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Forecasting Monthly Sales Using Single Exponential Smoothing: An Evaluation and Performance Analysis

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***Abstract* — Micro, Small, and Medium Enterprises (MSMEs) have a strategic role in Indonesia's economy, contributing more than 60% to the Gross Domestic Product (GDP) and absorbing the majority of the national workforce. One of the MSME sectors that is growing rapidly is the food and beverage industry, including home cake shops. However, many MSME actors have not utilized scientific methods in business decision-making, especially in sales forecasting. In fact, accurate sales predictions are very important in managing production, raw material procurement, and operational efficiency. This study examines the performance of the Single Exponential Smoothing (SES) method compared to Holt's Linear Trend in predicting cake shop sales over the past two years. Based on the evaluation using MAE, RMSE, and MAPE, the SES model showed higher accuracy, with a MAPE value of 2.82%, lower than Holt's which reached 3.73%. These results indicate that a simple model like SES is better suited for sales data that does not have strong trends. These findings confirm that the selection of prediction models should consider the characteristics of the data, not just the complexity of the algorithms used.**

Keywords—MSME,Prediction, Sales, SES, Holt

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I. INTRODUCTION

Micro, Small, and Medium Enterprises (MSMEs) are the backbone of Indonesia's economy, with significant contributions to gross domestic product (GDP) and job creation. Based on data from the Ministry of Cooperatives and SMEs, in 2023 there will be more than 64 million MSMEs in Indonesia that contribute around 60.3% to the national GDP and absorb more than 97% of the national workforce [1]. Among various MSME sectors, the food and beverage industry, including home bakeries, is one of the areas that continues to grow consistently, driven by high consumer demand, lifestyle changes, and the increasing popularity of digital platforms for sales [2].

However, in the management of daily operations, many MSMEs, including cake shops, have not adopted a scientific approach in their business planning, especially in the aspect of sales forecasting. In fact, accurate sales forecasting plays an important role in determining production volume, raw material procurement, labor scheduling, and budget allocation. Inaccuracies in forecasting demand often lead to overstocking that increases storage costs or stockouts that lead to customer loss.

In the context of a bakery, which has products with a relatively short shelf life, forecasting errors can have a direct impact on financial losses and food waste. Therefore, a simple, accurate, and easily applicable prediction method is needed by small businesses without the need for advanced technological infrastructure. One of the things that can be done is with prediction techniques [3] [4]. One method that meets these criteria is Single Exponential Smoothing (SES) [5] [6], which is part of the classic time series forecasting method. SES works by giving more weight to the latest data and reducing the influence of old data, making it suitable for volatile sales data but lacking strong seasonal patterns. The main advantage of SES is its simplicity in implementation and

speed of computing, making it very suitable for MSMEs that have limited resources.

Several previous studies have shown that SES is able to provide fairly good predictive results in the context of retail sales [7] [8], even when compared to more complex forecasting methods [9]. However, studies that specifically apply this method to the case of MSMEs in cake shops in Indonesia are still very limited, especially in the context of evaluating predictive performance based on quantitative metrics such as MAE (Mean Absolute Error), RMSE (Root Mean Squared Error), and MAPE (Mean Absolute Percentage Error). By looking at the importance of accuracy in sales forecasting to support the sustainability and operational efficiency of MSMEs, this study aims to evaluate the performance of the Single Exponential Smoothing method in predicting monthly sales in a small-scale cake shop in Indonesia. The results of this study are expected to make a practical contribution to MSME actors in making data-based decisions and add to the treasure of literature on the application of simple statistical models in the context of microbusiness. Various previous studies have shown that the Single Exponential Smoothing (SES) method is still a solid and applicable forecasting approach, especially in the MSME environment and the small-scale retail sector in Indonesia. Compare the moving average and SES methods for forecasting banana chip sales and find that SES consistently provides a lower error rate (MAPE) [10]. Transformers have been actively studied for time-series forecasting in recent years. While often showing promising results in various scenarios, traditional Transformers are not designed to fully exploit the characteristics of time-series data [11]. Another research illustrates how the use of exponential smoothing in DSS can provide valuable guidance for retailers in optimizing inventory and making inventory decisions [12]. Meanwhile, the implementation of SES in the e-commerce platform and found that the optimal smoothing level (α) value of 0.9 was able to minimize errors [13].

Single Exponential Smoothing (SES) remains an effective basic method for sales forecasting [14] in various sectors such as corn production prediction [15] Furthermore, Manalu et al. implement SES for vehicle stock forecasting and obtain satisfactory performance in maintaining inventory availability [16], Some of these relevant studies reinforce the findings from previous studies that SES is easy to implement, computationally efficient, and has high accuracy for short-term forecasting needs in the MSME and small retail sectors. However, limitations arise when the data show a strong long or seasonal trend in conditions where additional methods such as Holt-Winters or integration with machine learning could yield better results.

II. METHODOLOGY

Data Collection

The initial stage in this study is to collect monthly sales data from a cake shop MSME in Indonesia. The data was collected historically over 25 months, i.e. from January 2022 to January 2024. The data source is obtained directly from the store's daily transaction records that have been recapped on a monthly basis.

Data Pre-processing

Before forecasting, the data will go through a pre-processing process which includes: checking the completeness of the data, handling missing values if any. Initial visualization of the data to see trends or patterns of sales fluctuations as well as transform the time format to the DateTime format if needed. The dataset is divided into two parts: Training data: January 2022 – July 2023 (80%). Testing data: August 2023 – January 2024 (20%)

Application of Single Exponential Smoothing (SES) Method

The Single Exponential Smoothing (SES) method is applied to the training data using automatically optimized α-level smoothing parameters.

Model Evaluation

To evaluate the accuracy of the SES model, three common statistical metrics were used: Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and Mean Absolute Percentage Error (MAPE)

Forecast for 2025

Once the model is proven to have a decent performance on the test data, the model is then used to forecast monthly sales for the next 12 months, i.e. for the period January to December 2025.

Interpretation and Analysis

The results of the forecast and evaluation values were analyzed descriptively. This analysis also includes a discussion of the advantages and limitations of the SES method when applied to MSMEs in the food sector with a relatively stable sales cycle but susceptible to monthly fluctuations.

III. RESULT AND DISCUSSION

An overview of the monthly sales trends of cake shops during January 2022 – January 2024 in detail on Fig *1*.

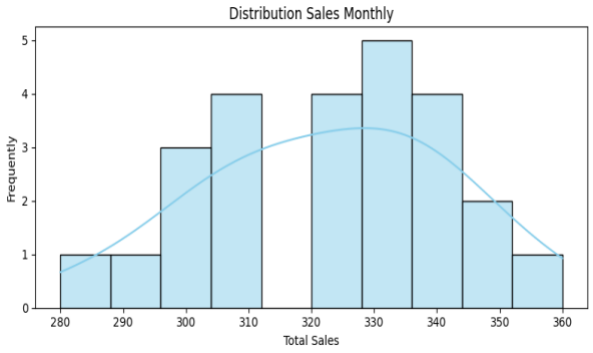

Fig 1. Sales Monthly

The next data presentation is about the distribution of sales data in the heatmap according to Fig *2*.

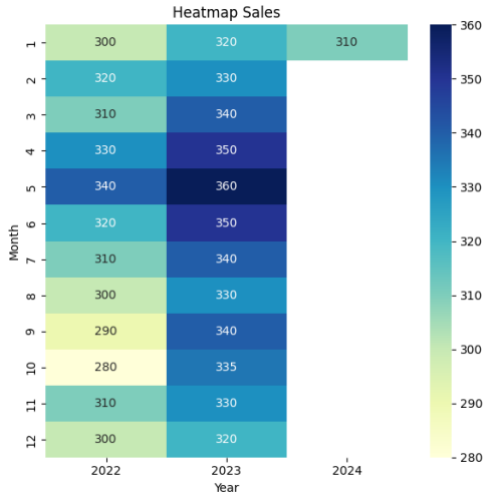

Fig 2. Heatmap Sales

Based on the data used, a descriptive value was obtained at Table I.

Table I. Descriptive Data

Detail	Value
Sales Count	25.000.000
Mean	322.600000
Std	19.954114
Min	280.000.000
Max	360.000000

Data based on the graph shows that fluctuations are quite frequent with fairly varied data. Total sales value in January 2022-January 2024 details on Fig *3*.

Single Exponential Smoothing

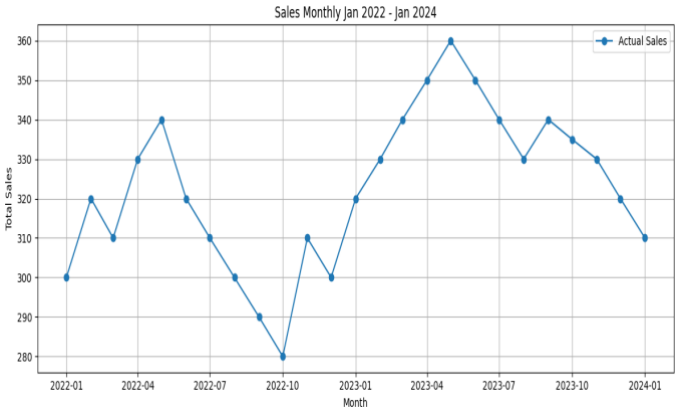

Fig 3. Sales Monthly Graph

Data forecasting and prediction using Single Exponential Smoothing and prediction values based on training data and data testing on Fig *4* and Fig *5*.

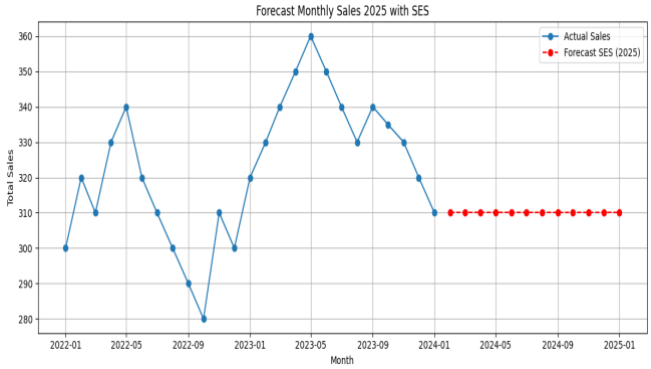

Fig 4. Forecast Using SES

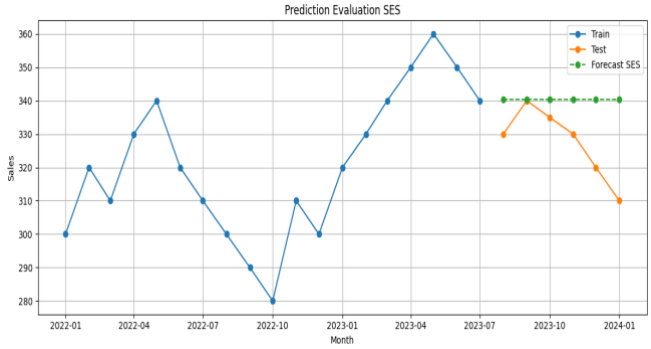

Fig 5. Prediction Evaluation SES

The prediction results using Single Exponential Smoothing produced a α value (smoothing level) of 0.961 with Performance Evaluation SES Model value MAE : 9.04 RMSE : 11.23 MAPE : 2.82%

Interpretation and Analysis

The α value (smoothing level) obtained shows how much weight the latest data is compared to the old data when predicting. A value close to 1 means that the model is very responsive to the latest data.

MAE (Mean Absolute Error) is about how many units of average sales are missed from the actual, for example 7.5 means that the average prediction misses ±7.5 sales.

RMSE (Root Mean Square Error) gives more weight to large errors, useful for assessing general accuracy.

MAPE (Mean Absolute Percentage Error) measures the relative error percentage, e.g. 2.5% means that the average prediction misses 2.5% of the original value.

The visualization shows how the SES prediction follows the test data pattern, but the SES tends to be smooth and may be less able to capture sudden fluctuations. The SES model is quite feasible as a baseline for the prediction of monthly sales of this data, especially since the data is relatively stable without extreme up/down trends. If sales data is growing or decreasing consistently, or there is a seasonal pattern, it is possible to use the Holt or Holt-Winters model. The next experiment uses Holt Linear Trends.

Holt's Linear Trend

The test results by adding holt's linear trend resulted in MAE values of 11.89, RMSE : 15.25 and MAPE : 3.73%. The results of the comparison of Single Exponential Smoothing with Holt Linear Trend are shown in Fig 6.

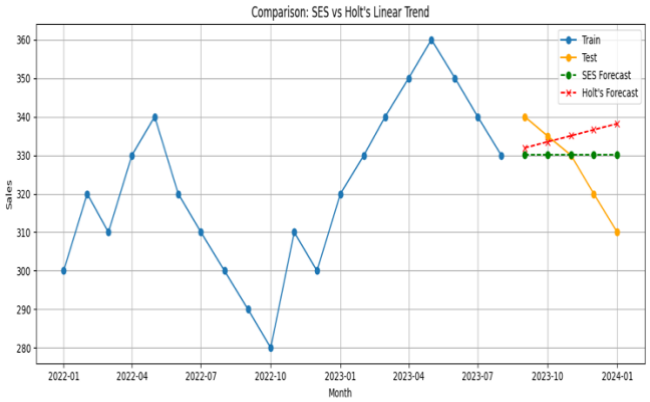

Fig 6. Comparison SES and Holt

Based on the above values, surprisingly SES performed better than Holt, MAE and RMSE SES values were lower than Holt, which means that the SES prediction is absolutely closer to the actual value, and the variability of error is smaller. The MAPE SES value is smaller (2.82%) than Holt's (3.73%), indicating that the proportion of error to actual value is also smaller, which is important in the context of business decision-making. Although Holt theoretically is more suitable for trending data, these results indicate that the trend patterns in the data are not strong enough or inconsistent, so the linear approach in Holt instead magnifies the error. These results confirm that the complexity of the model does not necessarily guarantee higher accuracy. Most likely, the movement of sales data in the test period is flat or slightly fluctuating, so a simple SES model is more accurate because it does not "force" linear trends like Holt. It also shows that for short-term forecasting and data with weak trends, SES can provide more stable and computationally efficient predictions. From these experiments, SES proved to provide more accurate predictions than Holt's Linear Trend, indicated by lower MAE, RMSE, and MAPE values. Although Holt is generally recommended for trending data, in this case the data characteristics seem to be more suitable for predicting with a simple smoothing method. This emphasizes the importance of exploratory analysis of data patterns before determining the forecasting method to use. The selection of the appropriate model is not always about the more complex ones, but the ones that are most appropriate for the data context and forecasting purposes.

IV. CONCLUSION

Based on the results of the existing research, the following points can be concluded:

a. Simple Exponential Smoothing model provides more accurate predictions than Holt's Linear Trend model, indicated by lower MAE, RMSE, and MAPE values.

b. Value MAPE SES was 2.82% smaller than Holt's (3.73%), which shows that the relative error of the SES prediction was smaller than the actual value.

c. Complexity of the Holt model does not guarantee higher accuracy, especially if the trends in the data are weak or inconsistent. The characteristics of sales data in the test period tend to be flat or slightly fluctuating, making it more suitable to use a simple model such as SES.

d. Results suggest that the selection of prediction models should be adjusted to the characteristics of the data, not simply based on the level of complexity of the method.

Suggestion of the research :

a. Perform a data pattern analysis before choosing a forecasting method, to ensure the model matches the data characteristics.

b. Conduct periodic evaluations of the model's performance as data characteristics can change over time.

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