forecasting results yi : Actual value n : Amount of data tested.placing them in the middle of columns. Any table or figure that takes up more than 1 column width must be positioned either at the top or at the bottom of the page

Photos must be crystal clear with such resolution to allow fine details visibility. The elements from any photo must be explained using numbers, letters, etc. The text within a figure or photo must have the same style, shape and height as the caption has.
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Table 7: Forescating accuracy results α = 0.4 Doubel Exponential Smoothing

Year	Production (ton)	S’	S”	at	bt	Forecast	E	E^2
2017	1.741.257	1,741,257	1,741,257	1,741,257	-	1,741,257	-	-
2018	1.710.784	1,741,257	1,741,257	1,741,257	-	1,741,257	-	-
2019	1.960.424	1,729,068	1,736,381	1,721,754	(4,876)	1,716,879	(7,314)	53,487,575
2020	1.965. 444	1,821,610	1,770,473	1,872,748	34,092	1,906,839	51,137	2,615,031,224
2021	1.724.398	1,879,144	1,813,941	1,944,346	43,468	1,987,815	65,203	4,251,368,406
				Total				6,919,887,205

4. Conclusions

The alpha value used in the calculation of corn production has the smallest MSE (*Mean Squared Error)* Value of alpha = 0.3 with total value 88349750273 for Single Exponential Smoothing. While for Double Exponential Smoothing the MSE (*Mean Squared Error)* value at alpha = 0.4 is 2,306,629,068.

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