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Cacao (Theobroma cacao) Production Forecasting in Lampung Province with the Double Exponential Smoothing Method

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A B S T R A C T

Cacao (Theobroma cacao) is one of the Indonesian plantation commodities which can be processed into cacao and chocolate products which contain natural antioxidants. In Lampung, the cacao commodity is very superior because every year it has significantly increased and cocoa production is one of the plantation commodities that has contributed to the export development of Lampung Province. In this case, forecasting can be used to estimate that cacao production will always experience an increase or decrease. Another function is to provide information for farmers and the government. Forecasting uses the Double Exponential Smoothing method because the technique is suitable for forecasting with trend patterns and for the long term. The results and discussion of this research is that cacao production has increased in forecasting for 10 years with good MAPE criteria, namely 10.81484. From the discussion above, forecasting cocoa production using the Exponential Smoothing method, namely the Double Exponential Smoothing technique assisted by R software, is suitable for use because it produces good forecasts and a low forecasting accuracy value.

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INTRODUCTION

Cocoa (*Theobroma cacao*) is one of the commodities produced by Indonesian plantations which can be processed into cocoa and chocolate products which contain natural antioxidants (Sari et al., 2015). Apart from that, cocoa is also a plantation commodity for the Indonesian export market which is very important as a foreign exchange earner besides natural gas and oil. In 2020, the area of cocoa plantations will be 1.51 million hectares, and cocoa bean production will increase to 720.66 thousand tons or 1.92 percent. An obstacle to cocoa development in Indonesia is the selection of land for cocoa plantations that does not take into account soil and climate conditions that are suitable for the growth of cocoa plants, where the soil's ability to support cocoa production and expansion is not achieved optimally (Arifin & Supriyatna, 2023).

One of the cocoa bean producing areas in Indonesia is Lampung Province. This province is the third largest smallholder cocoa bean producing area on the island of Sumatra after West Sumatra and Aceh with production and area of 56,671 tons and 78,701 ha respectively in 2021. Almost all (94%) of the cocoa plantations in that area is belongs to the people (Mulia Sari et al., 2017). Tanggamus Regency is one of the cocoa production centers in Lampung Province, which ranks first with the largest land area in Lampung Province. Cocoa plantations are spread across all sub-districts and Bulok Sub-district is one of the sub-districts where the majority of the population engages in cocoa farming, although it is not the highest in terms of land area and production. More precisely, Bulok District is the district with the fourth largest land area and production in Tanggamus Regency (Anggraeni et al., 2019).

Even though cocoa production always increases every year, it must be followed by good management of cocoa commodity productivity for the government, especially Lampung Province. This is because one of the plantation commodities that is very important for the economy of Lampung Province is cocoa. Cocoa is one of the plantation commodities that contributes to the development of Lampung Province's exports. Lampung Province's cocoa trade is mostly aimed at export. This is done because of the high level of world market demand and the price of cocoa on the world market which is relatively higher than the domestic price, therefore cocoa farmers and traders prefer to export cocoa (Widuri Prameswita, R Hanung Ismono, 2014).

Therefore, forecasting cocoa production can provide anticipation to help predict whether the amount of production will always increase or decrease in the future. Forecasting is also a science and art that can make predictions in the future (Indah & Rahmadani, 2018). When forecasting, past data is used in the forecasting calculation process (Lukiastuti, 2011). Forecasting consists of two methods, namely quantitative methods and qualitative methods. In this research, researchers used quantitative forecasting methods, quantitative methods consisting of time series models (Time Series) and regression models (Regression). Techniques in time series analysis also consist of moving average, exponential smoothing, decomposition, ARIMA (BoxJenkins) method and regression method.

Researchers use the Exponential Smoothing method, because the exponential smoothing method can provide forecasting with a moving average that is quite good and easy to use. In addition, the exponential smoothing method also has several advantages, including a significant reduction in data storage problems. As a result, there is no need to store all the historical data of the last observation, last forecast, and constant values that must be stored. This method only uses a small amount of past data and is used to predict data in the future (Spyros Makridakis, Steven C. Wheelwright, 1999). This method provides weights based on level (a), trend (β), and seasonality (γ), which is a constant or weight. The smoothing that will be selected later, the values of a, β, γ are between 0 and 1 (Ardiansah et al., 2021).

The Exponential Smoothing method also consists of Single Exponential Smoothing, Double Exponential Smoothing, and Triple Exponential Smoothing, of which the researcher will later choose these three to compare which of the three types is appropriate to use. In a forecasting value, one must also look at a small forecast error value, so that the forecasting value is close to high forecasting accuracy. Based on the explanation above, the researcher aims to conduct research to predict cocoa production in Lampung Province using the Double Exponential Smoothing method.

THEORETICAL REVIEW

Exponential Smoothing Method

Exponential Smoothing methods also have several advantages, including a significant reduction in data storage problems. As a result, there is no need to store all the historical data of the last observation, last forecast, and constant values that must be stored. In forecasting, the Exponential Smoothing method is one of the methods that is often used because it has quite good method accuracy, is simple, and efficient in carrying out forecast calculations (forecasting), is quite easy to adjust data and has a fairly high level of accuracy and has sophisticated weighting values.

Double Exponential Smoothing

This method is a development of Single Exponential Smoothing (Holt's Method), where the trend element is added to the calculation weight (Alfarisi, 2017). So on This method uses two types of weights in its calculations, namely level (α) and trend (β). The Double Exponential Smoothing method is usually more accurate for forecasting data experiencing an upward trend (Kurniagara, 2017). Mathematical form of Double Exponential Smoothing is as follows:

Overall Smoothing

$$A_t = aY_t + (1 - a)(A_{t-1} + T_{t-1})$$

Trend Smoothing

$$T_t = \beta(A_t - A_{t-1}) + (1 - \beta)T_{t-1}$$

Forecast

$$F_{t+m} = A_t + T_t m$$

Information:
A_t = Exponential Smoothing Value
α = Smoothing Constant for data (0 < α < 1)
β = Smoothing Constant for trend estimation
(0 < β < 1)
Y_t = Actual Value in Period t
T_t = Trend Estimation
F_{t+m} = Forecast Value
m = The number of future periods that will be predicted

MAE (Mean Absolute Error)
The average absolute value of the prediction error is known as MAE (not to be ignored positive or negative sign) (Yudaruddin, 2019).

$$MAE = \sum_{t=1}^{n} \frac{|X_t - Y_t|}{n}$$

Atau

$$MAE = \sum_{t=1}^{n} \frac{|actual - forecasting|}{n}$$

Information:
$X_t - Y_t$ = the difference between the actual data value and the forecast for period t
n = data period

MSE (Mean Squared Error)
MSE can measure the average squared difference between predicted values and actual values. And MSE is a second method for evaluating an overall forecasting error.

$$MSE = \sum_{t=1}^{n} \frac{(X_t - Y_t)^2}{n}$$

Atau

$$MSE = \sum_{t=1}^{n} \frac{(Forecasting\ Errors)^2}{n}$$

MAPE *(Mean Absolute Percentage Error)*

The average absolute difference between the estimated value and the actual value is expressed as a percentage of the actual value. So it is used to calculate MAPE. If it has values for n periods, both predicted and actual values.

$$MAPE = \frac{100\%}{n}\sum_{t=1}^{n}\frac{|X_t - Y_t|}{X_t}$$

Atau

$$MAPE = \sum absolute\ percent\ error$$

Information:

X_t = actual data in period t

Y_t = forecasting value in period t

n = amount of data

METHODOLOGY

This research was conducted with a sample, namely cocoa production in Lampung Province with a population from historical data from 2000-2021. The data collection technique used is secondary data, which is data collected indirectly. This research uses secondary data from the Lampung Province BPS website. To carry out forecasting using the Double Exponential Smoothing method which is carried out with the help of the R Software application.

The R software application is a free application with a programming language and open software environment for statistical computing and graphics. The advantage of using R software is that it is easy to create quality plots of data publications that are well designed and provide good quality and include the required mathematical symbols or formulas. . Another advantage is that it helps simplify research. Therefore, R software can support researchers in forecasting using the exponential smoothing method, apart from being quite popular and easy to obtain (Handayani et al., 2022).

The design of this research can be described as follows are collect data on the amount of cocoa production from the website of the Lampung Province Central Statistics Agency. The data was taken from 2000 – 2021, plot data on cocoa production in Lampung Province. Then, calculate forecasting using the Exponential Smoothing method with the Double Exponential Smoothing technique, on cocoa production with the R software application.

RESEARCH RESULT

The research results obtained on cocoa forecasting in Lampung Province are

1. Input cocoa data from 2000-2021 into RStudio, with TXT data type.
2. Previously activated the library in RStudio that is needed for forecasting.
3. Then, define the data by writing a time series formula in the RStudio console. Next plot the amount of cocoa production from 2000-2021.

4. Determine the forecast error value in the data resulting from the forecast. With value Forecasting accuracy can compare forecast results with actual data. If level Forecasting accuracy increases as the value of forecasting error decreases. Or This means that the smaller the error rate, the higher the level of accuracy forecasting and vice versa (Lusiana & Yuliarty, 2020).
5. Finally, describe the results of cocoa production forecasting in tabular form, as follows reference or teaching materials for researchers, while for farmers and the government as one piece of information to help improve the economy in Lampung Province

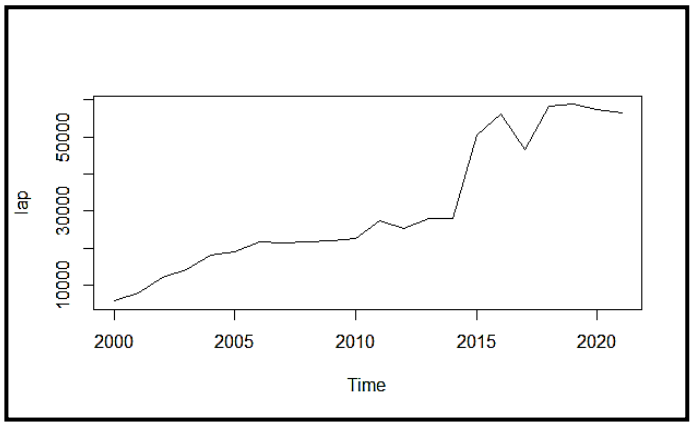

Figure 1. Cocoa Production Plot

Calculation of forecasting cocoa production using the Double Exponential Smoothing technique.

Write the formula for the Double Exponential Smoothing technique into the RStudio console and then plot the data.

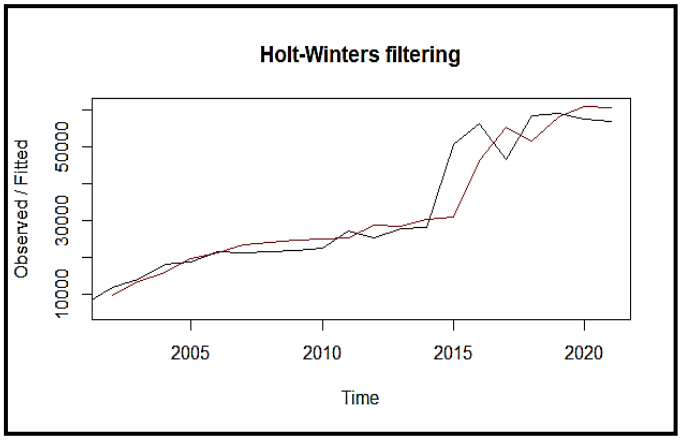

Figure 2. Cocoa Production Plot using the Double Exponential Smoothing technique

With parameter values $\alpha = 0.6762752$ and $\beta = 0$

The Double Exponential Smoothing technique is a smoothing technique in the form of data patterns trend and in smoothing calculations the technique uses

the parameter values α and β. The forecasting plot for cocoa production for the next 10 years is as follows:

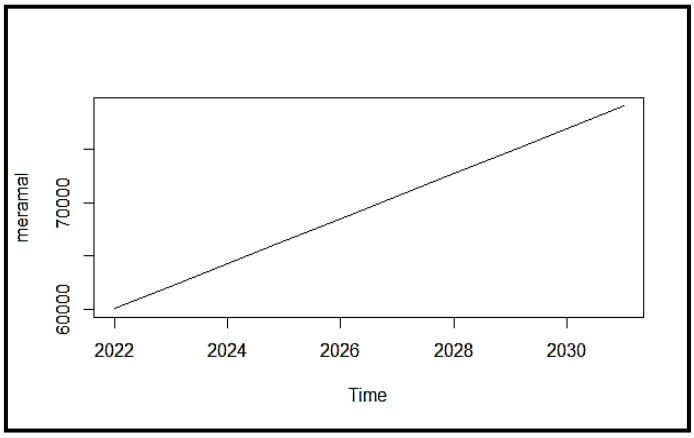

Figure 3. Cocoa Production Forecasting Plot using the Double Exponential Smoothing technique

It can be seen from the results of forecasting cocoa production using the Double Exponential Smoothing technique shows the forecast value which tends to increase every year and produces values that are not constant (different). Thus, the cocoa commodity is commodities that have quite large opportunities in the economy in Lampung Province, because the forecast produces a significant increase in value over 10 years furthermore. However, the government and farmers also maintain the quality of cocoa continues to increase cocoa production. The forecasting value for cocoa production is as follows :

Table 1. Forecasting Value of Cocoa Production with Double Exponential Smoothing

Year	Forecasting Value (In Tons)
2022	60.066,78
2023	62.172,78
2024	64.278,78
2025	66.384,78
2026	68.490,78
2027	70.596,78

2028	72.702,78
2029	74.808,78
2030	76.914,78
2031	79.020,78

After obtaining the forecasting results, the researcher calculated the forecasting accuracy value (forecast error) to determine the level of accuracy and to find out how big the value is errors in the methods used to handle problems in production forecasting cocoa using the Double Exponential Smoothing technique (Purwanto & Hanief, 2017). As follows forecasting accuracy value of cocoa production:

Table 2. Forecast Error Values for Cocoa Production with Double Exponential Smoothing

Forecast error	Value
MAE	0,1081484
MSE	0,01845481
MAPE	10,81484

DISCUSSION

So from the results of the research above, after carrying out forecasting calculations on production cocoa using the Exponential Smoothing method, namely the Double Exponential Smoothing technique. So It can be seen that the Double Exponential Smoothing technique is a suitable technique used in forecasting cocoa production because it has forecast error values, namely MAE, MSE, MAPE with low values and very good MAPE value criteria with MAPE = 10.81484. It can be said that the data for forecasting cocoa production uses the Double Exponential Smoothing has the highest level of accuracy or has a forecasting value that is close to it the real value occurs in the future.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results and discussions that have been obtained, production forecasting cocoa in Lampung Province using the application-assisted Double Exponential Smoothing technique R software produces forecasting values that experience an increasing trend every year with a MAPE value = 10.81484, namely the good category.

ADVANCED RESEARCH

For further research, you can try using other time series methods such as moving average, decomposition, and the ARIMA (box-Jenkins) method. To compare methods that are more suitable for forecasting cocoa production in Lampung Province.

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