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Implementation of Double Exponential Smoothing Holt Method in Forecasting Commercial Rice Sales in Perum Bulog Sub Divre Medan

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ABSTRACT

Logistics general company or Perum BULOG is a state-owned public company engaged in food logistics, especially rice. To carry out its functions, this agency is assisted by several regional divisions or subdivisions, one of which is the Medan Sub-Divisional Division having its address at Timbang Deli, Medan Amplas District, Medan City. Forecasting is a technique for estimating a value in the future by paying attention to historical data or current data. The purpose of this study is to analyze data based on historical data patterns and predict using the Double Exponential Smoothing Holt method by finding optimal parameters based on the smallest MAPE value. The results of this study obtained a graph of data patterns that experienced an upward trend so that it could be predicted using the Double Exponential Smoothing Holt method with optimal parameters, namely dan and based on the smallest MAPE value, which was 0.0418052 and also the results of forecasting commercial rice sales at Perum BULOG Sub Divre Medan which will increase by 151.3 kg per month, namely in January 2022 by 865369 kg, in February 2022 by 865540.3 kg, in March 2022 by 865691.6 kg , in April 2022 by 865842.9 kg, in May 2022 amounted to 865994.2 kg, and in June 2022 amounted to 866145.5 kg.

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1. INTRODUCTION

The development of sales services or product distribution is recognized very rapidly today, one of the factors is consumer demand. Every company must always want success in selling or distributing its products successfully in the future. In achieving this success definitely requires planning and forecasting. Therefore, every company must have inventory and sales records to find out whether sales have increased or decreased. Forecasting is a technique for estimating a value in the future by paying attention to past data and current data.

Logistics general company or Perum BULOG is a state-owned public company engaged in food logistics, especially rice. As a company that carries out government duties, BULOG is responsible for handling rice food security. In addition, BULOG also fulfills the need for rice food through commercial commodities. As a company engaged in the commercial sector, of course BULOG must be a company that also maintains market price stability. This is what causes demand instability in BULOG's commercial rice, because product prices tend to be stable compared to market prices. Many people use BULOG commodity products when the price of the product in the market is high, but the demand will decrease if the price in the market is low. (Islamic, 2019)

The imbalance in the quantity of rice between supply and demand can also result in losses. If supply is greater than demand, the quality of rice will decrease from time to time. This can result in waste and even loss for the company because it may have to be disposed of. Vice versa, if the demand is more than the supply of rice, there will be a stock out or shortage of rice stock. Perum BULOG itself experiences various problems in its operations, one of which is experiencing excess rice stock every month. This is because one of the functions of this company is to maintain food safety. However, if this situation continues to occur every month, there will be an imbalance in the quantity of rice (excess stock). Therefore, forecasting needs to be done to avoid this imbalance.

Definition of Forecasting

Forecasting according to Sudjana (1989) is a process of estimating (measurement) the amount or amount of something in the future based on data in the past which is analyzed scientifically, especially using statistical methods. Based on the time horizon, forecasting is grouped into three parts, namely short-term forecasting, medium-term forecasting, and long-term forecasting.

Based on their nature, forecasting techniques can be divided into two main categories, namely:

1. Qualitative Forecasting
   This forecasting is done without a mathematical model, usually because the existing data is not representative enough to predict the future. The advantage of this forecasting is that the costs incurred are very cheap (without data) and can be obtained quickly, while the drawback is that it is subjective, so it is often said to be unscientific.
2. Quantitative Forecasting
   The use of this forecast is based on the availability of raw data along with a series of mathematical rules to predict future results. There are two quantitative forecasting models, namely the causal model and the time series model.

Forecasting Procedure

To perform forecasting, it takes the following steps:

1. Determine the problem to be analyzed (problem formulation) and collect the data needed in the analysis process.
2. Prepare the data so that the data can be processed correctly.
3. Determine the forecasting method in accordance with the data that has been prepared.
4. Apply the established method and make predictions on the data for some time to come.
5. Evaluating the results of forecasting and drawing conclusions (Isnayati, 2017)

Time Series

Periodic data is data collected from time to time to describe a development or trend of events/activities, usually at the same distance or time interval. Periodic data is also called time series data or abbreviated as time series. Time series data is data that is collected, recorded, and observed over time sequentially. The time period can be yearly, quarterly, monthly, weekly, and in some cases daily or hourly (Nurmaulidar, et al, 2016). Data patterns for time series are divided into horizontal patterns (H), seasonal patterns, cyclical patterns, and trend patterns.

Exponential Smoothing Method

The exponential smoothing method is probably the most frequently used time series method. This method is very simple to understand and apply. (Bails and Peppers, 1982). This method is a forecasting method that applies a weighting system to historical data for forecasting. The amount of weight changes exponentially depending on the historical data. The following equation is the general form used in calculating forecasts using the exponential smoothing method:

$$F_{t+m} = \alpha Y_t + (1-\alpha) F_t \qquad (2.1)$$

with:

= forecast value for the future period
= smoothing parameter values
= actual value of period t
= forecast value of period t

Methods in Exponential Smoothing

1. Single Exponential Smoothing Method
   This method is also known as the single smoothing method. This method is usually used when the time series data is obtained and their fluctuations are stationary (irregular), short-term, and usually only 1 month ahead.

$$F_{t+1} = \alpha Y_t + (1-\alpha)F_t \tag{2.2}$$

2. Double Exponential Smoothing Method
   This method is a development of single exponential smoothing where there is an element of trend in the weight of the calculation. Trend is a smoothed estimate of the average growth at the end of each period. There are 2 types of this method, namely:
   a. Double Exponential Smoothing Brown
      This method is proposed by Brown which can be calculated with three data values and one value for . This approach also gives decreasing weight to past observations. In principle, this method is the same as the single exponential smoothing method, but in this method there are two smoothing constants. The formula used in the implementation of Double Exponential Smoothing Brown is as follows:

$$S_t^{'} = \alpha Y_t + (1-\alpha)S_{t-1}^{'} \tag{2.3}$$

$$S_t^{''} = \alpha S_t^{'} + (1-\alpha)S_{t-1}^{''} \tag{2.4}$$

$$a_t = S_t^{'} + \left(S_t^{'} - S_t^{''}\right) = 2S_t^{'} - S_t^{''} \tag{2.5}$$

$$b_t = \frac{\alpha}{1-\alpha}\left(S_t^{'} - S_t^{''}\right) \tag{2.6}$$

$$F_{t+m} = a_t + b_t m \tag{2.7}$$

Description:

$S_t^{'}$	= first smoothing value
$S_t^{''}$	= second smoothing value
a_t, b_t	= value of smoothing constant
Y_t	= actual value of period t
α	= smoothing parameters
m	= number of future periods to be forecast
F_{t+m}	= forecast value for period to t+m

   b. Double Exponential Smoothing Holt
      Conceptually, the Double Exponential Smoothing Brown and Double Exponential Smoothing Holt methods are similar, but Holt does not use the smoothing formula directly. Trend values are worked out using different parameters from the two parameters used in the actual time series. In previous research conducted by Anjasari in 2018 said that the double exponential smoothing holt method cannot perform smoothing for seasonal data patterns but is only carried out for data patterns that show trends and averages (means). The advantages of the Holt method have also been proven from several existing studies. For example, the research conducted by Astri Yulitasari (2011) and Nurdina Awwaliyah (2013) which predicted by comparing the Brown and Holt methods concluded that the Holt method had the smallest error value by entering a large parameter value. The basic equation of Holt's method is:

$$S'_t = \alpha Y_t + (1-\alpha)(S'_{t-1} + t_{t-1}) \tag{2.8}$$

$$t_t = \beta(S'_t - S'_{t-1}) + (1-\beta)t_{t-1} \tag{2.9}$$

$$F_{t+m} = S'_t + t_t m \tag{2.10}$$

with,

Y_t = actual value of period t

S'_t = single exponential smoothing's value

t_t = trend value of period t

α, β = smoothing parameters between 0-1

Accuracy Measure Parameters

The accuracy of the forecasting measurement results, which is a measure of error about the level of difference between forecasting results and actual demand, there are 3 commonly used measures, namely MAD, MSE, and MAPE. The value of the MAD and MSE forecast sizes depends on the size of the forecasted item. If forecasting goods are measured in thousands, the MAD and MSE values can be very large. For this reason, it is better to use MAPE because the absolute average difference between the predicted and actual values is reflected as a percentage of the actual values. Then, the right parameter is chosen based on the smallest MAPE value. The MAPE formula is as follows:

$$MAPE = \frac{\sum_{t=1}^{n} \left| (Y_t - F_t) \times 100\% \right|}{n} \quad (2.11)$$

2. RESEARCH METHODE

The research that will be carried out is a case study, namely the type of approach in research that is directly related to the object of research by asking for research data (sales data) directly from the Perum BULOG Sub-Division Medan for 1 month.

The steps taken to conduct this research are as follows:

a. Collecting data on commercial rice sales in the monthly period from July 2018 – December 2021.
b. Plotting the data to determine the pattern of research data.
c. Installing 2 different parameters. The parameter values are specified in the range $0 < \alpha, \beta < 1$.
d. Calculate the value of single exponential smoothing using equation (2.8).
e. Calculate the trend value using equation (2.9).
f. Calculate the forecast value using equation (2.10).
g. Calculate the MAPE error value using equation (2.11).
h. Finding the best parameter values by comparing all the parameter values that have been searched.
i. Draw conclusion.

3. RESULT AND ANALYSIS

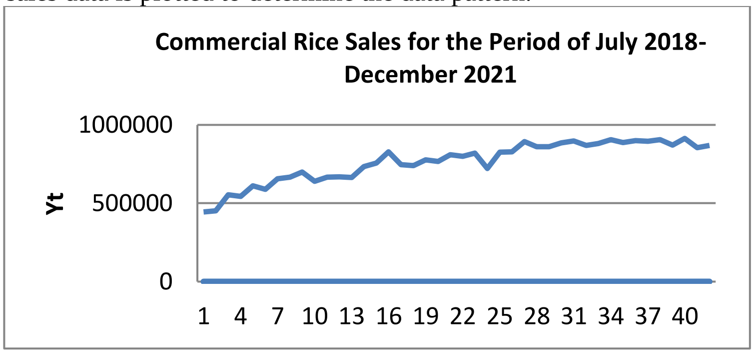
Commercial rice sales data obtained from Perum BULOG Sub-Divre Medan are as follows:

Table 4.1: Commercial Rice Sales for the Period of July 2018-December 2021

Years	Month	Period	Sales (Kg)
2018	July	1	444550.0
	August	2	452675.0
	September	3	554800.0
	October	4	542950.0
	November	5	611390.0
	December	6	587900.0
2019	January	7	656990.0
	February	8	666537.8
	March	9	698671.0

	April	10	640642.0
	May	11	666266.2
	June	12	668551.0
	July	13	663730.0
	August	14	733485.0
	September	15	756462.0
	October	16	827361.2
	November	17	745611.0
	December	18	740532.0
2020	January	19	777680.0
	February	20	767594.0
	March	21	809760.0
	April	22	798608.0
	May	23	819185.0
	June	24	721999.0
	July	25	825745.0
	August	26	829079.0
	September	27	894436.0
	October	28	860838.0
	November	29	859830.0
	December	30	884362.0
2021	January	31	897621.0
	February	32	868303.0
	March	33	881265.0
	April	34	905232.0
	May	35	887375.0
	June	36	900450.0
	July	37	895545.0
	August	38	906469.0
	September	39	871225.0
	October	40	913815.0
	November	41	853951.0
	December	42	869400.0

Commercial rice sales data is plotted to determine the data pattern.



The data plot above shows that the data is experiencing an uptrend so that it can be analyzed using the Double Exponential Smoothing Holt method using two smoothing parameters, namely α and β.

Data Analysis Using Double Exponential Smoothing Holt Method

Data analysis using the double exponential smoothing holt method is carried out using the data in table 4.1 as the initial data to search for forecasting with predetermined steps. In finding S'_t and T_t, performed one-to-one pairing between alpha values 0.1-0.9 and beta values 0.1-0.9.

After analyzing in accordance with the procedures or steps that have been determined to get the error value of each pair of values of α and β, then the smallest MAPE value is found, namely, 0.0418 with the value of $\alpha = 0{,}7$ and $\beta = 0{,}1$.

Best Parameter Selection

The best parameter selection is determined by the smallest MAPE value, namely by comparing all MAPE values from the values $0 < \alpha < 1$ (0.1 0.2 0.3 ... 0.9) and $0 < \beta < 1$ (0.1 0.2 0.3 ... 0 ,9) which is presented in table 4.3.

Table 4.3 Value of MAPE

alpha / beta	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.0465	0.0445	0.0438	0.0433	0.0428	0.0423	0.0418	0.0424	0.0444
0.2	0.0479	0.0458	0.0445	0.0434	0.0427	0.0421	0.0423	0.0440	0.0464
0.3	0.0511	0.0484	0.0464	0.0447	0.0435	0.0425	0.0435	0.0452	0.0482
0.4	0.0562	0.0523	0.0494	0.0466	0.0449	0.0441	0.0447	0.0470	0.0500
0.5	0.0627	0.0575	0.0536	0.0496	0.0469	0.0458	0.0463	0.0487	0.0521
0.6	0.0705	0.0637	0.0584	0.0533	0.0499	0.0478	0.0480	0.0502	0.0546
0.7	0.0824	0.0723	0.0643	0.0577	0.0534	0.0501	0.0495	0.0517	0.0578
0.8	0.1018	0.0847	0.0719	0.0625	0.0567	0.0523	0.0506	0.0534	0.0611
0.9	0.1395	0.1038	0.0803	0.0669	0.0595	0.0540	0.0514	0.0552	0.0649

Based on Table 4.3, it can be concluded that the smallest MAPE value is at $\alpha = 0{,}7$ and $\beta = 0{,}1$, with MAPE = 0.0418. To prove that the optimal parameter values at $\alpha = 0{,}7$ and $\beta = 0{,}1$, then we look for the MAPE value in the vicinity. Take values from 0.01 to 0.03 less than and greater than each parameter.

Table 4.4: MAPE values in the surrounding $\alpha = 0{,}7$ and $\beta = 0{,}1$

alpha / beta	0,67	0,68	0,69	0,70	0,71	0,72	0,73
0,07	0.0420770	0.0420267	0.0419895	0.0419549	0.0419204	0.0418860	0.0418516
0,08	0.0420243	0.0419741	0.0419391	0.0419042	0.0418694	0.0418347	0.0418078
0,09	0.0419687	0.0419262	0.0418909	0.0418611	0.0418332	0.0418055	0.0418488
0,1	0.0419307	0.0419019	0.0418733	0.0418447	0.0418163	0.0418269	0.0418939
0,11	0.0419169	0.0418875	0.0418582	0.0418291	0.0418052	0.0418724	0.0419397
0,12	0.0419035	0.0418735	0.0418436	0.0418138	0.0418508	0.0419182	0.0419858
0,13	0.0418902	0.0418595	0.0418290	0.0418289	0.0418964	0.0419641	0.0420320

It turns out that, after pairing with the respective alpha and beta in the vicinity of and , we get an even smaller MAPE value of 0.0418052 at $\alpha = 0{,}71$ dan $\beta = 0{,}11$. The author also searches for optimal parameters with initial parameter values $\alpha = 0{,}7$ and $\beta = 0{,}1$ by using Data Solver in Microsoft Excel and gets the same MAPE results, namely 0.0418052 at $\alpha = 0{,}71$ dan $\beta = 0{,}11$.

Forecasting Commercial Rice Sales at Perum BULOG Sub-Divre Medan

After getting the best parameters, namely at and , then it can be calculated forecasting sales of commercial rice using equation (2.10) with the value because the predicted sales for the next 6 months. The results of the experience are as follows:

F_{43} (January 2022)	865369 Kg
F_{44} (February 2022)	865540,3 Kg
F_{45} (March 2022)	865691,6 Kg
F_{46} (April 2022)	865842,6 Kg
F_{47} (May 2022)	865994,2 Kg
F_{48} (June 2022)	866145,5 Kg

From the results of forecasting calculations, it can be seen that commercial rice sales for the next 6 months will experience a small increase. This is because the previous historical data also experienced an uptrend even though the data fluctuated.

4. CONCLUSION

Based on the research that has been done, the authors can draw conclusions, namely data analysis using the double exponential smoothing holt method to obtain optimal results with the smallest MAPE, which is 0.0418052 on parameter values and and forecasting results in January 2022 of 865389 kg , in February 2022 it is 865540.3 kg, in March 2022 it is 8655540.6 kg, in April 2022 it is 865691.9 kg, in May 2022 it is 865994.2 kg, and in June 2022 it is 866145.5 kg with a significant increase relatively small.

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