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Article

Medical Product Sales Forecasting for Business Optimization Using Double Exponential Smoothing

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Abstract: Accurate sales forecasting plays a critical role in inventory management, particularly for medical equipment companies where stock availability directly affects operational efficiency and customer service. However, many small and medium-scale distributors still lack reliable forecasting systems, resulting in overstocking, high storage costs, or stockouts that lead to missed sales opportunities. Addressing this gap, this study aims to develop a web-based sales prediction system for PT Etiqa Prima Utama—a medical equipment distributor in Padang, West Sumatra—by applying the Double Exponential Smoothing method. The system was designed using PHP and MySQL to generate monthly sales forecasts for various medical products based on historical data. Key findings show diverse forecast accuracy across 20 product categories. The Glucose HK product achieved the lowest MAPE value at 10%, indicating excellent predictive performance, while the Clean Chem product showed the highest MAPE at 54%. Several other products, such as Total Bilirubin (12%), Urea (10%), and Diluent 20L (14%), demonstrated favorable accuracy with MAPE values below 60%. These results imply that Double Exponential Smoothing can support inventory optimization by providing reasonably accurate forecasts for most products, enabling better stock planning and more informed decision-making within the company.

Keywords: Medical Equipment; Sales Forecasting; Double Exponential Smoothing; Time Series Analysis; Inventory Management.

1. Introduction

The development of information technology in Indonesia is currently experiencing rapid growth, serving to facilitate various human activities [1], [2]. The use of information technology has expanded in data processing, management, and analysis, enabling the generation of relevant, fast, and accurate information [3]. The application of this technology has reached various sectors, including government institutions [4], private companies [5], [6], and the general public, particularly in the business sector [7], [8]. Entrepreneurs are increasingly utilizing information technology to support the development of their businesses.

One important technique in decision-making is forecasting, which is used to predict future values based on historical data [9] - [11]. Time series forecasting is the process of analyzing sequential data using statistical methods and modeling techniques to generate predictions and support strategic, data-driven decision-making [12], [13]. This method falls under the category of quantitative forecasting [14], [15]. Examples of time series forecasting include predicting next week's weather, estimating daily stock closing prices, and similar applications [3].

Forecasting is both an art and a science used to predict future events. In forecasting, historical data (such as last year's sales) are analyzed to estimate future periods using mathematical models [9]. In business, forecasting can be utilized for managing and planning sales strategies as well as determining inventory levels for the upcoming months or years [16].

In the context of business management, the management of human resources, finances, and time is crucial for achieving organizational goals effectively [17]. Good management principles enable companies to face dynamic market changes. Management is defined as the process of organizing and controlling both physical and non-

physical resources in a planned, conscious, and systematic manner to achieve predetermined objectives [18]. Business refers to economic activities carried out by individuals or organizations aimed at producing, selling, or promoting products or services to generate profit [19].

One forecasting method relevant to business operations is Double Exponential Smoothing, which can provide accurate predictions by accounting for trend and seasonal patterns [20]. This method is applied to time series data to analyze trends and levels within the data sequence. In the prediction process using this method, determining the alpha parameter and measuring error using MAPE (Mean Absolute Percentage Error) are required [21].

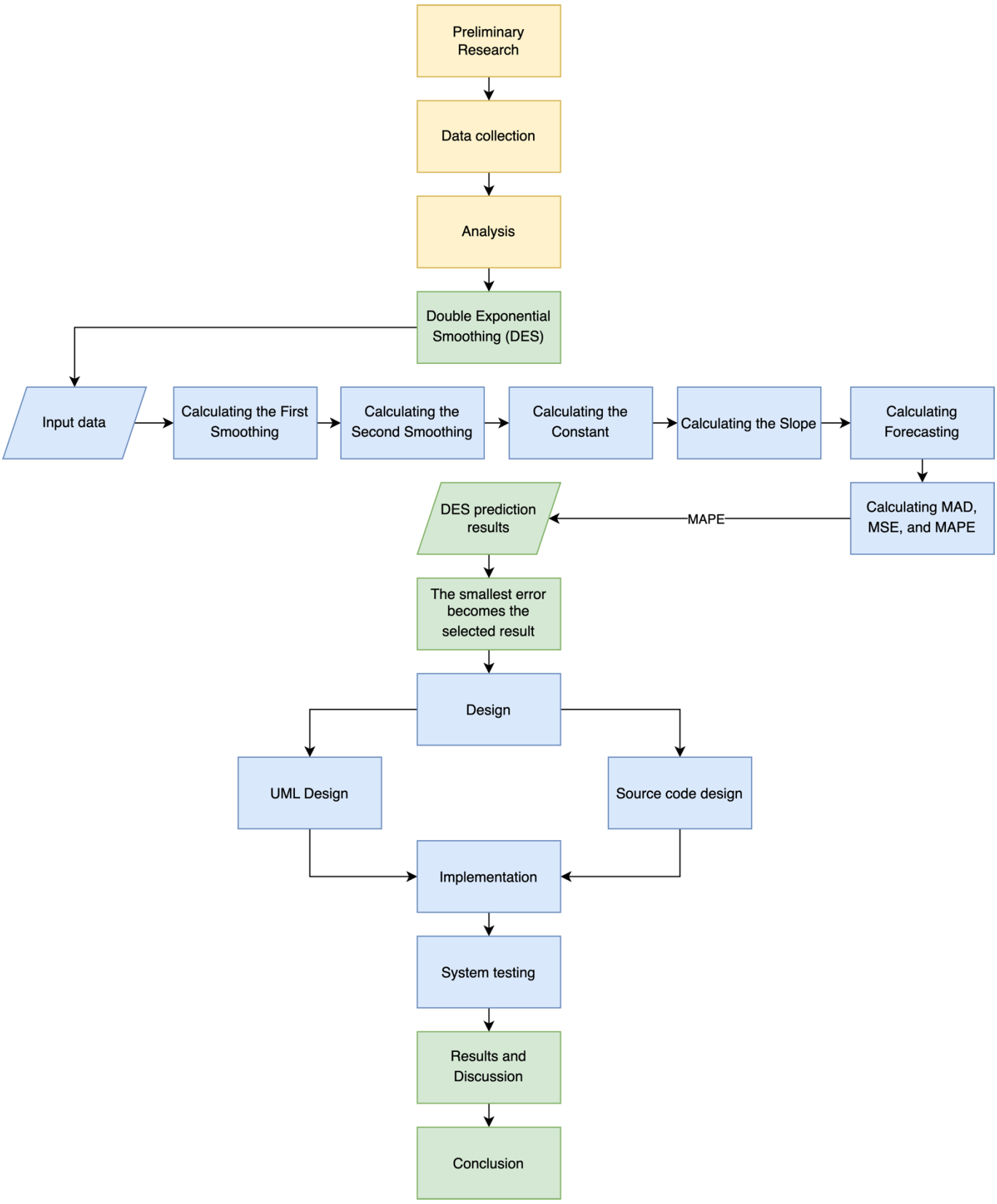


Figure 2. Research framework.

Double Exponential Smoothing is effective when historical data exhibit a trend and utilize accumulated data. Several types of exponential smoothing exist, including Single Exponential Smoothing for stationary data, Double Exponential Smoothing for data with trends, and Triple Exponential Smoothing for data containing both trends and seasonality [22] - [24].

Previous studies demonstrate the effectiveness of forecasting methods such as Double Exponential Smoothing. For example, Masa *et al* [25] successfully forecasted coal production trends in Indonesia with low MAPE, proving the reliability of the method. In another study, Zaky *et al* [26] applied the same method to forecast the Human Development Index in East Kalimantan, projecting an increase from 77.95 in 2023 to 80.01 in 2027.

In the industrial context, Sahid [27] stated that DES is more accurate than Single Exponential Smoothing in forecasting sugar production. Meanwhile, [28] used Triple Exponential Smoothing to forecast motor vehicle tax revenue in North Sumatra, achieving a MAPE below 10%. Other studies indicate that Triple Exponential Smoothing performs better in predicting bank income, emphasizing the importance of seasonal factors in financial analysis [29].

Other researchers highlight the importance of selecting the correct method. For instance, Syakir and Budiman [30] found ARIMA to be more accurate for forecasting cake sales, while a study by Putri and Utomo [31] demonstrated the advantages of Single Exponential Smoothing in predicting hospital patient numbers. Additionally, [32] emphasized the importance of parameter tuning in DES, as supported by Anisah [33].

Based on this background, this study aims to optimize business management at PT Etiqa Prima Utama through the application of the Double Exponential Smoothing method in forecasting medical equipment sales. Thus, the study is expected to contribute to better decision-making and improved efficiency in inventory management.

2. Research Methodology

Double Exponential Smoothing is an effective forecasting method for time series data that exhibits a trend. This method incorporates two main components—the level and the trend—allowing it to produce more accurate predictions in the presence of fluctuations. The process involves determining an alpha parameter, which is used to update the level component, while the trend component is calculated based on the difference between the current level and the previous level. Through this approach, companies can forecast future values and plan more effective strategies.

The stages of the research process are presented in Figure 1. Figure 1 illustrates the research workflow and the methods applied, beginning with data input, calculation of the first smoothing value (S_t'), the second smoothing value (S_t''), determination of the level component (a_t), calculation of the slope component (b_t), and the forecast-ing value (F_{t+m}), followed by the computation of error metrics using MAD, MSE, and MAPE. The step-by-step procedure for solving cases using the Double Exponential Smoothing (DES) method is described as follows:

2.1. Data Input

In the initial stage, sales data for medical equipment from January to December 2024 are required. This dataset serves as an essential foundation for the forecasting process, ensuring that the analysis reflects patterns and trends that correspond to real-world conditions.

2.2. Calculating the First Smoothing (S_t')

To obtain the first smoothing value, the following formula is used:

$$S_t' = \alpha X_t + (1 - \alpha) S_{t-1}' \quad (1)$$

Where α (alpha) is a smoothing parameter ranging from 0 to 1.

2.3. Calculating the Second Smoothing (S_t'')

The next step is to compute the second smoothing value using the result of the first smoothing:

$$S_t'' = \alpha S_t' + (1 - \alpha) S_{t-1}'' \quad (2)$$

2.4. Calculating the Constant (a_t)

To determine the constant value, the following formula is applied:

$$a_t = 2S_t' - S_t'' \quad (3)$$

This value provides essential information for the subsequent forecasting steps.

2.5. Calculating the Slope (b_t)

Next, the slope value is calculated to identify the direction and magnitude of the trend:

$$b_t = \frac{\alpha}{1 - \alpha}(S_t' - S_t'') \quad (4)$$

2.6. Calculating Forecasting (F_{t+m})

The forecasting value is determined using the following formula:

$$F_{t+m} = a_t - b_t \cdot m, \text{ where } m=1 \text{ in this study.} \quad (5)$$

Here, m represents the desired forecasting period.

Table 1. Actual data.

Sales Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ALT	10	5	12	4	10	7	6	1	5	2	14	5
AST	4	3	10	4	10	4	8	1	9	2	12	7
Basolvse II 1 L	13	5	9	5	4	3	8	4	2	1	5	1
Bilirubin Direct	10	7	7	5	6	14	11	2	4	9	10	4
…	…	…	…	…	…	…	…	…	…	…	…	…
Uric Acid	12	6	12	6	7	12	4	11	3	1	8	1
Whitediff 1L	6	12	6	6	6	7	5	2	3	7	1	1

2.7. Calculating MAD, MSE, and MAPE

To evaluate the accuracy of the forecasting results, the following metrics are computed:

$$MAD = \frac{1}{n}\sum |A_t - F_t| \quad (6)$$

$$MSE = \frac{1}{n}\sum (A_t - F_t)^2 \quad (7)$$

$$MAPE = \frac{1}{n}\sum \left|\frac{A_t - F_t}{A_t}\right| \times 100 \quad (8)$$

Mean Absolute Deviation (MAD) measures the average of absolute errors; Mean Square Error (MSE) measures the average squared error; and Mean Absolute Percentage Error (MAPE) expresses the error as a percentage. MAPE is particularly useful because it allows comparison of errors across periods or models with different scales.

2.8. MAPE Value Interpretation

The MAPE value serves as the primary indicator for evaluating the final accuracy of the sales forecasting results, as it reflects the percentage of prediction error.

2.9. DES Forecasting Results

The forecasting output generated using the Double Exponential Smoothing method is expected to provide meaningful insights for predicting future medical equipment sales at PT Etiqa Prima Utama.

3. Results and Discussion

3.1. DES Method Processing

The forecasting process in this study applies the Double Exponential Smoothing (DES) method using actual sales data for the year 2024, as presented in Table 1. The dataset exhibits diverse fluctuations across 20 product types, making DES an appropriate choice due to its ability to capture changes in level and trend within time-series data. The calculations were executed automatically through a PHP- and MySQL-based application, ensuring that all smoothing processes and trend component estimations were performed consistently and free from manual errors.

The results show that DES produces varying levels of accuracy for different products. For items with relatively stable sales patterns, the first and second smoothing values generate level and trend components that align proportionally with actual data fluctuations, resulting in predictions that closely approximate real conditions. This is evident in several products with high accuracy. Glukosa HK, for example, achieved the lowest MAPE value of 10%, indicating that its sales pattern is easily learned by the model. A similar pattern is found in Urea, which also obtained a MAPE of 10%, and in Bilirubin Total, which reached a MAPE of 12%. These low MAPE values indicate that the sales movements of these products are consistent, enabling the model to capture their historical tendencies effectively.

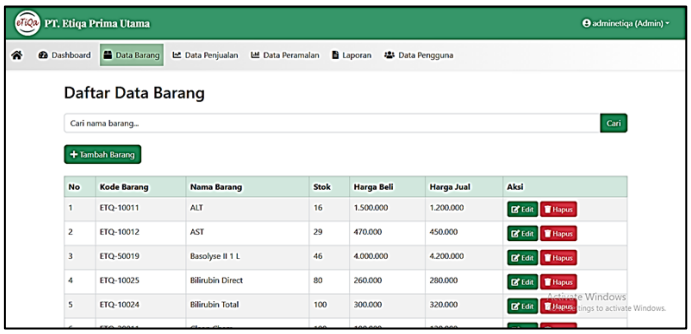
Another product, Diluent 20L, achieved a MAPE of 14%, which is still considered accurate and suitable for inventory planning. Although monthly variations exist, its sales pattern remains sufficiently predictable for DES to model effectively. Overall, most products in the dataset demonstrate good accuracy, particularly those with moderately stable demand.

Conversely, several products exhibit highly irregular sales patterns, resulting in higher MAPE values. The most notable case is Clean Chem, with a MAPE of 54%, indicating that its erratic month-to-month sales fluctuations are difficult for the DES model to follow. Such inconsistent patterns make it challenging for the trend component to stabilize, leading to greater prediction errors compared to other products.

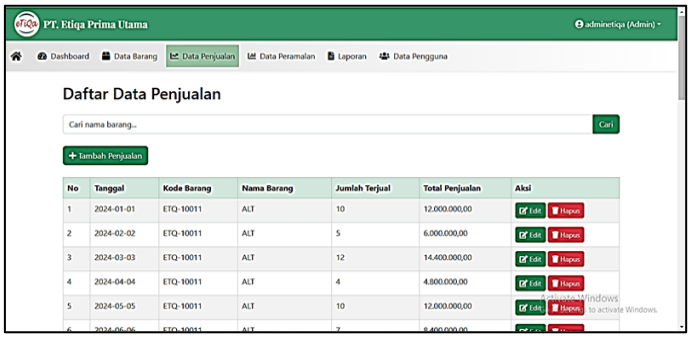
Despite these variations, the overall findings show that DES remains effective as a forecasting foundation for PT Etiqa Prima Utama. For most products, the MAPE values fall within an accurate and reliable range. Based on the optimal alpha and corresponding MAPE values, the system generates sales estimates for upcoming periods, including January 2025. These predictions provide an initial indication of inventory needs based on the historical trends reflected in Table 1.

In general, the results of this study affirm that implementing DES within a web-based forecasting system can support the company in planning inventory more accurately. By understanding which products exhibit stable patterns and which do not, the company can better

adjust purchasing strategies and stock management, thereby minimizing the risks of overstocking or stock-outs.



(a)



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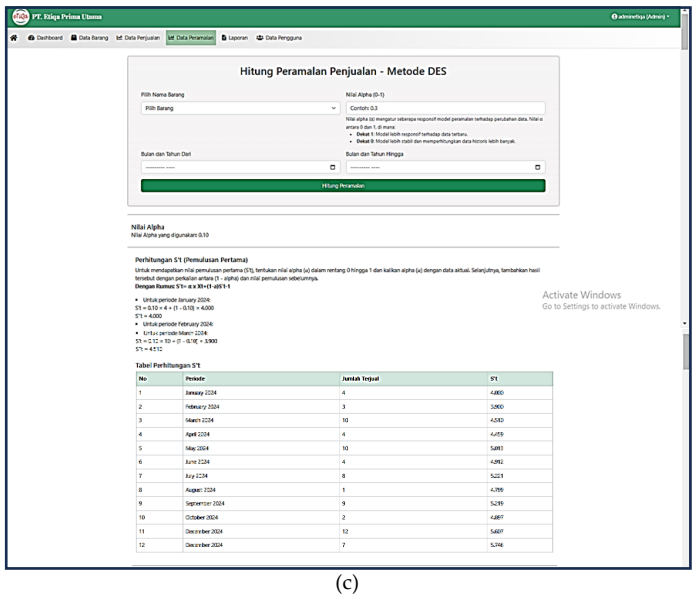

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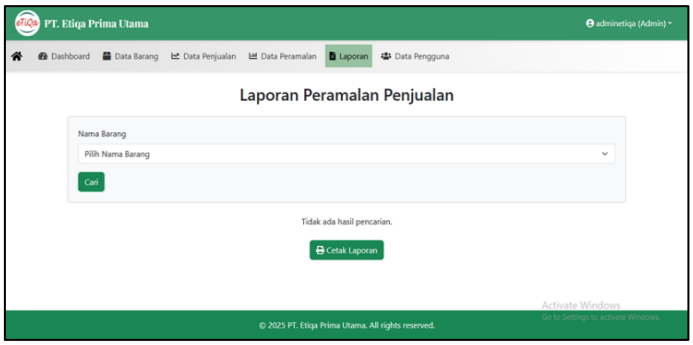

(d)

Figure 2. System Interface Screens: (a) Input Item Menu Page, (b) Sales Input Menu Page, (c) Forecasting Menu Page, and (d) Report Menu Page.

3.2. Implementation of the DES Method

The manual data-processing procedure needs to be further developed by integrating it into an application designed using the PHP programming language and a MySQL database. The use of this application facilitates users or managers in performing sales forecasting quickly and accurately.

3.2.1. Input Item Menu Page

The item data page displays information such as item name, price, and stock in a tabular format. The administrator has access to edit or delete data as needed. The interface for this page is shown in Figure 2a.

3.2.2. Sales Input Menu Page

The sales data page displays a list of sales records containing the date, item code, item name, quantity sold, and total sales. The administrator can edit or delete sales data directly through this page. The interface of this page is presented in Figure 2b.

3.2.3. Forecasting Menu Page

On the forecasting page, the administrator can perform sales prediction calculations based on monthly sales data. The administrator selects the product name, determines the alpha value, and specifies the forecasting period. The interface of this forecasting page is shown in Figure 2c.

3.2.4. Report Page

On this page, administrators and managers can view the results of the DES forecasting calculation by searching for the product name. The report page interface is displayed in Figure 2d.

5. Conclusion

Based on the research conducted, the web-based sales forecasting system using the Double Exponential Smoothing method can assist PT Etiqa Prima Utama in optimizing inventory management and business decision-making. By utilizing historical data, the system is able to generate sales predictions with varying levels of accuracy across 20 product types. Glukosa HK demonstrates the highest accuracy with the lowest MAPE value of 10%, while Clean Chem shows the highest prediction error with a MAPE of 54%. Other products, such as Bilirubin Total (12%), Urea (10%), and Diluent 20L (14%), also show reasonably good predictive performance with MAPE values below 60%. The implementation of this system is expected to help the company determine more precise stock levels, thereby reducing the risk of overstocking or stock shortages and ultimately improving operational efficiency and customer satisfaction.

6. Declarations

6.1. Author Contributions

Salsa Fitriansyah: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources; **Sumijan:** Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft; **Devia Kartika:** Validation, Formal analysis, Data Curation.

6.2. Institutional Review Board Statement

Not applicable.

6.3. Informed Consent Statement

Not applicable.

6.4. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6.5. Acknowledgment

Not applicable.

6.6. Conflicts of Interest

The authors declare no conflicts of interest.

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