Machine Learning in Business: Enhancing Inventory Stability via Forecast-Based Inventory Strategies Using Holt's Linear Trend Double Exponential Smoothing

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Abstract— **Ineffective inventory management can lead to stock shortages, affecting sales and customer satisfaction negatively. To address these issue, effective and accurate strategies are crucial. This study aims to enhance inventory management at the Terang Teknik Electronics Store in Pontianak, West Kalimantan, where procurement decisions currently rely on owner intuition rather than systematic analysis. To optimize the calculation of safety stock and reorder point, this study integrates safety stock and reorder point strategies with Holt's Linear Trend Double Exponential Smoothing forecast method. Sales data from 4,228 items sold between January to December, 2023 were analyzed. Using purposive sampling to select 982 items from the highest sales category "Warranty Lamp" and focusing to MYLED Beta brand. The results include the determination of safety stock, and reorder point for various MYLED Beta wattages. The safety stock for this product are 5 watts at 4 units; 10 watts at 7 units; 15 watts at 2 units; and 20 watts at 5 units. The reorder points are 5 watts at 8 units; 10 watts at 13 units; 15 watts at 7 units; and 20 watts at 8 pcs units. Implementing safety stock and reorder point strategies, inventory management become more efficient and enhance product availability.**

Keywords—Forecast; Double Exponential Smoothing; Safety Stock; Reorder Point; Strategic Inventory Management

I. INTRODUCTION

Stock shortages caused by ineffective inventory management can negatively impact sales and customer satisfaction. Managers of businesses must ensure that customer can always obtain their items when they need. A business often achieves success in a competitive environment by quickly adapting to market demand. As supply chain evolve, the structures of these chains become increasingly complex, resulting in significant issues such as information and delays [1]. Managers must ensure sufficient availability to prevent loss of market share or displacement.

Terang Teknik Electronic Store is a retail business that sells various household electronic products and electrical materials in Pontianak, West Kalimantan. The store currently bases its procurement decisions on owner intuition rather than systematic analysis. This approach has resulted in unstable merchandise inventory levels, leading to both overstock and understock in the store's warehouse. These instabilities not only diminish operational efficiency and negatively impact customer satisfaction and sales performance. To address these issues, we implement inventory strategies to improve the effectiveness of inventory management. Implementation requires the use of data-driven insights to establish a more stable and accurate inventory management. This study focuses on integrating safety stock and reorder point strategies with Holt's Linear Trend Double Exponential Smoothing method to optimize the calculation of safety stock levels and reorder point at Terang Teknik Electronics Store.

Accurate and relevant forecasting can be used to estimate supply and demand and manage merchandise unavailability [2]. Forecasting has the capability to quantify trends, mitigate inventory volatility, and forecast sales for an upcoming year [3]. Forecasting helps managers of businesses make optimal decisions regarding operational problems [4]. Holt's Linear Trend Smoothing is a suitable method to identify trend indata [5]. This method is capable of mapping trends without assumptions and managing trends precisely. Time series dataset can be separated into residual seasonality and trend for forecasting if the data follows a trend [6]. With precise and relevant forecasting results, forecast method can be integrated and used to design strategies related to merchandise unavailability issues. Integrating forecasting with inventory management helps strategic decisions within the supply chain can be more effectively controlled [7], including determining safety stock strategies and inventory reorder point strategies.

Safety Stock is a crucial inventory strategy that prevents out of stock leaks and ensures uninterrupted production and distribution processes [8]. Implementing a safety stock strategy enables businesses to mitigate the risk of inventory unavailability resulting from delayed supplier deliveries, sudden demand fluctuations, or other disruptions in the supply chain. Reorder point represents the inventory level at which a new order should be initiated to replenish stock before stock depletes or falls below a predefined safe level. Implementing the reorder point helps businesses achieve strategic inventory management balance and ensures that managers refrain from ordering excessively early to avoid excess inventory and high store cost [9]. Based on consumption rate, lead time for delivery, and desired safety stock, the reorder point is crucial for maintaining inventory within a secure threshold. Integrating forecasting with safety stock inventory strategies enhances the precision in determining safety stock levels by relying on historical data analysis and demand patterns. In addition, the safety stock becomes more adaptive to market fluctuations. The integrated approach enhances the effectiveness of safety stock inventory strategies compared to those based solely on raw unprocessed demand data.

II. RESEARCH METHODS

The object of this study is Terang Teknik Electronic Store, which currently relies on the owner's intuition for procurement without data analysis, resulting in unstable availability of merchandise in the store's warehouse. We adopt a quantitative approach, analyzing sales data including dates, days, product names, quantities, product categories, and total purchases. This study aims to enhance inventory management by determining the safety stock and reorder point for electronic products and integrating forecasting with safety stock and reorder point inventory strategies in a store's supply chain. Accurate forecasting results are used as parameters in these calculations because the resulting safety stock and reorder point are more responsive to future demand conditions. The data collected include sales information from Terang Teknik Electronic Store over a one-year period, from January to December, 2023. The study population comprises 4,228 items. Using purposive sampling, sample was selected based on the highest sales category, comprising 982 items (23% of the data population). The selected items belong to the "Warranty Lamps" category and focus on the MYLED Beta brand.

The "Warranty Lamp" data collected from sales history goes through a data cleaning process. Data cleaning process involving the removal of columns such as day, category, dan total purchase, leaving only columns for date, product name, and quantity. Then, the data is reorganized and summarized into a table format. The data is organized by month as the main parameter to facilitate more detailed analysis. The purpose of this data processing is to streamline the preparation for more focused predictive models by eliminating unnecessary columns and summarizing the data.

The cleaned data are input into the prediction model. The prediction model employs Holt's Linear Trend method. This method involves several parameters that need to be considered: level (L_t), trend (B_t), alpha (α), and beta (β). L_t represents the estimated level of the series at time t, which is the typical value anticipated at specific point in time. B_t represents the estimated trend of the series at time t, representing the direction and rate of change in the data at that specific point in time. Alpha (α) is the smoothing parameter for the level with given values where $0 \leq \alpha \geq 1$, higher values of α enhance the prediction model's responsiveness to data changes. Beta (β) is the smoothing parameter for the trend with given values where $0 \leq \beta \geq 1$, higher values of β indicate a more significant impact of recent trend data in adjusting the prediction model. The formulation for using the forecasting method is as follows:

$$Level\ equation\ = L_t = \alpha y_t + (1-\alpha)(L_{t-1} + B_{t-1}) \quad (1)$$

$$Trend\ equation\ = B_t = \beta(L_t - L_{t-1}) + (1-\beta)B_{t-1} \quad (2)$$

$$Forecast\ equation\ = \hat{y}_{t+h|t} = L_t + B_t \quad (3)$$

The forecasted result is represented as the basic for calculating safety stock and reorder point. Calculating the safety stock and reorder point can help control inventory by maintaining stock stability [10]. The formula for safety stock depends on lead time and standard deviation. There are three parameters needed before calculating safety stock: Z, standard deviation (σ), dan LT. In safety stock calculations, the Z value is determined from specified service level. Service level measures the effectiveness of meeting customer demand within a specified timeframe by indicating the percentage of order or demand fulfilled from available stock or resources without out of stock. Standard deviation (σ) is the variation of demand or lead time from average value in inventory management. LT is the lead time, which refers to the duration from ordering an item until it arrives and is ready for use or sale, encompassing the purchase order initiation with suppliers, shipping, and receipt at the warehouse or storage location. Below is the formula for safety stock:

$$Safety\ Stock\ = Z \times \sigma\ \times \sqrt{LT} \tag{4}$$

Next the calculation of the reorder point. There are two parameters that need to be known before calculating the reorder point: demand during lead time and safety stock [11] [12]. Below is the formula for calculation:

$$Reorder\ Point = Demand\ during\ Lead\ Time + Safety\ Stock \tag{5}$$

III. RESULT AND DISCUSSION

Holt's Linear Trend was used to assess the processed sales data. This analysis focuses on warranty lamps products under the MYLED Beta brand, which come in four power variations: 5 watts, 10 watts, 15 watts, and 20 watts, using sales history data from January to December, 2023. Mean absolute percentage error (MAPE), mean squared error (MSE), root mean square error (RMSE) utilized as a metric for evaluating prediction accuracy. Table 1 presents the forecast results for the MYLED Beta products with the four different watt variations:

Table 1. Demand forecast result

	5 Watt	**10 Watt**	**15 Watt**	**20 Watt**
March	10	18	26	11
April	14	13	20	9
May	13	20	20	9
June	13	28	20	13
July	12	32	18	17
August	14	33	20	18
September	15	30	20	19
October	18	26	25	21
November	17	27	22	20
December	25	34	20	21
Alpha and Beta	0.7 and 0.7	0.8 and 0.8	0.6 and 0.6	0.5 and 0.3
MAPE	13.5%	14.5%	14%	12.6%
MSE	12.4	28	13.1	9.8
RMSE	3.5	5.3	3.6	3.1

Source: Authors's Analysis (2024)

Table 1 presents the demand forecast for March–December 2024. Data from January and February are used as the basis to identifying early demand trends and patterns that affect later periods. Therefore, January and February data are not included in Table 1. The forecast results indicate that the error rates for each watt variant are below 15%, which demonstrates that the predictions are sufficiently accurate for designing safety stock and reorder point strategies. The error rates are measured for each watt variant were 13.5% for 5 watts; 14.5% for 10 watts; 14% for 15 watts; and 12.6% for 20 watts. With MSE ranging from 9.8 to 28 and RMSE ranging from 3.1 to 5.3, the forecast results showed acceptable variations between predicted and actual values for each watt variant. Forecasting accuracy is critical in efficient supply chain management and, ultimately business success [13]. The varying values of alpha (α) and beta (β) for each variant indicate customized adjustments in predicting monthly demand levels and trends. With these low error metrics values, the predictions can effectively support further calculations for safety stock and reorder point inventory strategies.

Following the forecast results, calculations for safety stock and reorder point parameters include lead time, demand during lead time, standard deviation of demand, and desired service level. In this study, service level of 95% is targeted, achieved by setting a tolerance limit of 5% in safety stock calculations [14]. The demand during lead time is seven days indicating the maximum time for items to reach the store. Table 2 presents the outcomes of the safety stock and reorder point calculations:

Table 2. Calculation results of safety stock and reorder point

	5 Watt	10 Watt	15 Watt	20 Watt
Lead Time (7 days/30 days)	0.233	0.233	0.233	0.233
Z (Service Level 95%)	1.96	1.96	1.96	1.96
Mean	15.16202	26.02655	21.08939	15.80785
Standard Deviation	4.270696	7.039628	2.552595	4.737599
Demand during Lead Time	3.5	6.1	4.9	3.7
Safety Stock	4.0	6.7	2.4	4.5
Reorder Point	7.6	12.7	7.3	8.2

Source: Authors's Analysis (2024)

Table 2 shows the results of safety stock and reorder point calculations for each different watt variant. The safety stock of these products are 4 units for 5 watts; 7 units for 10 watts; 2 units for 15 watts; and 5 units for 20 watts. Meanwhile, the reorder point for these products are 8 units for 5 watts; 13 units for 10 watts; 7 units for 15 watts; and 8 units for 20 watts.

IV. CONCLUSION

In this study, the Holt's Linear Trend method is utilized to forecast the demand for MYLED Beta warranty lamps at Terang Teknik Electronic Store in future periods enabling the managers of businesses to discern monthly demand trends and patterns, optimize inventory management, and estimate the sales volume for MYLED Beta brand warranty lamps. The forecast results are then used as parameters to calculate safety stock and reorder point, which help determine the optimal quantity and timing for replenishing stock. Forecast results are used to optimize the calculation of safety stock levels and reorder point. Forecasting is used because the resulting safety stock and reorder point are more responsive to future demand conditions.

The study outcome involves determining the safety stock quantities for MYLED Beta warranty lamps. Safety stock for each wattage variant are 4 units for 5 watts; 7 units for 10 watts; 2 units for 15 watts; and 5 units for 20 watts. Safety stock allow managers of businesses to anticipate demand fluctuations and uncertainties in procurement processes, thereby maintaining consistent product availability in warehouse and reducing the risk of stock outs. Meanwhile, the reorder point for these products are 8 units for 5 watts; 13 units for 10 watts; 7 units for 15 watts; and 8 units for 20 watts. Reorder point serves as a guide to determine the optimal time to order products, thus preventing stockout situations.

The implementation of safety stock and reorder point strategies based on this study is crucial for Terang Teknik Electronic Store in supply chain management. These strategies aim to enhance product availability of MYLED Beta brand warranty lamps and minimize the risk of lost sales due to insufficient inventory. Utilizing safety stock and reorder point in the ordering process helps the owner of Terang Teknik Electronic Store ensuring uninterrupted sales processes [11] manage inventory more efficiently and reduce the risk of stockouts. Safety stock and reorder point strategies enables the store to better meet customer demand, prevent lost sales, and enhance overall customer satisfaction, [15] reduce the risks associated with both overstocking and understocking.

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