Development of a Web-Based Forecasting System Using the Holt-Winters Exponential Smoothing Method to Improve Accuracy in Predicting Cut Flower Harvest Needs

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***Abstract*—Information is the result of data processing so it becomes important for the recipient and is useful as a basis for decision making. In the flower business, production information is needed to determine the number of cut flowers to match customer demand in the future. This aims to minimize losses that occur due to a shortage or excess of cut flowers. There are still live flower shops that use manual methods and feelings to determine cut flower needs. Therefore, a website-based forecasting system is needed to provide estimated flower cuts for the next period for businessmen. The application was built using the PHP programming language by implementing the Holt-Winters exponential smoothing forecasting method. The Holt-Winters method was used to estimate flower needs, especially cut flowers for bouquet products. Calculation of error score in the method was calculated by MAPE testing. Based on the test results, it is known that the error score in the Holt-Winters forecasting method for the number of cut flowers in a bouquet of Aster, Roses, and Pikok is 13.89%, 16.54%, and 13.23% respectively and they are in Good category. This method has lower error percentage for Aster, Rose, and Pikok flower respectively by 3.95%, 1.86%, and 14.01% than by using florist former method.**

Keywords—forecasting, website, holt-winters exponential smoothing, flower bouquet

I. INTRODUCTION

Information is the result of data processing that transforms it into a form that is important for the recipient and serves as a basis for decision-making, the effects of which can be felt either immediately or in the future. Information is extremely important and valuable for a company because accurate and timely information can be used by managers as a consideration for future decision-making [1]. In the fresh flower business, predictive information is needed to determine the number of cut flowers to be harvested to match the customer demand at a future time. This aims to minimize losses caused by either a shortage or surplus of flower harvests. An excess in the number of flowers leads to losses due to the limited shelf life of flowers, which lasts only 3-5 days post-harvest. Beyond that time, the flowers will wilt and become unsellable. On the other hand, a shortage in the flower harvest will increase the transportation costs from the flower farm to the flower shop, which can range from IDR 150,000 to IDR 200,000 per trip.

Shenda Florist is a small and medium-sized enterprise (SME) located in Surabaya and has been operating since 2019. Shenda Florist primarily sells various floral arrangements using fresh flowers. Their current products include flower boards, wreaths, and bouquets. To meet its flower needs, Shenda Florist owns a flower farm of approximately 10 hectares in Batu, Malang. Flower harvesting is usually done every three days, with a harvest volume reaching 50 kg per trip. Occasionally, harvesting is done at shorter intervals if there are many orders, which increases operational costs. Currently, the determination of the harvest quantity sometime is done manually by using moving average method or based on incoming orders or intuition. Therefore, predictive information is needed as a reference for making decisions regarding the number of flowers to be harvested from the farm to the shop.

In this study, the author developed a web-based forecasting system using PHP from the Laravel platform to generate forecast information on the number of cut flowers needed by Shenda Florist. The system uses the Holt-Winters Exponential Smoothing forecasting method. The Holt-Winters method is based on three smoothing equations: one for the stationary component, one for the trend, and one for the seasonal component [2]. This method was chosen because the sales pattern of Shenda Florist's floral arrangements is seasonal and tends to increase. Sales are particularly high in certain months, such as February and December. Furthermore, the sales data shows a year-over-year increase. The sales data used in this study is from the past two years, specifically for bouquet floral arrangement products. The training data consists of bouquet flower demand data from 2022, while the testing data is from 2023.

Problem Statement In obtaining forecasting results for cut flower harvests, specifically for bouquet-making needs, the author uses the Holt-Winters Exponential Smoothing method, leading to the following problem statements: How can the Holt-Winters Exponential Smoothing method be applied to floral arrangement products, particularly for the cut flower needs of bouquet products using PHP. What is the accuracy of the Holt-Winters Exponential Smoothing method in forecasting the cut flower needs for floral arrangement products, specifically for bouquet products?

Scope of the Study Based on the defined problem statements, the scope of this study is as follows: The forecasting calculations in this study use the Holt-Winters Exponential Smoothing method. The product selected for forecasting is the cut flower product, specifically for bouquet-making needs. The research object is Shenda Florist in Surabaya, using historical data from the past two years. The objectives of this research are: To apply the Holt-Winters

Exponential Smoothing method for forecasting the cut flower needs, particularly for bouquet products. To assess the accuracy of the forecasting calculations using the Holt-Winters Exponential Smoothing method for the cut flower needs of bouquet products.

II. LITERATUR REVIEW

The Holt-Winters Exponential Smoothing method has become one of the most widely used techniques in time series forecasting due to its ability to effectively capture level, trend, and seasonal components (Holt, 1957; Winters, 1960). Initially introduced by Holt (1957) as an extension of exponential smoothing to accommodate trends, the method was further developed by Winters (1960) to include seasonal variations, thus enhancing its applicability to various real-world datasets.

The effectiveness of the Holt-Winters method has been demonstrated in various forecasting contexts. For example, [3] in their study on retail sales forecasting highlighted the performance of this method compared to ARIMA models. In the field of public health, the Holt-Winters method has been used to predict vaccine demand. applied this method to forecast child immunization rates in the Bicol region of the Philippines. [4]

Holt-Winters has also been combined with machine learning techniques to improve forecasting accuracy proposed a hybrid model that integrates Holt-Winters Exponential Smoothing with artificial neural networks, resulting in superior performance in energy consumption forecasting compared to traditional approaches [5]. Addressed this by integrating adaptive smoothing parameters, allowing the model to dynamically adjust to changing data patterns, thereby improving its resilience in volatile environments [6].

The method was applied for short-term electricity demand forecasting, finding that Holt-Winters was more effective than autoregressive integrated moving average (ARIMA) models in capturing the seasonal components of energy data [5]. In the transportation sector, used this method to forecast highway traffic in Malaysia [6].

Zhang et al. (2019) combined the Holt-Winters method with regression analysis to estimate retail product demand in the Chinese market. Investigated the application of the Holt-Winters method in forecasting stock prices, concluding that it provided more accurate short-term predictions when applied to stock data with strong seasonal trends. In healthcare, Holt-Winters was used by to forecast child vaccination demand in the Bicol region of the Philippines [7]. Another study by Adhikari and Agrawal proposed a modified version of the Holt-Winters model to account for irregular seasonal changes, demonstrating that adjusting the smoothing parameters yielded better results in more dynamic environments [7]. Examined the co [9] mparison between the Holt-Winters method and machine learning techniques in forecasting water consumption in urban areas [8].

III. RESEARCH METHOD

forecasting is an estimate or prediction of something that has not yet occurred in the future. A time series is a sequence of observations indexed by time, usually ordered at regular intervals and related. Time series data is an indicator analyzed to estimate future values. Time series data is used in fields such as agriculture, tourism, economics, and business to support future value forecasting. One of the time series methods frequently used in forecasting is Holt-Winters exponential smoothing [3].

The Holt-Winters Exponential Smoothing forecasting method is one of several time series forecasting models. Winters' triple exponential smoothing method is better known as the Holt-Winters method, which is based on three smoothing equations: level, trend, and seasonal components [2]. The Holt-Winters smoothing method can be used when the data contains trend and seasonal components [4], requiring three smoothing parameters: α for the process level, β for the trend, and γ for the seasonal component, aiming to minimize the MAPE value.

There are two Holt-Winters methods: additive and multiplicative. [5] the multiplicative Holt-Winters method is used when the plot of the original data shows varying seasonal fluctuations. The smoothing equation using the multiplicative Holt-Winters method is presented [2].

The Mean Absolute Percentage Error (MAPE) is a statistical measure of forecasting accuracy that provides information about the magnitude of the forecasting error compared to the actual value in the series (Fanhausen, 2022). According to Pei-Chann Chang (2007) in Fanhausen (2022), MAPE is categorized into four levels:

<10% = Very good
10% - 20% = Good
20% - 50% = Fair
50% = Poor

The calculation of MAPE involves summing the total errors after first subtracting the actual data value from the forecasted value, then dividing by the actual data. MAPE represents the percentage of forecasting error, [6] which is formulated as follows:

$$\boxed{\mathrm{MAPE} = \frac{\sum_{i=1}^{n} \left| \frac{Yt - \widehat{Yt}}{\widehat{Yt}} \right|}{n} \; x \; 100\%} \tag{1}$$

Description:
Yt: Actual Value
Yt': Forecasted Value
N: Number of Data

IV. RESULT AND DISCUSSION

In this study, the author employs the Holt-Winters Exponential Smoothing method to forecast the demand for cut flowers at Shenda Florist Surabaya, specifically focusing on bouquet products. The forecasting calculations are conducted using a computer program developed in PHP. The error values from the forecasts are calculated using MAPE. The data used for the calculations are daily sales data of bouquets from the 2022–2023 period, consisting of 1,098 orders. The daily order data is then grouped weekly, resulting in 48 data points for each year. The training data is from 2022–2023, while the testing data is from 2023. In this research, the program is designed to generate weekly forecast data for the demand for cut flowers throughout 2024, producing 48 data points annually. The purpose of this forecasting program is to assist Shenda Florist Surabaya in determining the weekly harvest number of flowers, thereby minimizing losses caused by inaccurate harvest predictions.

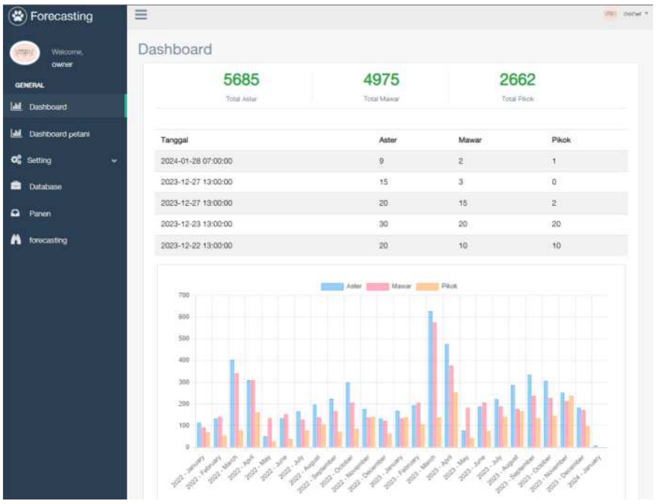

Fig. 1. Dashboard page

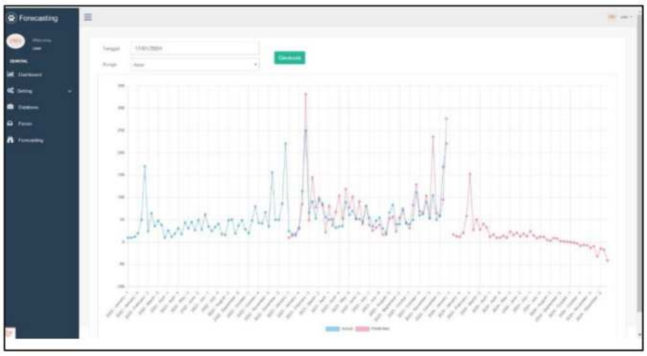

Fig. 2. Forecasting page

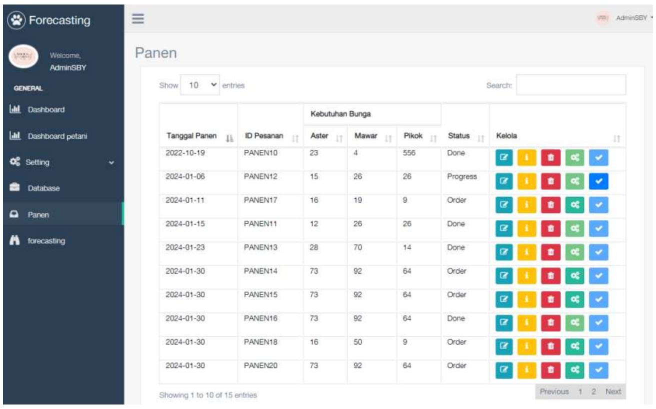

Fig. 3. Harvest page

The system is developed using the Waterfall Model within the SDLC, which is also known as the sequential linear model or classic life cycle model. The Waterfall model provides a step-by-step sequential approach to the software life cycle, starting from the analysis phase, followed by design, coding, testing, and support.

In this forecasting process, the Holt-Winters forecast values were calculated using the system.

2023 - January - 1	10	2023 - July - 1	48
2023 - January - 2	11	2023 - July - 2	34
2023 - January - 3	16	2023 - July - 3	46
2023 - January - 4	28	2023 - July - 4	55
2023 - February - 1	75	2023 - August - 1	24
2023 - February - 2	236	2023 - August - 2	20
2023 - February - 3	87	2023 - August - 3	62
2023 - February - 4	112	2023 - August - 4	64
2023 - March - 1	58	2023 - September - 1	26
2023 - March - 2	116	2023 - September - 2	49
2023 - March - 3	78	2023 - September - 3	75
2023 - March - 4	69	2023 - September - 4	32
2023 - April - 1	63	2023 - October - 1	29
2023 - April - 2	52	2023 - October - 2	52
2023 - April - 3	29	2023 - October - 3	120
2023 - April - 4	30	2023 - October - 4	64
2023 - May - 1	85	2023 - November - 1	62
2023 - May - 2	123	2023 - November - 2	99
2023 - May - 3	63	2023 - November - 3	51
2023 - May - 4	67	2023 - November - 4	230
2023 - June - 1	41	2023 - December - 1	51
2023 - June - 2	77	2023 - December - 2	59
2023 - June - 3	47	2023 - December - 3	114
2023 - June - 4	79	2023 - December - 4	285

Fig. 4. System calculation for aster flowers

Below are charts of the actual data of flower harvest number marked in green line and result of Holt-Winter prediction number marked in blue in the forecasting system.

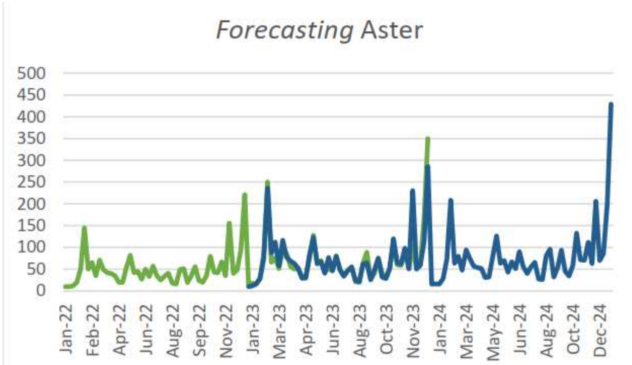

Fig. 5. Calculation graph holt-winters aster flower

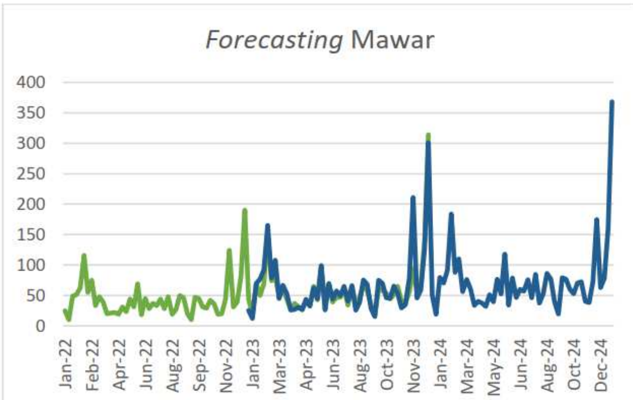

Fig. 6. Calculation graph holt-winters mawar flower

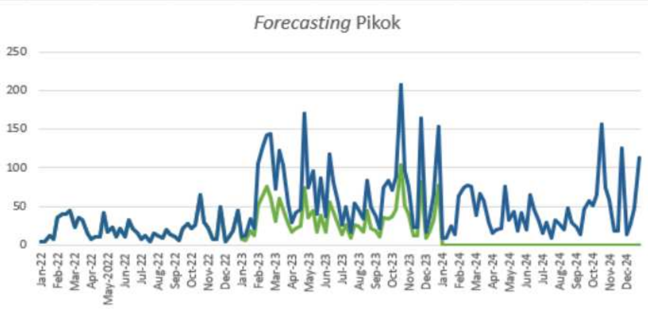

Fig. 7. Calculation graph *holt-winters* pikok flower

A. MAPE Calculation Testing

The testing used in this research involves comparing the forecast results with the actual data from 2023. Below is number of Aster flower in weekly demand in January 2023 and 2024. Herewith also included the prediction result of Holt-Winter method and Moving Average. The later is method being used by the florist to predict number of harvests.

TABLE I. PREDICTION RESULT OF HOLT-WINTER METHOD AND MOVING AVERAGE.

Week	2023	2024	Holt-Winter	Moving Average
1	10	15	10	12.5
2	10	18	11	14
3	12	15	16	13.5
4	20	30	28	25

The calculations are done using the MAPE (Mean Absolute Percentage Error) method. Below is the MAPE calculation case for the first week of January 2023.

$$\text{MAPE} = \frac{\sum_{i=1}^{n}\left|\frac{Yt-\hat{Y}t}{\hat{Y}t}\right|}{n} x\ 100\%$$

$$Yt - Yt' = 15 - 10 = 5$$

$$|Yt - Yt'| = |15 - 10| = 4{,}9137$$

$$|(Yt - Yt')/Yt'| = |(15 - 10)/10| = 0{,}4872$$

$$\sum_{i=1}^{n}\left|\frac{Yt-\widetilde{Y}t}{\widetilde{Y}t}\right| = 0{,}4872 + \ldots + 0{,}2259 = 6{,}666$$

$$\frac{\sum_{i=1}^{n}\left|\frac{Yt-\hat{Y}t}{\hat{Y}t}\right|}{n} x\ 100\% = 6{,}666/48*100\%$$

$$= \mathbf{13{,}8876\%}$$

Fig. 8. MAPE Calculation of Aster Flower Prediction by Using Holt-Winters Method

Therefore, here are results of MAPE calculation of Aster, Mawar, and Pikok flower prediction by using Holt-Winters method compared to Moving Average method.

TABLE II. RESULTS OF MAPE CALCULATION OF ASTER, MAWAR, AND PIKOK FLOWER PREDICTION BY USING HOLT-WINTERS METHOD COMPARED TO MOVING AVERAGE METHOD

Flower	Holt-Winter	Moving Average
Aster	13.8876%	17.8395%
Mawar	16.5419%	18.4011%
Pikok	13.2318%	27.2517%

B. Result Analysis

The error calculation results using MAPE for flower harvest forecasting in 2023, rounded to two decimal places, are as follows: 13.89% for Aster, 16.54% for Rose, and 13.23% for Pikok. According to Pei-Chann Chang, these figures fall into the "Good" category. The error percentage by using Holt-Winter method is lower respectively by 3.95%, 1.86%, and 14.01% than by using Moving Average method. Thus, accuracy is improved compared to Moving Average.

V. CONCLUSION

Conclusions derived from the application of the Holt-Winters Exponential Smoothing method to calculate weekly flower harvest requirements for bouquet products at Shenda Florist Surabaya are:

1. The Holt-Winters exponential smoothing method can be used to forecast the flower harvest requirements for bouquet products at Shenda Florist Surabaya for the years 2023 and 2024, using 2022–2023 data as training data and 2023 data as test data.
2. The Holt-Winters forecasting method can be applied to a web-based system using the PHP programming language.
3. The forecasting results using Holt-Winters show MAPE values in the "Good" category, with forecast error values for Aster flowers at 13.89%, Roses at 16.54%, and Pikok at 13.23%.
4. The error percentage by using Holt-Winter method is lower for Aster, Rose, and Pikok flower respectively by 3.95%, 1.86%, and 14.01% than by using Moving Average method.
5. The system is beneficial to Shenda Florist for improving harvest efficiency, thereby reducing harvest accommodation costs, and it benefits farmers by providing more accurate and systematic harvest orders.

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