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Prediction Analysis of Buled Bread Production Using Holt's Exponential Smoothing

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ABSTRACT

This research aim to Analysis of Buled Bread Production Using Holt's Exponential Smoothing. The number of loaves produced by Buled bread still uses estimates, causing the number of loaves produced to be excessive. The excess number of loaves produced increases production costs, which can cause losses. The method broadcast in forecasting is Holt's exponential smoothing because the data displayed shows an increasing trend that is not affected by the season. The calculation process uses Microsoft Excel and add-ins. The results of the calculation produce a Mean Absolute Percentage Error (MAPE) value of 3.58% so that it can be used to forecast production data in the following month. The value of $\alpha = 0.8808$ and the value of $\beta = 0.042$ are the best values based on calculations using the Solver Add-in. Based on these parameter values, predictive data is produced for each week in the following month.

Keywords: Time series data, Holt's exponential smoothing, Forecasting, Buled Bread

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INTRODUCTION

Along with the progress of the times, science and technology are becoming more sophisticated and influential in every aspect of life. Information technology can meet all information needs and make human work easier(Effendi & Rahmawati, 2018). Business owners or entrepreneurs need a technology role to help them succeed in publication, production, and sales (Laksmana et al., 2019). Companies are starting to pay attention to production levels amidst today's very tight business competition. This is done with the same awareness that it is important to support business growth and sustainability by increasing the company's understanding of stable production volumes so that they can maintain product quality and predict product production levels (Sutriadi, 2021; Adiastuty et al., 2020; Adiastuty et al., 2020).

Bread is now a common and rapidly growing food. No wonder bread became part of our daily lives and even became the main menu as a substitute for breakfast(Laksmana et al., 2019). The rise in bread consumption is increasing along with the high demands of practicality and mobility on today's modern lifestyle (B et al., 2024). The risen consumptions have resulted in many bread industries emerging so that companies need to ensure the survival of their by doing good management one in the production process. Determining the correct quantity of production can suppress the occurrence of production costs to become more efficient, so that potential losses can be minimized. The production process that produces a product for the consumer is the result of converting raw materials into finished goods. There are many aspects to be taken into account during the production process, one of which is to determine the quantity of production (Nurhayati et al., 2024; Maulana & Wiharno, 2022; Maulana et al., 2022). The amount of product to be produced affects the total cost to be spent so that there is no amount of production that exceeds or falls below demand. This can result in losses both of consumer satisfaction and excessive costs spent.

Buled Bread is one of the stores that operates in the food field that provides a variety of bread products, cakes and beverages. Buled bread is a product that is characteristic in addition to other foods. The process of determining the quantity of production uses manual estimates that are either uncertain or simply descriptive. The use of technology is only for recording sales data, but it hasn't determined or predicted the amount of bread to be produced every day. This pattern leads to the occurrence of raw materials, semi-finished, or finished products that are not sold or even deficient (Sunarjoet al., 2021; Wiharno et al., 2023; Yunengsih et al., 2023). Prophecy is one of the methods used to predict future situations through the exploitation of past circumstances which has the aim of minimizing the error of prophecy. Forecasting is essential in one of the sales strategies, which is to make predictions or forecasts of sales. As for the data used, it is a time series data that must be analyzed first whether it includes data that has no pattern, has a trend, seasonality, cyclical, or random variation (Manalu & Adzimatinur, 2024; Manalu et al., 2023; Manalu et al., 2023). The pattern component affects the method used. The single exponential smoothing method or moving average often gives very accurate results, but if the data indicates a particular trend, the more accurate model used is Brown’s exponential smoothing or Holt’s Exponential Smoothing (Hikmah et al., 2018).

LITERATURE REVIEW

Forecasting

Forecasting is a method of predicting future situations and conditions based on historical data. Prediction is essential to ensuring that future planning can be done effectively and

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efficiently (Miftah Fadila et al., 2024). Prediction or prediction is the discipline used to predict future events. There are two types of prediction: qualitative prediction that relies on intuition without using mathematical or statistical calculation approaches, and quantitative predictions that use mathematically calculated approaches by analyzing historical data to project future conditions (Fitriani & Rakhma Devi, 2022; Octavia et al., 2023; Jahidah et al., 2024).

Time Series Data Analysis

Time series is a set of values that have similar statistical characteristics and are organized according to the time order of occurrence. If a variable can be observed over a certain period of time, and its historical data contains information about future variable changes, then such past observation data can be used to predict the value of the variable in the future (Jamaludin & Sugiyanto, 2023). Time series models are more commonly used in forecasting or prediction. In the method of time series prediction, there are two main theories tested, namely smoothing and decomposition. The principle of smoothing is based on the calculation of the average of previous errors, by summing up the value of previous predictions and the percentage difference between actual and predictable values. Meanwhile, decomposition methods divide time data into several components, such as trend, cyclical, seasonal, and random effects, and then combine predictions of each component. The components of the time row are as follows:

1. (Trend). Represents a general change that can be up (positive), down (negative) or data on a data over time.
2. (Seasonal). Indicates data changes that have recurring patterns with fixed time ranges such as daily, weekly or monthly.
3. Cycle (Cyclic). Has similar seasonal characteristics but has a longer duration of recurrence change with a fixed frequency
4. Unpredictable fluctuations (IrregularorResidual) (Wahyu & Hendrik, 2023).

Holts Exponential Smoothing

Holt's linear method is one of the methods introduced by Holt. This method is applied to timeline data that has a linear trend and is not affected by the seasons. This model uses a different smoothing parameter from the original data by using two parameters, α and β. (Anung Anindityo & Maryanah Safitri, 2023). Holt's Exponential Smoothing method is a development of SES that adds slope components to the prediction process. This makes this method more effective in capturing and predicting time series data that has a linear trend (Rosita & Moonlight, 2024).

Level equation:

$$Y_{t-1} = L_t + T_t$$

Level Smooting Equation:

$$A_t = \alpha Y_t + (1-\alpha)(A_{t-1} + T_{t-1})$$

Trend Equation:

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

with,

Y_{t-1} : estimated value for period t-1
A_t : level value in period t
T_t : trend value in time t
α : smoothing parameter for level that is between 0 and 1

 DOI: https://doi.org/10.61242/ijabo.24.415

β : smooting parameter of trend that is from 0 to 1
Y_t : actual value at period t

If the A1 value is unknown, the A1 value is taken from the first data value in the first row

RMSE and MAPE

The effectiveness of the model in this study can be assessed through the use of Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). RMSE is a technique employed to evaluate the accuracy of forecast methods by gauging how closely the model's estimates match the actual results. It specifically measures the accuracy by comparing the forecasted outcomes with the validation dataset. On the other hand, MAPE is a percentage-based metric that helps determine the precision of a forecast (Ariqoh et al., 2022).

The equations of the mean square error (RMSE) are:

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(Y_t - Y_{t-1})^2}{n}}$$

With,
Y_t : Actual value
Y_{t-1} : Forecasted value
n : number of data

The Equation of the mean absolute percentage error (MAPE) are:

$$MAPE = \sum_{i=1}^{n} \left| \frac{Y_t - Y_{t-1}}{Y_{t-1}} \right| X\ 100\%$$

With,
Y_t : Actual value
Y_{t-1} : Forecasted value
n : number of data

RESEARCH METHOD

This research was conducted at one of the Buled Bread stores located in Kuningan. The research method used includes collecting primary data from sales data from June to November. Buled Bread sells various types of Buled bread flavors and various drinks. The available flavors are chocolate, vanilla, cheese, original, Buled bread, unyil bread and others. The focus of the data taken is Buled bread and its variants. All data is taken by paying attention to research ethics and maintaining the confidentiality of the data obtained. The method for analysis uses the Holt's exponential smoothing method in order to predict sales for weeks 1, 2, 3 and 4 of the following month, namely December.

Data collection

The data used is time series data in the form of daily bread sales data from June 2023 to November 2023. The data taken consists of transaction date data, purchased product data, payment data, cashier data and data on the number of products purchased.

 DOI: https://doi.org/10.61242/ijabo.24.415

Determination of data analysis

The daily sales data obtained is then processed into weekly sales data for June to November. The use of weekly data is due to see the seasonal factors and trends in the data. The data is visualized in the form of a plot graph. The results of data processing can be seen in Figure 1.

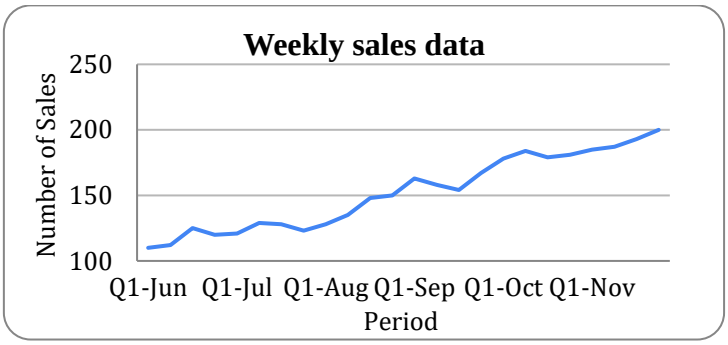

Figure 1. Buled Bread Sales Chart Per Week June to November
Source: *Result of research*

Based on the figure 1 above, it appears that sales data indicates an upward trend but does not have a seasonal component. The seasonal component is visible when the recurrence of data peaks is constant or appears at a certain time. The chart above shows the peak of repeated data increases but not within a fixed time frame

Finding Smoothing Values

The smoothing value is found using the smoothing level equation. The results of smoothing using Microsoft Excel are obtained as in Table 1.

Table 1. Smoothing calculation results

Month	Sales	Level
Q1-Jun	110	110,00
Q2-Jun	112	112,00
Q3-Jun	125	116,20
Q4-Jun	120	119,44
Q1-Jul	121	122,29
….	….	….
….	….	….
….	….	….
Q2-Nov	187	193,83
Q3-Nov	193	196,19
Q4-Nov	200	199,15

The Table 1 represents the results of a smoothing calculation, which is commonly used in forecasting to reduce fluctuations in data and create a clearer trend. In this case, the smoothing technique has been applied to sales data over a period of time, showing both the raw sales values and the smoothed or "level" values for each quarter and month. In Q1-Jun, the actual sales are 110, and the smoothed value is also 110. By Q3-Nov, actual sales have reached 193, while the smoothed value (level) is 196.19, showing a more gradual progression.

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Finding the trend value

The trend value is calculated using formula 3, namely the trend equation. The results of the trend value calculation can be seen in table 2.

Table 2. Results of trend value calculation

Month	Sales	Level	Trend
Q1-Jun	110	110,00	2,00
Q2-Jun	112	112,00	2,00
Q3-Jun	125	116,20	3,10
Q4-Jun	120	119,44	3,17
Q1-Jul	121	122,29	3,01
….	….	….	….
….	….	….	….
….	….	….	….
Q2-Nov	*187*	*193,83*	*3,16*
Q3-Nov	*193*	*196,19*	*2,76*
Q4-Nov	*200*	*199,15*	*2,86*

The table represents the results of a trend value calculation based on sales data, which aims to identify the overall direction of sales performance over time. In this case, both smoothed values and trend values have been calculated to capture the general pattern of growth or decline in the data.

In Q1-Jun, the actual sales are 110, the smoothed level is also 110, and the trend value is 2.00. This indicates a steady but minor upward movement.

By Q3-Nov, actual sales have increased to 193, the smoothed value (level) is 196.19, and the trend value is 2.76. The trend here shows a slight downward adjustment in the rate of growth compared to earlier periods.

Calculating Forecasting and Error Values

The calculation process uses Microsoft Excel and the Data Analysis and Solver Add-in to find the smallest error value. The smallest error value is able to produce the most efficient α and β values. In the first step, determine the temporary α and β values to obtain the percentage error values of MAPE and RMSE. The values used are 0.2 for α and 0.5 for β. Based on the calculation results, the data obtained are as in table 3.

Table 3. Results of Calculation Forecasting and Error Values

Month	Sales	Level	Trend	Forecast	Error	Absolute Error	Squared Error
Q1-Jun	110	110,00	2,00				
Q2-Jun	112	112,00	2,00	112,00	0,00	0,00	0,00
Q3-Jun	125	116,20	3,10	114,00	11,00	0,10	121,00
Q4-Jun	120	119,44	3,17	119,30	0,70	0,01	0,49
Q1-Jul	121	122,29	3,01	122,61	-1,61	0,01	2,59
….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….
Q2-Nov	187	193,83	3,16	195,53	-8,53	0,04	72,84
Q3-Nov	193	196,19	2,76	196,98	-3,98	0,02	15,86
Q4-Nov	200	199,15	2,86	198,94	1,06	0,01	1,12
Q1-Dec				202,02			
Q2-Dec				204,88			
Q3-Dec				207,74			
Q4-Dec				210,61			

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The calculation results above produce MAPE data of 3.79% and RMSE of 1.48. MAPE of 3.79%: This indicates that, on average, the forecasted values differ from the actual values by 3.79%. A lower MAPE value indicates a more accurate forecast. In this case, a MAPE of 3.79% suggests a highly accurate forecasting model, as a MAPE below 10% is often considered very good in many applications. RMSE of 1.48: RMSE measures the average magnitude of forecast errors, with larger errors being more heavily weighted. In this case, an RMSE of 1.48 means that the forecasted values, on average, deviate from the actual values by 1.48 units (depending on the unit of measurement, such as sales, temperature, etc.). Like MAPE, a lower RMSE value indicates better accuracy.

Calculating the Best MAPE Value

The next step is to use the Add-in solver to find the smallest MAPE value to get the best alpha and beta values. The smallest MAPE value using the Add-in Solver is 3.58% with an alpha value of 0.8808 and a beta value of 0.0042. The new alpha and beta values produce new forecast values for December weeks 1, 2, 3 and 4 as shown in table 2.
Table 2 Calculations Using Holt's Exponential Smoothing with values $\alpha = 0.9961$ and $\beta = 0.02661$

Table 4. Results of forecasting calculation and Error Values using Best MAPE Value

Month	Sales	Level	Trend	Forecast	Error	Absolute Error	Squared Error
Q1-Jun	110	110,00	2,00				
Q2-Jun	112	112,00	2,00	112,00	0,00	0,00	0,00
Q3-Jun	125	123,69	2,41	114,00	11,00	0,10	121,00
Q4-Jun	120	120,73	2,18	126,10	-6,10	0,05	37,23
Q1-Jul	121	121,23	2,11	122,91	-1,91	0,02	3,65
….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….
Q2-Nov	187	187,11	2,99	187,94	-0,94	0,00	0,88
Q3-Nov	193	192,66	3,10	190,11	2,89	0,02	8,37
Q4-Nov	200	199,49	3,26	195,76	4,24	0,02	17,99
Q1-Dec				202,76			
Q2-Dec				206,02			
Q3-Dec				209,28			
Q4-Dec				212,54			

Based on the calculation results in table 4, the comparison results between sales data and forecast results can be visualized as shown in Figure 2.

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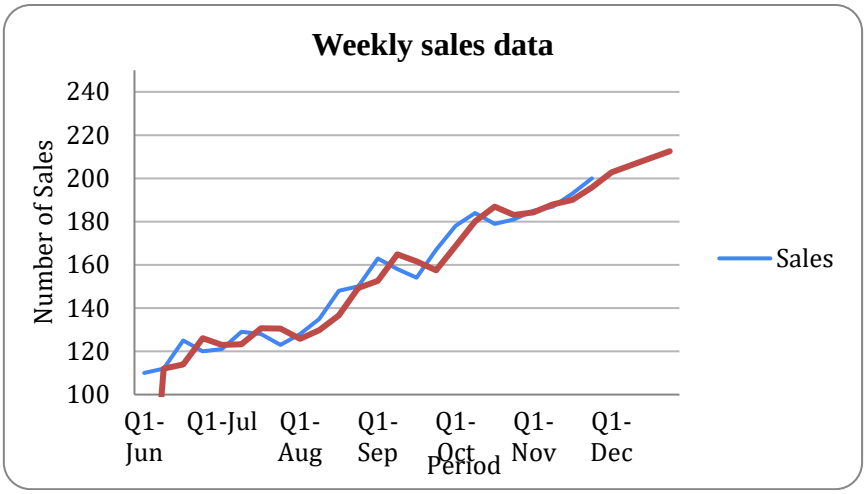

Figure 2. Comparison Chart between sales data and forecasting data
Source: *Result of research*

DISCUSSION

This study aims to implement the Holt's exponential smoothing method on sales at Buled bakery in order to be used as a consideration for the amount of bread produced in the next period. The use of the Holt's exponential smoothing method was chosen based on the plot graph showing that After the study was conducted, the value in the initial step using the value $\alpha = 0.2$ and the value $\beta = 0.5$ obtained a MAPE value of 3.79. Determination of alpha and beta values affects the prediction results of the forecasting method used. Microsoft Ecxel has an Add-in feature that is able to find the best alpha and beta values using the solver menu without having to experiment one by one for alpha and beta values.

The values used as a reference for determining the best alpha and beta are using the smallest MAPE value reference to get the best alpha and beta values. The calculation results obtained a MAPE value of 3.58 with a value of $\alpha = 0.8808$ and $\beta = 0.0425$. The prediction of the amount of bread that must be produced in December, the first to fourth weeks is as follows:

Table 5. Result of Forecasting on December

Period	Forecasting
Q1-Dec	202,76
Q2-Dec	206,02
Q3-Dec	209,28
Q4-Dec	212,54

CONCLUSIONS

Based on the results of the research that has been conducted using primary data and tools in the form of Microsoft Excel to forecast sales data in the first week to the fourth week in December 2023, it was found that the values $\alpha = 0.8808$ and $\beta = 0.042$ which produced a MAPE value of 3.58% and an RMSE value of 1.32. The results of the forecasting produced forecast values for the first to fourth weeks in sequence of 202, 206, 209, and 212. This method produces a good MAPE value so that it can be used to forecast data in Buled Bakery. However, to be even better, initial testing needs to be carried out to see whether the data has a trend or not using the Augmented Dickey-Fuller (ADF) test.

The implications of these findings suggest that the forecasting method used it is recommended that Buled Bakery performs an initial test to determine whether the sales

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data exhibits a trend using the Augmented Dickey-Fuller (ADF) test. By identifying whether a trend exists, the bakery can choose a more appropriate forecasting model, ensuring more consistent and accurate predictions for future sales. This adjustment could lead to better decision-making in inventory management and production planning.

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