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Forecasting Pertalite Stock Expenditures Using Exponential Smoothing and Linear Regression

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Abstrak

Di era industri dan bisnis saat ini, manajemen inventaris yang efektif sangat penting untuk mempertahankan operasional, khususnya di industri bahan bakar. Pertalite, bahan bakar populer di Indonesia yang terkenal dengan angka oktan 90, memadukan kebersihan, efisiensi, dan harga yang terjangkau. Terlepas dari manfaatnya, mengelola pengeluaran stok tetap menjadi tantangan karena metode perkiraan yang tidak tepat. Penelitian ini bertujuan untuk menyempurnakan peramalan saham Pertalite dengan menerapkan teknik data mining, khususnya pemulusan eksponensial dan regresi linier, untuk mengidentifikasi pola dan tren. Dengan menggunakan data penjualan Pertalite pada Mei 2022 hingga April 2024 di SPBU Pertamina di Lampung Utara, penelitian mengevaluasi bagaimana metode tersebut dapat meningkatkan akurasi peramalan. Hasilnya menunjukkan bahwa regresi linier secara efektif memprediksi tren, sedangkan pemulusan eksponensial, dengan nilai alfa berkisar antara 0,1 hingga 0,9, menangkap tren dan variasi dari waktu ke waktu. Temuan ini menyoroti bahwa kedua metode tersebut menawarkan perkiraan yang stabil untuk bulan-bulan tertentu, menekankan kegunaannya dalam memahami pola penjualan bahan bakar Pertalite. Studi ini menggarisbawahi pentingnya peramalan yang akurat untuk pengelolaan inventaris yang lebih baik, membantu memenuhi permintaan pasar dan memastikan efisiensi operasional.

Kata kunci*— Exponential Smoothing, Linear Regression, Pertalite, Forecast*

Abstract

In the current industrial and business era, effective inventory management is crucial for sustaining operations, especially in the fuel industry. Pertalite, a popular fuel in Indonesia known for its octane number of 90, combines cleanliness, efficiency, and affordability. Despite its benefits, managing stock expenditures remains challenging due to imprecise forecasting methods. This study aims to enhance Pertalite stock forecasting by applying data mining techniques, specifically exponential smoothing and linear regression, to identify patterns and trends. Using Pertalite sales data from May 2022 to April 2024 at a Pertamina gas station in North Lampung, the research evaluates how these methods can improve forecasting accuracy. The results reveal that linear regression effectively predicts trends, while exponential smoothing, with alpha values ranging from 0.1 to 0.9, captures both trends and variations over time. The findings highlight that both methods offer stable forecasts for certain months, emphasizing their utility in understanding Pertalite fuel sales patterns. This study underscores

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the importance of accurate forecasting for better inventory management, helping to meet market demands and ensure operational efficiency.

Keywords— *Exponential Smoothing, Linear Regression, Pertalite, Forecasts*

1. INTRODUCTION

In the modern industrial and business era, inventory management has become a critical aspect of the operational sustainability of a company[1]. This is very relevant in the fuel industry, where inventory management is a determining factor in maintaining smooth distribution and meeting market needs[2]. ertalite, as a type of fuel that is widely used in Indonesia, faces significant challenges in managing its stock expenditure, primarily due to fluctuations in demand and the difficulty in accurate forecasting.

Pertalite, with its octane number of 90, serves as an intermediate solution for consumers transitioning from Premium[3]. Its advantages include cleanliness and efficiency, with a Research Octane Number (RON) above 88, making it cleaner and more environmentally friendly than Premium. Additionally, Pertalite is priced lower than Pertamax, offering a more economical choice for consumers[4]. However, the lack of precise information for predicting Pertalite fuel stocks poses a major obstacle to effective inventory management, necessitating specialized methods to address this issue. Data mining, which utilizes statistical, mathematical, artificial intelligence, and machine learning techniques, offers solutions by identifying patterns and trends for stock forecasting.

Recent studies conducted by Febri Liantoni et al Forecasting Bitcoin's price using double exponential smoothing based on MAPE is crucial due to its volatile nature and energy-intensive production. This study analyzes Bitcoin's price from 2017 to 2019 using data from www.cryptocompare.com. The best alpha (α) parameter, crucial for accurate forecasting, indicating the system's reliability for decision-making in Bitcoin trading. This research bridges gaps in understanding Bitcoin's fluctuating value and supports informed financial strategies[5]. investigations conducted by Rathimala Kannan et al Recent changes in the labor market emphasize graduates' employability, yet studies on whether higher education imparts the needed skills are limited. This paper uses educational data mining (EDM) to predict students' soft skills—professional, analytical, linguistic, communication, and ethical—based on socio-economic, academic, and institutional data. Using linear regression, probabilistic neural networks, and regression tree techniques on data from 12,411 students, linear regression showed superior predictive performance. These insights can help institutions enhance student success and employability by tailoring their programs[6]. Similarly, linear regression and exponential smoothing are selected for Pertalite stock forecasting due to their ability to handle time series data effectively and incorporate various influencing factors. Exponential smoothing improves forecast accuracy by placing greater weight on recent data, while linear regression analyzes relationships between dependent and independent variables—such as historical sales data, seasonal trends, and external factors—to create robust predictive models.

In the research process, initial steps involve data collection from historical Pertalite sales, analyzing seasonal patterns, and identifying external factors affecting demand fluctuations. This data is then processed through exponential smoothing to generate initial forecasts, refined further using linear regression to incorporate additional predictive variables and enhance model accuracy. This study contributes by providing a systematic approach to forecasting Pertalite stocks, addressing specific challenges in inventory management within the fuel industry. By integrating exponential smoothing and linear regression, it aims to improve decision-making processes related to stock management, ensuring efficient distribution and meeting market demands effectively.

2. METHODS

In pertalite fuel inventory management, there are challenges in effectively controlling stock expenditure. Inaccurate forecasts could result in an imbalance between supply and demand, ultimately causing financial losses and dissatisfaction among customers.

Integration and Comparison: The methods will be applied in parallel to generate forecasts, allowing for a comparison of their accuracy and reliability under different conditions. This approach will provide a comprehensive evaluation of forecasting performance. Results from one method can validate and refine the other; for instance, insights from linear regression about influential variables can adjust the parameters of the exponential smoothing model. This iterative process ensures that both methods' strengths are utilized.

Combining Insights: In some cases, forecasts from both methods may be combined using techniques like averaging or weighting based on performance. This combined approach aims to enhance forecast accuracy and provide a robust solution for inventory management.

Overall, integrating exponential smoothing and linear regression will offer a more thorough approach to Pertalite stock forecasting, addressing inventory management challenges effectively.

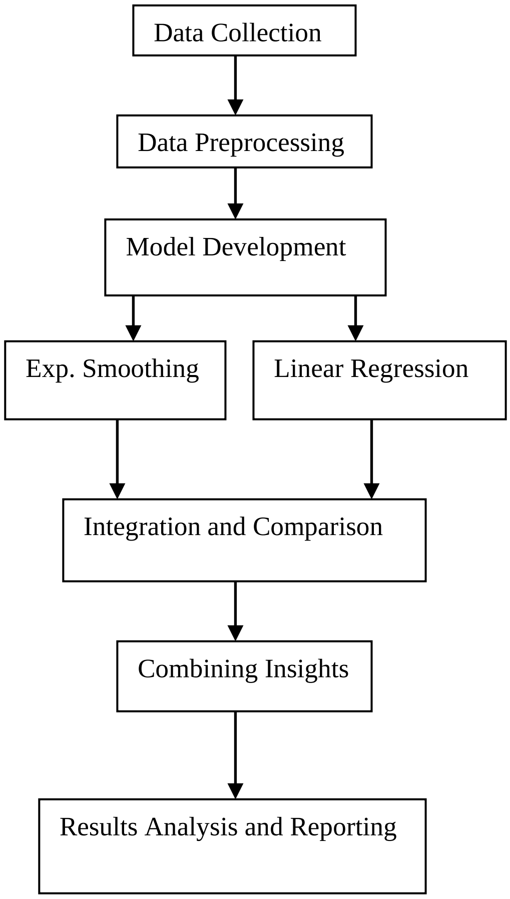

Figure 1. Diagram Research Scheme

2.1 Pertalite

Pertalite, an innovative type of fuel oil (BBM) produced by Pertamina, boasts superior fuel quality in comparison to premium gasoline. With a Research Octane Number (RON) of 90, exceeding Premium's RON of 88, Pertalite offers numerous benefits. Specifically recommended for vehicles with compression ratios ranging from 9.1 to 10.1 and manufactured from the year 2000 onwards, particularly those equipped with Electronic Fuel Injection (EFI) technology and catalytic converters, Pertalite is composed primarily of naphtha. By incorporating the High

Octane Mogas Component (HOMC), which increases its RON from 65–70 to 90, and introducing the EcoSAVE additive, Pertalite ensures smoother engine performance, improved cleanliness, and enhanced fuel efficiency[4].

The superior characteristics of Pertalite, such as its higher RON and enhanced fuel efficiency, present specific challenges in stock forecasting. The demand for Pertalite is highly sensitive to market conditions, including fuel price fluctuations, seasonal changes, and shifts in consumer preference, particularly as consumers increasingly seek out higher-quality, environmentally friendly fuel options for their modern vehicles. This variability in demand can make it difficult to accurately forecast the required stock levels.

Moreover, the specific use of Pertalite in vehicles with certain engine types, especially those with EFI technology and catalytic converters, adds another layer of complexity. As these vehicles become more prevalent, the demand for Pertalite may increase disproportionately, making it essential to account for these trends in forecasting models. Failure to accurately predict this demand could result in either overstocking, leading to increased storage costs and potential fuel degradation, or understocking, which could disrupt supply chains and customer satisfaction. Therefore, the unique attributes of Pertalite necessitate a robust and adaptive stock forecasting approach to balance supply with fluctuating demand effectively**.**

2.2 Exponential Smoothing

Exponential smoothing, a method utilized in time series analysis, is pivotal for predicting future data points based on historical observations[7]. It operates by assigning exponentially diminishing weights to older data points while prioritizing recent data. This technique proves especially advantageous for datasets exhibiting trend or seasonality, effectively capturing short-term fluctuations while attenuating random variations. Widely adopted across diverse domains like finance, economics, and inventory management, exponential smoothing facilitates precise predictions and enhances decision-making processes[8]. The fundamental formula for exponential smoothing is:

Ft+1=α×Yt+(1−α)×FtF_{t+1} = \alpha \times Y_t + (1 - \alpha) \times F_tFt+1=α×Yt+(1−α)×Ft

This formula amalgamates the current observation at time t with the prior forecast to generate a novel forecast for the upcoming period. The value of α\alphaα dictates the weight allocated to the most recent observation vis-à-vis the preceding forecast. A smaller α\alphaα assigns more significance to historical data, yielding smoother forecasts, whereas a larger α\alphaα prioritizes recent data, rendering the forecast more adaptable to fluctuations.

Various iterations of exponential smoothing exist, including simple exponential smoothing, double exponential smoothing (Holt's method), and triple exponential smoothing (Holt-Winters method), which integrate supplementary components to encapsulate trend and seasonality within the data.

In the context of Pertalite stock forecasting, exponential smoothing was chosen for its ability to handle the inherent seasonality and trends in fuel demand. Given the fluctuating nature of fuel consumption, which can be influenced by various factors such as holidays, economic conditions, and policy changes, exponential smoothing provides a flexible yet robust method for capturing these variations.

This technique is particularly well-suited for Pertalite because it allows the forecasting model to be sensitive to recent changes in demand while still considering long-term patterns. For instance, daily or weekly sales data can be used to apply exponential smoothing, enabling the model to quickly adapt to sudden shifts in consumption patterns, such as those caused by unexpected market changes or temporary supply chain disruptions. By applying this method to different time intervals, the forecasting model can be fine-tuned to balance responsiveness with stability, ensuring that stock levels are maintained at optimal levels to meet consumer demand without overstocking.

Various iterations of exponential smoothing exist, including simple exponential smoothing, double exponential smoothing (Holt's method), and triple exponential smoothing (Holt-Winters method), which integrate supplementary components to encapsulate trend and seasonality within the data. The specific choice of method will depend on the presence and strength of trends or seasonal patterns in Pertalite sales data, with more advanced methods like Holt-Winters being employed if these components are significant.

2.3 Linear Regression

Linear regression serves as a statistical tool for modeling the relationship between a dependent variable and one or more independent variables[9]. It operates under the assumption of a linear relationship between these variables, implying that changes in the independent variable(s) correlate with a consistent alteration in the dependent variable[10]. In a simple linear regression model with one independent variable, the fundamental equation is expressed as[11]:

Y=β0+β1X+εY = \beta_0 + \beta_1 X + \varepsilonY=β0+β1X+ε

The primary objective of linear regression is to ascertain the values of β0\beta_0β0 and β1\beta_1β1 that minimize the sum of squared deviations between the observed Y values and those predicted by the regression equation. This optimization process is typically accomplished through the method of least squares.

Linear regression finds extensive application across diverse domains, including economics, finance, biology, and the social sciences. Its utility lies in analyzing relationships between variables, making predictions, and comprehending the influence of independent variables on the dependent variable[12].

Linear regression was chosen for forecasting Pertalite stock expenditure due to its effectiveness in quantifying the relationship between fuel stock levels and various influencing factors. This approach is particularly relevant for understanding how changes in independent variables, such as historical sales data, seasonal trends, or external factors (e.g., market prices or promotional activities), impact stock expenditure.

To build an accurate linear regression model, relevant independent variables will be selected based on their potential impact on Pertalite stock expenditure. These variables may include:

- Historical Sales Data: Previous sales figures can help identify patterns and predict future demand.
- Seasonal Trends: Variations in fuel consumption due to seasonal factors, such as higher demand during holidays or colder months.
- Market Prices: Fluctuations in fuel prices that may influence consumer behavior and purchase volumes.
- Promotional Activities: The impact of marketing campaigns or discounts on fuel sales.

The selection of these variables will be guided by data analysis and domain knowledge to ensure they contribute meaningfully to the model. Multivariate linear regression may be used if multiple independent variables are considered simultaneously to understand their combined effect on stock expenditure. The model's accuracy will be assessed using metrics such as R-squared, which indicates how well the independent variables explain the variability in the dependent variable. By leveraging linear regression, Pertalite stock expenditure can be predicted more effectively, providing insights into how various factors drive changes in stock levels and enabling more informed inventory management decisions**.**

3. RESULTS AND DISCUSSION

3.1 RESULTS

In this research, data was collected from a Pertamina gas station in North Lampung, specifically focusing on Pertalite fuel sales from May 2022 to April 2024. The dataset obtained is as follows:

TABLE 1
DATA SET

Month	A (Total (liters))	B (Amount (RUpiah))
May-22	262893	2011131450
Jun-22	262629	2009111850
Jul-22	258858	1980263700
Aug-22	168702	1290570300
Sep-22	230490	2304900000
Oct-22	212552	2125520000
Nov-22	236137	2361370000
Dec-22	297369	2973690000
Jan-23	266294	2662940000
Feb-23	257834	2578340000
Mar-23	330799	3307990000
Apr-23	326645	3266450000
May-23	337758	3377580000
Jun-23	363749	3637490000
Jul-23	300104	3001040000
Aug-23	339907	3399070000
Sep-23	340705	3407050000
Oct-23	308176	3081760000
Nov-23	297765	2977650000
Dec-23	291210	2912100000
Jan-24	313011	3130110000
Feb-24	283174	2831740000
Mar-24	235465	2354650000
Apr-24	255270	2552700000

3.1.1 Regresi Linier

From the dataset, data A represents the Total (Liter) column, and data B represents the Amount (Rupiah) column. Using the linear regression method, the following values are obtained:

- Average of A: 282,395.67
- Average of B: 2,730,634,054.17
- Slope coefficient (beta_1): 11,642.90
- Intercept (beta_0): -557,269,299.75

These parameters help in predicting the stock expenditure (Amount in Rupiah) based on the total liters of Pertalite sold.

Table 2
Data Set

Month	A (Total (liters))	B (Amount (RUpiah))	Prediction	Conclusion
May-22	262893	2011131450	25.035.665.361	Up

Jun-22	262629	2009111850	25.004.928.116	Up
Jul-22	258858	1980263700	24.565.874.511	Up
Aug-22	168702	1290570300	14.069.105.269	Up
Sep-22	230490	2304900000	21.263.017.798	Down
Oct-22	212552	2125520000	19.174.515.128	Down
Nov-22	236137	2361370000	2.192.049.213	Down
Dec-22	297369	2973690000	29.049.670.157	Down
Jan-23	266294	2662940000	25.431.640.251	Down
Feb-23	257834	2578340000	24.446.651.257	Down
Mar-23	330799	3307990000	3.294.189.026	Down
Apr-23	326645	3266450000	32.458.244.365	Down
May-23	337758	3377580000	33.752.119.388	Down
Jun-23	363749	3637490000	3.677.822.447	Up
Jul-23	300104	3001040000	2.936.810.336	Down
Aug-23	339907	3399070000	3.400.232.522	Up
Sep-23	340705	3407050000	34.095.235.531	Up
Oct-23	308176	3081760000	3.030.791.792	Down
Nov-23	297765	2977650000	29.095.776.025	Down
Dec-23	291210	2912100000	2.833.258.420	Down
Jan-24	313011	3130110000	3.087.085.194	Down
Feb-24	283174	2831740000	2.739.696.108	Down
Mar-24	235465	2354650000	2.184.225.187	Down
Apr-24	255270	2552700000	2.414.812.741	Down

Interpretation and Implications:

1. **Forecast Predictions:**
   - **Upward Trend:** Months where the predicted value is higher than the actual amount (e.g., May-22, Jun-22, Jul-22) suggest that the forecasted expenditure is greater than what was actually recorded. This indicates an overestimation of stock needs for these periods.
   - **Downward Trend:** Months where the predicted value is lower than the actual amount (e.g., Aug-22, Sep-22, Oct-22) indicate an underestimation of stock needs, leading to potential shortages and unmet demand.
2. **Implications for Pertalite Stock Management:**
   - **Inventory Adjustments:** The predictions suggest areas where inventory management can be optimized. Overestimations may lead to excess stock and increased holding costs, while underestimations can result in stockouts and potential revenue loss.
   - **Forecast Refinement:** Using the insights from the linear regression model, adjustments can be made to improve accuracy. For instance, incorporating additional independent variables (e.g., market conditions, promotional activities) might enhance prediction precision.
   - **Strategic Planning:** Understanding periods with discrepancies can help in strategic planning. For example, if certain months consistently show significant forecast errors, it might be necessary to review and refine the forecasting approach for those specific times.

Overall, the linear regression model provides a foundation for understanding the relationship between stock levels and expenditure. By interpreting these predictions and their implications, Pertalite can enhance its stock management strategies to better align with actual demand and minimize financial risks.

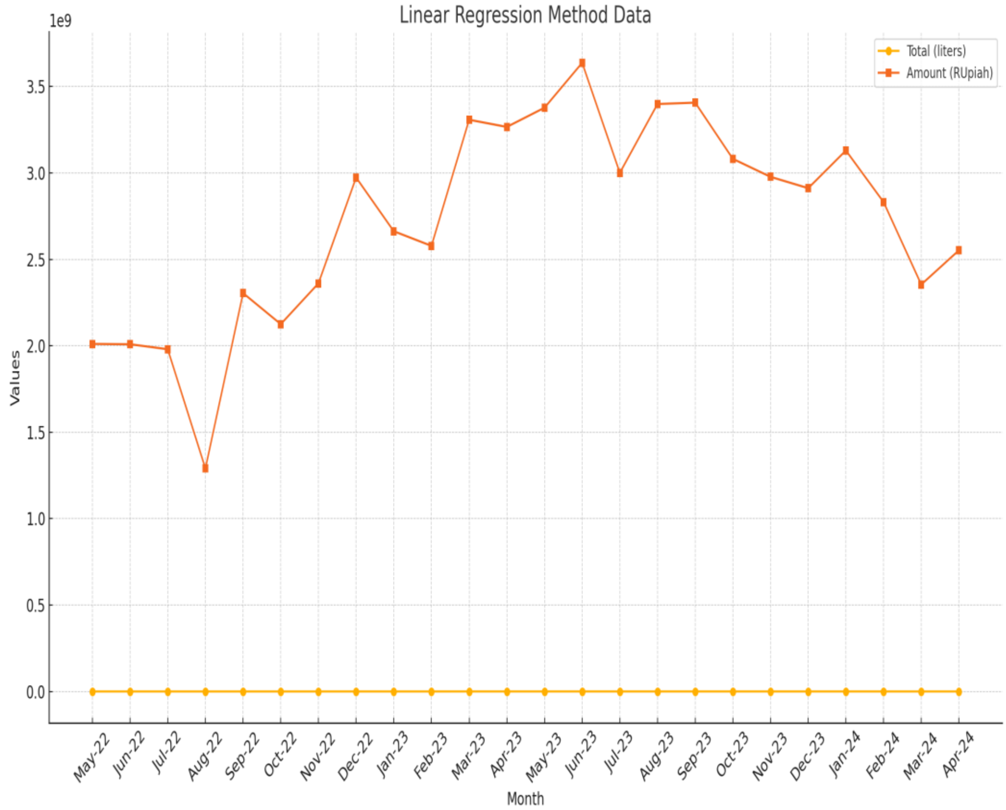

Figure 1. forecasting linear regression method

3.1.2 Exponential Smoothing

In this research, the exponential smoothing method with alpha values ranging from 0.1 to 0.9 is employed to forecast the amount of rupiah from total sales of Pertalite fuel every month. The reference dataset spans from May 2022 to April 2024, and the forecasting process is conducted sequentially for each subsequent month. Table 3 illustrates an example using an alpha value of 0.1.

Table 3
Forecasting Exponential Smoothing

Month	**A (Total (liters))**	**B (Amount (RUpiah))**	α = 0.1	
			Level (L1)	Smoothing (S1)
May-22	262893	2011131450,00	262893	0
Jun-22	262629	2009111850,00	262629	0
Jul-22	258858	1980263700,00	258858	0
Aug-22	168702	1290570300,00	168702	4,90987E-07
Sep-22	230490	2304900000,00	230490	0
Oct-22	212552	2125520000,00	212552	6,18608E-07
Nov-22	236137	2361370000,00	236137	6,87249E-07

Dec-22	297369	2973690000,00	297369	1,73092E-06
Jan-23	266294	2662940000,00	266294	0
Feb-23	257834	2578340000,00	257834	0
Mar-23	330799	3307990000,00	330799	1,9255E-06
Apr-23	326645	3266450000,00	326645	0
May-23	337758	3377580000,00	337758	0
Jun-23	363749	3637490000,00	363749	2,1173E-06
Jul-23	300104	3001040000,00	300104	1,74684E-06
Aug-23	339907	3399070000,00	339907	0
Sep-23	340705	3407050000,00	340705	0
Oct-23	308176	3081760000,00	308176	0
Nov-23	297765	2977650000,00	297765	0
Dec-23	291210	2912100000,00	291210	0
Jan-24	313011	3130110000,00	313011	0
Feb-24	283174	2831740000,00	283174	0
Mar-24	235465	2354650000,00	235465	0
Apr-24	255270	2552700000,00	255270	0

Table 5 shows the maximum forecasted values obtained for each month across the range of alpha values from α = 0.1 to α = 0.9, where Estimates are more fluid and less responsive to recent changes. High Alpha (0.9) Forecasts are more responsive to recent changes and fluctuate more with current data.

Table 5
Forecasted A = 0.1 To A = 0.9

No	**Mont**	**Value α**	**Predicted Value**
1	Nov 2022	α = 0.1	6.87249×10^{-7}
2	Jun 2023	α = 0.2	3637490000
3	Nov 2022	α = 0.3	6.87249×10^{-7}
4	Jun 2023	α = 0.4	3637490000
5	Nov 2022	α = 0.5	6.87249 x 10-7
6	Jun 2023	α = 0.6	3637490000
7	Nov 2023	α = 0.7	6.87249×10^{-7}
8	Jun 2023	α = 0.8	3637490000
9	Nov 2023	α = 0.9	6.87249×10^{-7}

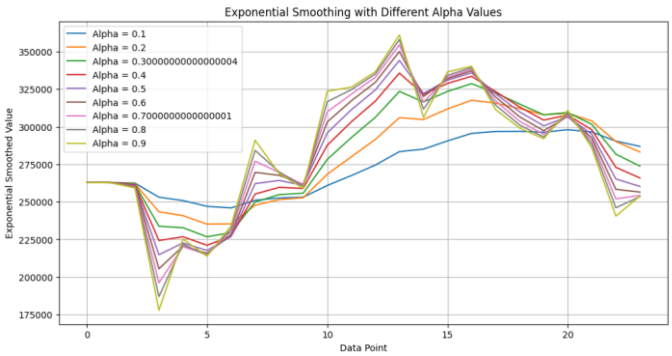

Figure 1. forecasting exponential smoothing α = 0.1 TO α = 0.9

From the table data, it can be inferred that the predicted value for November remains consistently around 6.87249×10−76.87249 \times 10^-7}6.87249×10−7 across all alpha values from 0.1 to 0.9. This consistency suggests that the forecast for November shows little sensitivity to the alpha value used. Similarly, for June, the predicted value remains stable at approximately 3,637,490,000; 3,637,490,000; 3,637,490,000 for alpha values ranging from 0.2 to 0.8. This stability indicates that the forecast for June also demonstrates minimal variability depending on the alpha value. This conclusion is based on the observation that the predicted values for both November and June remain relatively steady despite the range of alpha values from 0,1.

3.2 DISCUSSION

3.2.1 Linear Regression Analysis

a. The dataset collected from a Pertamina gas station in North Lampung spans from May 2022 to April 2024, focusing on Pertalite fuel sales. Linear regression analysis yielded the following key values:

- Average Total (liters): 282,395.67
- Average Amount (Rupiah): 2,730,634,054.17
- Slope coefficient (beta_1): 11,642.90
- Intercept (beta_0): -557,269,299.75

b. Using these coefficients, predictions were made for each month from May 2022 to April 2024, indicating upward or downward trends based on the linear regression model.

3.2.2 Exponential Smoothing Analysis

a. Exponential smoothing with alpha values ranging from 0.1 to 0.9 was applied to forecast Pertalite fuel sales monthly from May 2022 to April 2024. The method aims to capture trends and variations over time.

b. Table 3 provides an example with alpha set to 0.1, demonstrating how smoothing levels evolve over the forecast period.

4. CONCLUSIONS

For November, the predicted values remain stable around 6.87249×10−76.87249 \times 10^{-7}6.87249×10−7 for alpha values from 0.1 to 0.9. This suggests that the forecast for November is robust and less influenced by the choice of alpha. Similarly, for June, the predicted values remain steady at approximately 3,637,490,000; 3,637,490,000; and 3,637,490,000 for alpha values ranging from 0.2 to 0.8. Overall, the performance of the forecasting models varied: Linear Regression provided forecasts with fluctuating accuracy depending on the month, effectively capturing trends in stock expenditure but showing variability with occasional overestimation or underestimation. In contrast, Exponential Smoothing offered forecasts that were more responsive to recent data changes; however, its stability across different alpha values meant that while it adapted to recent fluctuations, its predictions remained consistently similar for certain months

In comparing the methods, linear regression exhibited greater sensitivity to underlying stock data patterns, though it needed careful adjustment for external factors to enhance accuracy. Exponential smoothing, on the other hand, provided smoother forecasts but occasionally lacked responsiveness to sudden changes in stock patterns. Regarding robustness, exponential smoothing proved reliable with minimal variability across different alpha values, while linear regression's forecasts showed significant variability depending on the input data and model parameters. For Pertalite stock management, leveraging both linear regression and exponential smoothing methods could yield a more comprehensive forecasting approach. While linear regression is effective for understanding long-term trends and relationships, exponential smoothing provides real-time adjustments for recent data fluctuations. Future research should consider exploring hybrid models that integrate both forecasting methods or incorporate additional variables, such as market conditions and economic indicators, to improve accuracy. Testing these methods across different regions or fuel types could further validate their applicability and enhance forecasting precision

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