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Forecasting Rice Production for Strategic Decision Making in Agribusiness Management: Aplication of Brown's Double Exponential Smoothing in Batubara District

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ABSTRACT
An assessment of what will occur in the future is called a forecast. For Indonesians, rice is a staple food, and because of its most crucial role, forecasting is required to satisfy community demands. For that, we require an indicator that can use Brown's double exponential smoothing method to illustrate the rise and fall in Batu Bara District's rice production in 2021. The time series approach, which employs historical data to forecast future events, includes Brown's double exponential smoothing method. Using the parameter α, the data demonstrates a trend. The value that yields the least Mean Square Error (MSE) is the ideal parameter value. The data processing results indicate that the parameter α = 0,1 has an MSE of 362.579.150,59. The volume of rice output in 2021 is predicted to be 118.082,84 tons using the forecasting equation F_(t+m) = 117.773,25+309,5m.

Keyword: Brown Double Exponential Smoothing Method, Forecasting, Mean Square Error (MSE).

1. Introduction

Forecasting involves predicting an event that has yet to occur. Forecasting involves anticipating a future event based on historical data. Forecasting may serve as a foundation for planning, oversight, and decision making. One aspect of this is forecasting production. This projection serves as the foundation for

establishing the inventory system's control policy and creating a production plan [1].

The exponential smoothing technique is commonly applied as a forecasting approach. The development of exponential smoothing as a forecasting technique originated in the 1950s from Brown's initial research. In Robert G. Brown's role as a research operations analyst for the US Navy during World War II. Brown altered exponential smoothing for discrete datasets and created a technique for trend and seasonality analysis. Currently, this method has been extensively utilized for prediction [2].

For Indonesians, rice is a fundamental part of their diet. The quantity of rice consumed in Indonesia is increasing each year, and with the rising population, it will be an issue if rice supplies are insufficient. The problem with rice requirements involves not only managing with what is on hand but also ensuring there is sufficient supply to meet demand at times. We require a signal that can sometimes meet the demand for it. A sign that can show whether rice output is rising or falling.

2. Related Work

2.1 Understanding and Basic Concepts of Forecasting

Forecasting involves predicting the future value of a variable by using its past value or by referencing a related variable. Forecasting is the practice or discipline of anticipating upcoming occurrences. This can be accomplished by utilizing historical data and forecasting it into the future using a type of mathematical model. Alternatively, you can employ a mix of mathematical models that are refined with thoughtful considerations [3].

Forecasting is performed to estimate the quantity of demands for a product and represents the initial phase of the production planning and control process. The aim of forecasting in production tasks is to assist with uncertainty, allowing for an estimate that closely reflects the real scenario [4].

Quantitative forecasting relies on historical quantitative data for predictions. The results of forecasting are heavily reliant on the method employed in the prediction. Using various methods will yield distinct forecasting outcomes; thus, when applying this approach, it is essential to evaluate the quality of the method employed. The more effective the method employed, the lesser the difference between the predicted outcomes and the actual events that transpire. Quantitative forecasting can be utilized only when the following three conditions are present:

a. There is information about the past.
b. This information can be quantified in the form of data.
c. It can be assumed that some aspects of the past pattern will continue in the future.

2.2 Properties of Forecasting Results

When creating predictions or using the outcomes of a prediction, there are multiple factors to take into account, which are:

1. Forecasting must contain errors, meaning that the fortune teller can only reduce the uncertainty that will occur, but can't get rid of the uncertainty.
2. Forecasting provides information about the size of the error, meaning that because forecasting must contain errors, then it is important for the fortune teller to inform how much error may occur.
3. Short-term forecasts are more accurate than long-term forecasts. This is because short-term forecasting of factors that affect demand is relatively constant, while the longer the forecasting period, the greater the possibility of changes in the factors that affect demand.

2.3 Forecasting Steps

There are basically three important forecasting steps, that is:

1. Analyze previous data. This stage is useful for patterns that occurred in the past. This analysis is done by making tabulations of the data so that the pattern of the data can be known.
2. Determine the method used. Each method will give different forecasting results.
3. Projecting past data using the method used and considering several factors of change.

2.4 Periodic Series Forecasting Method

The time series method was introduced by George E.P.Box and Gwilym M.Jenkins in 1970 through their book entitled Time Series Analysis: Forecasting and Control. Since that, time series started to develop a lot [5]. Time series analysis starts with graphing the data against a time scale, followed by examining the graph, and ultimately searching for a coherent structure or trend in the data. The aim of the analysis is to identify the pattern of the series of relevant variables relying on their past values and extend that pattern to predict future values of these variables.

A crucial phase in selecting a suitable time series method is to analyze the nature of the data pattern, allowing for the examination of the most fitting method matched to the pattern. Data patterns may be classified into four categories:

1. Horizontal Pola

   This pattern occurs when the data value fluctuates around the average value. The horizontal data pattern is shown in the figure1.

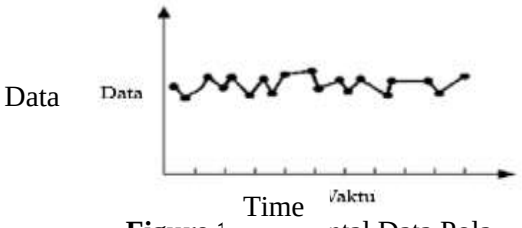

Figure 1. Horizontal Data Pola

2. Seasonal Pola

   This data pattern occurs when the data value is strongly influenced by seasonal factors. The seasonal data pattern is shown in the figure 2.

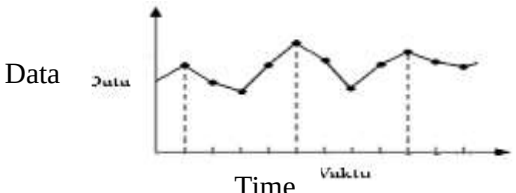

Figure 2. Seasonal Data Pola

3. Cyclical Pola

   This data pattern occurs when the data has a continuous upward or downward trend. The cyclical data pattern is shown in the figure 3.

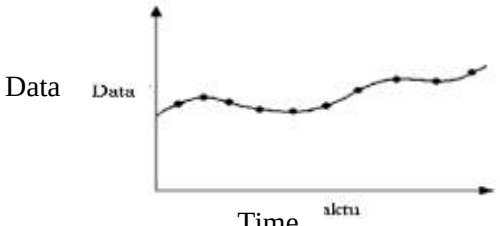

Figure 3. Cyclical Data Pola

4. Trend Pola

   This data pattern occurs when the data has a tendency to rise or fall from the observation data for the long term. The trend data pattern is shown in the figure 4.

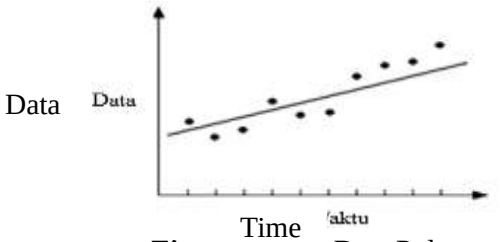

Figure 4. Trend Data Pola

2.5 Selection of Forecasting Techniques and Methods

In choosing a forecasting method, it is necessary to know in advance the important features of decision making and analysis of the situation in preparing forecasts. There are six factors to consider, as follows:

1. Time Horizon

There are two aspects of the time horizon associated with each forecasting method, namely the scope of time in the future and the number of periods for the desired forecast.

2. Determination Level

   The level of determination required is closely related to the level of detail required in a forecast.
3. Data Availability

   If from past data it is known that there is a seasonal pattern so, for forecasting one year ahead, the seasonal variation method should be used.
4. Data Pattern Shape

   The main basis of the forecasting method is the assumption that the kinds of patterns found in the forecasted data will be sustainable.
5. Cost

   Generally there are four cost elements involved in using a forecasting procedure, that is data storage fee, development cost, execution operation and opportunity to use forecasting method techniques.
6. Types and Models

   Models are a series in which time is described as an important element for determining changes in patterns. This model really needs to be considered because each model has different abilities in analyzing circumstances for decision making.

2.6 Smoothing Method

The smoothing technique aims to minimize seasonal fluctuations in historical data by generating a weighted average from a series of previous data points. This method's forecasting accuracy will be evident in short-term predictions, whereas long-term forecasts tend to be less precise. The smoothing technique includes various forms [4]:

1. Moving Average Method
   a. Middle Value
   b. Single Moving Average
   c. Double Moving Average
   d. Other moving average combinations
2. Exponential Smoothing Method

   Exponential smoothing is a type of moving average forecasting technique that weighs past data in an exponential manner so that the most recent data has a greater weight or scale in the moving average.

The general form of the exponential smoothing method is:

$$F_{t+m} = \alpha X_t + (1-\alpha)F_t \quad (1)$$

Where:

F_{t+m} = forecast one period ahead
X_t = actual data in period *t*
F_t = forecast in period *t*
α = smoothing constant

2.7 One Parameter Linear Double Exponential Smoothing Method of Brown

Brown's double exponential smoothing is a linear model put forth by Brown. This approach is applied when the data reveals a trend. Trend is a refined calculation of the mean growth by the conclusion of the timeframe. This approach employs two phases of smoothing utilizing identical parameters, specifically α. The process for implementing Brown's double exponential smoothing includes the following steps:

$$(S_t') = \alpha X_t + (1-\alpha)S_{t-1}' \quad (2)$$
$$(S_t'') = \alpha S_t' + (1-\alpha)S_{t-1}'' \quad (3)$$
$$a_t = 2S_t' - S_t'' \quad (4)$$
$$b_t = \frac{\alpha}{(1-\alpha)}(S_t' - S_t'') \quad (5)$$
$$F_{t+m} = a_t + b_t(m) \quad (6)$$

2.8 Forecasting Accuracy Measure

The accuracy of forecasting is assessed to determine the significance of the forecasting parameter. An ideal prediction occurs when the estimated variable equals the actual value. Achieving consistently accurate predictions is quite challenging, some even deem it impossible. Forecasting inaccuracies can arise not only from mistakes in choosing methods but also from the insufficient amount of data collected, which fails to accurately capture the true pattern of the variable involved.

Forecasting results in the same period, the deviations that occur can be defined as follows:

$$e_t = X_t - F_t \quad (7)$$

Some formulas that can measure the accuracy of forecasting are as follows:

1. Mean Square Error (MSE)

   Mean Square Error amplify the influence of big error numbers, but on the other hand it reduces the number of forecasting errors that are smaller than one unit. The formula for calculating the average squared error is as follows:

   $$MSE = \sum_t^N \frac{e_t^2}{N} \quad (8)$$

2. Sum of Square Error (SSE)

Sum of Square Error states the sum of the squares of deviations, which is usually called the sum of squares for error. Sum of square error diperoleh denga cara mengkuadratkan kesalahan dan kemudian menjumlahkan seluruh kesalahan. Where the smaller the value of the sum of square error, then the better the forecast. The formula for calculating the sum of square error is as follows:

$$SSE = \sum_t^N e_t^2 \quad (9)$$

3. Mean Absolute Percentage Error (MAPE)

   Mean Absolute Percentage Error is the average of the overall percentage error (difference) between the actual data and the forecasted data. The formula for calculating the mean absolute percentage error is as follows:

$$MAPE = \sum_{t=1}^N \frac{|PE_t|}{N} \quad (10)$$

Percentage error is the percentage error of an experience:

$$PE = \left(\frac{X_t - F_t}{X_t}\right) \times 100\% \quad (11)$$

Where:

e_t = error in period *t*
X_t = actual data in period *t*
F_t = forecast value in period *t*
N = number of periods
PE = error percentage

2.9 Validity

Validity is a testing phase conducted on the material of a tool, aimed at assessing the precision of the instruments utilized in a research study [6]. The validity test aims to assess the effectiveness of the research instrument employed. In forecasting rice production, the validity test is meant to support forecasting decisions, allowing for an understanding of the accuracy and appropriateness of the forecast's application. If the r count exceeds the r table, the data is valid; however, if the r count is less than the r table, the data is invalid and unsuitable for analysis.

3. Methodology

3.1 Data Source

The data used in this study is secondary data obtained from the Central Statistics Agency (BPS) of Batu Bara District in numbers. The secondary data needed in this study is data on the amount of rice production in Batu Bara District for the period 2010-2020.

3.2 Steps in Research Method

The steps used in this research are as follows:

1. Do Library Research

   References that will be studied in this research include forecasting the amount of production and the double exponential smoothing method in the form of a textbook, journals and previous research.
2. Data Collection

   The data used in this research is secondary data, namely data taken from the Central Bureau of Statistics of Batu Bara District in Figures. The data obtained is data on the amount of rice production in Batu Bara District in 2010-2020.
3. Data Processing

   In data processing as a tool to assist the author in obtaining the results of calculations using Excel 2013 software. The steps involved in data processing are as follows:
   a. Plotting data to find out data patterns
   b. Determine the parameter value to be used based on the smallest Mean Square Error (MSE) value
   c. Determine the single exponential smoothing value
   d. Determine the double exponential smoothing value
   e. Determine the constant value
   f. Determine the trend value
   g. Making forecasts
4. Record results and conclusions

3.3 Research Methods

The methods in this research are as follows:

1. Brown's Double Exponential Smoothing Method

   The double exponential smoothing method is a linear model proposed by Brown and the smoothing process is carried out twice. The steps in using Brown's double exponential smoothing method are as follows:
   a. Single exponential smoothing value
   b. Double exponential smoothing value
   c. Determine the constant value
   d. Determine the trend value
   e. Determine forecast
2. Determining the value of the parameter α using the Mean Square Error (MSE)

4. Result and Discussion

4.1 Data Analysis

The data that will be processed by the author is data per year on the amount of rice production starting in 2010-2020. The data to be processed in this research is data on rice production in 2010-2020 in Batu Bara District. The data obtained by converting rice to rice.

Table 1. Total rice production in 2010-2020

Year	Rice Production (Tons)
2010	171.461,6
2011	160.374
2012	189.392
2013	182.097
2014	173.841,40
2015	188.729,15
2016	160.933,87
2017	252.268,08
2018	192.355,99
2019	169.244,93
2020	166.054,13

Source: BPS Batu Bara District in Figures

Table 2. Total rice production in 2010-2020

Year	Rice Production (Tons)
2010	109.769,72
2011	102.671,43
2012	121.248,76
2013	116.578,5
2014	111.293,26
2015	120.824,4
2016	103.029,86
2017	161.502,02
2018	123.146,3
2019	108.350,6
2020	106.307,85

Source: Conversion calculation result

The plot of rice production data in Batu Bara District is shown in Figure 5

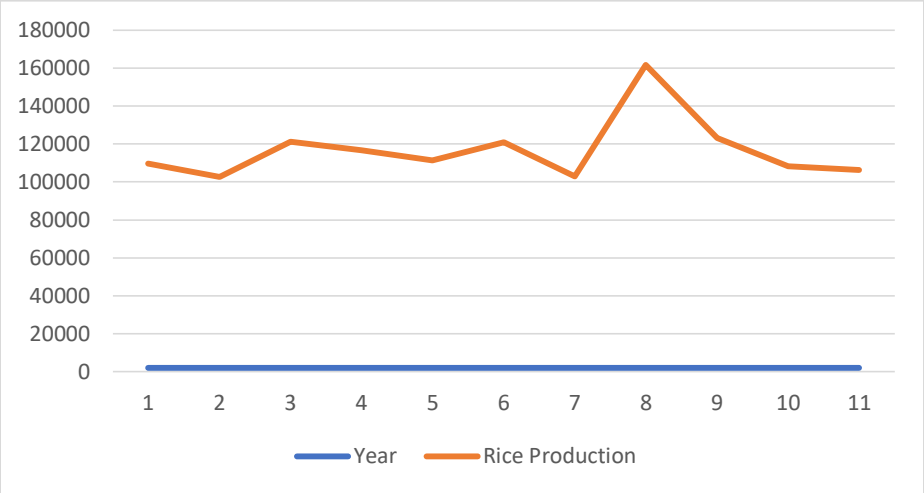

Figure 5. Plot of data on the amount of rice production

From Figure 5 it can be seen that the plot of data on the amount of rice production from 2010-2020 is not stationary or shows a data pattern that contains a trend, Therefore, Brown's double exponential smoothing method can be used.

4.2 Forecasting Using Brown's Double Exponential Smoothing

Table 3. Brown's double exponential smoothing α=0,1

Year	X_t	S'_t	S''_t	a_t	b_t	F_{t+m}	e_t	e_t^2
2010	109769,72	109769,72	109769,72					
2011	102671,43	109059,89	109698,73	108421,04	-70,98			
2012	121248,76	110278,78	109756,74	110800,81	58,00	108350,06	12898,70	166376420,00
2013	116578,50	110908,75	109871,94	111945,56	115,20	110858,82	5719,68	32714768,16
2014	111293,26	110947,20	109979,46	111914,93	107,53	112060,76	-767,49	589045,92
2015	120824,40	111934,92	110175,01	113694,83	195,55	112022,46	8801,94	77474181,91
2016	103029,86	111044,41	110261,95	111826,88	86,94	113890,37	-10860,51	117950694,09
2017	161502,02	116090,18	110844,77	121335,58	582,82	111913,82	49588,21	2458990288,26
2018	123146,30	116795,79	111439,87	122151,70	595,10	121918,40	1227,91	1507751,50
2019	108350,60	115951,27	111891,01	120011,53	451,14	122746,80	-14396,20	207250539,71
2020	106307,85	114986,93	112200,61	117773,25	309,59	120462,66	-14154,81	200358665,74
				Amount				3.263.212.355,28

For α = 0,1 ; n = 9, where the value of n is obtained from the number of data years that have a final forecast error value, then:

$$MSE = \frac{\sum_{t=1}^{n} e_t^2}{n}$$

$$= \frac{3.263.212.355,28}{9}$$

$$= 362.579.150,59$$

4.3 Parameter α Selection Best

In selecting the best parameter, it is chosen based on the smallest Mean Square Error (MSE) value. The following are the results of the calculation of the Mean Square Error (MSE) for the parameters $\alpha = 0{,}1$ to $\alpha = 0{,}9$ in table 4.

Table 4. MSE values for parameters $\alpha = 0{,}1$ to $\alpha = 0{,}9$

Parameters α	MSE
0.1	362.579.150,59
0.2	420.344.979,31
0.3	489.041.666,72
0.4	567.748.736,80
0.5	665.843.982,79
0.6	795.312.335,07
0.7	970.254.289,49
0.8	1.209.092.843,32
0.9	1.539.608.836,27

Source: Calculation results

Based on table 4, it can be seen that the value of the parameter which produces the smallest Mean Square Error (MSE) value is the value of $a = 0{,}1$, so that forecasting can be done using Brown's double exponential smoothing method with parameter value $a = 0{,}1$.

4.4 Determining Forecast Value

To determine the value of the forecast in the coming year, use the formula $F_{t+m} = a_t + b_t(m)$, is calculated as follows :

$F_{t+m} = a_t + b_t(m)$

$F_{2020+1} = a_{2020} + b_{2020}$

$F_{2021} = 117.773{,}25 + 309{,}59$

$F_{2021} \approx 118.082{,}84$

Based on the forecasting results, the total rice production in Batu Bara District in 2021 is 118.082,84 tons. The forecast figures predict that the amount of rice production will increase by 11,08 percent.

The forecast indicates growth even as the area of rice fields is declining, which commonly occurs. This is attributed to factors like high-quality seeds and sufficient rainfall. Regarding the elements that can boost agricultural output projections, there must be an increase in input usage, including more workers, fertilizers, pesticides, and advancements in agricultural technology [7].

Thus, from the explanation provided, it can be inferred that a decrease in land area does not necessarily lead to a decline in projections. This can be achieved by raising other input elements to ensure that the anticipated performance goals remain intact.

5. Conclusions and Future Research

5.1 Conclusion

According to the data analysis in chapter 4, the findings derived are as follows:

1. From the results of data processing from 2010 to 2020 for the amount of rice production in Batu Bara District using the double exponential smoothing method from Brown, obtained the value of Mean Square Error (MSE) smallest at $\alpha = 0{,}1$ that is with MSE=362.579.150,59
2. The form of the forecasting equation for the amount of rice production in Batu Bara District in 2021 is $F_{t+m} = 117.773{,}25 + 309{,}5m$
3. Forecasting the amount of rice production in 2021 is 118,082.84 tons

5.2 Future Research

In additional research on forecasting, other variables can be incorporated to enhance the predictions of rice production levels, including various factors that influence production outcomes.

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