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Evaluation of Use of Linear Regression to Predict Profit, Selling Price, and Stock on HSR Wheels Platform

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Abstract

In the ever-evolving digital era, the e-commerce sector faces significant challenges in efficiently managing sales, selling prices, and inventory. This study aims to evaluate the effectiveness of a linear regression model in predicting sales, selling prices, and stock levels on the HSR Wheels e-commerce platform. A quantitative method was used by analyzing daily transaction data to identify the relationship between the time variable and sales, profit, and stock. The results showed that linear regression has limitations in modeling data complexity, with low R^2 scores and high Mean Absolute Error (MAE) values. These findings indicate the need for more advanced predictive models, such as machine learning algorithms, to improve prediction accuracy. This research is expected to contribute to developing more efficient and relevant sales strategies for e-commerce platforms.

Keywords: e-commerce, linear regression, sales efficiency, sales prediction, data analysis techniques.

Introduction

E-commerce is a business activity that uses information network technology as a means and commodity exchange as its core (Pan et al., 2021). In the increasingly competitive e-commerce landscape, companies like HSR Wheels face significant challenges in managing sales and inventory efficiently. Increasing competition and rising consumer expectations require a deeper understanding of sales trends and the optimization of operational efficiency. Currently, HSR Wheels struggles to accurately predict sales and profit percentages, which directly impacts inventory management and strategic decision-making. Whether excessive or insufficient, non-optimal inventory levels pose a major problem as they can lead to high storage costs or lost sales opportunities. Furthermore, inaccurate profit percentage predictions hinder long-term financial planning and business strategy. In this context, the statistical approach of

linear regression emerges as a potential solution for modeling the relationship between factors such as time and advertising costs with sales and profit. Linear Regression is a statistical method that makes mathematical predictions between variables (Dwi Cahaya Putra et al., 2023).

In the rapidly evolving e-commerce landscape, companies are increasingly required to optimize operational efficiency and accurately predict sales trends to remain competitive. HSR Wheels, an established player in the industry, faces challenges in predicting sales, profits, and effectively managing inventory. Addressing these challenges is crucial for maintaining profitability and customer satisfaction. Previous research has laid the groundwork for understanding the dynamics of sales prediction and inventory management in e-commerce. The importance of time series analysis for accurate price forecasting in e-commerce, particularly in the agricultural sector, has been highlighted (Choong et al., 2021). Their research emphasizes how effective price estimation can improve supply chain management (SCM) and assist stakeholders in making informed decisions. Advanced prediction techniques have been explored through the development of PriceCop, a tool that utilizes linear regression and machine learning to monitor and predict product prices (Zaim Shahrel et al., 2021). This approach underscores the potential of integrating advanced analytical methods with user-centric applications to enhance decision-making processes in online shopping. Furthermore,

Literature Review

Predictive Analytics in the E-commerce Context

E-commerce is a business activity that uses information network technology as its primary means (Pan et al., 2021). In this highly competitive landscape, companies are required to continuously optimize operational efficiency and accurately predict sales trends to remain viable. A significant challenge faced by e-commerce platforms like HSR Wheels is the effective management of sales, pricing, and inventory. Failure to accurately predict demand and profit can lead to serious problems, such as high storage costs or lost sales opportunities, which ultimately hinder strategic planning. Therefore, predictive analytics plays a crucial role in optimizing e-commerce operations by analyzing historical data for better decision-making.

Linear Regression as a Predictive Tool

One of the fundamental statistical methods used for predictive modeling is **linear regression**. This method is a statistical approach that performs mathematical predictions to model the relationship between one dependent variable and one or more independent variables (Dwi Cahaya Putra et al., 2023). In a business context, linear regression is often applied as a potential solution to model the relationship between factors such as time and variables like sales and profit Dwi Cahaya Putra et al., 2023). Due to its simplicity, this method serves as a logical starting point for predictive analysis.

Previous Studies on Price Prediction and Consumer Behavior

The existing literature highlights various efforts to apply predictive models within the e-commerce domain.

a. **Choong et al. (2021)** reviewed the importance of time-series analysis for accurate price forecasting, particularly in the agricultural sector for products sold via e-commerce platforms. Their study emphasizes how effective price estimation can enhance supply chain management (SCM) (Choong et al., 2021).

b. **Zaim Shahrel et al. (2021)** developed a tool named "PriceCop," which utilizes linear regression and machine learning methods to monitor and predict product prices. This approach underscores the potential for integrating advanced analytical methods into user-centric applications (Zaim Shahrel et al., 2021).

c. **Ketipov et al. (2023)** investigated how machine learning can be used to predict user behavior in e-commerce, providing insights into consumer preferences and improving the personalization of the shopping experience (Ketipov et al., 2023).

These studies collectively affirm the crucial role of predictive analytics in driving efficiency in the e-commerce sector.

Model Performance Evaluation

To determine the effectiveness of a predictive model, quantitative evaluation is essential. Standard metrics commonly used to evaluate regression models include **Mean Absolute Error (MAE)** and the **R^2 Score (Coefficient of Determination)**.

a. **MAE** measures the average of the absolute differences between predicted and actual values, providing an indication of how far the predictions are from the true values (Nurahman & Ernawati, 2024).

b. The **R^2 Score** measures the proportion of the variance in the dependent variable that is predictable from the independent variable(s) (Syahputra et al., 2020). This metric is often used to assess how well the observed data fits the predictive model that was developed (Rohman et al., 2021).

The combination of MAE and R^2 Score can provide a more comprehensive evaluation of a model's performance (Listyawati & Kristiana, 2021).

Limitations of Linear Regression and the Need for More Advanced Models

Although useful as a baseline model, linear regression has significant limitations. It assumes a linear relationship between variables, which is often unable to capture the complexity of real-world e-commerce data. The results of this study show that when applied to the HSR Wheels sales data, linear regression produced a high MAE and a very low R^2 Score. This indicates its inability to capture the underlying patterns in the data.

This limitation points to the need to explore more advanced models that can handle non-linear relationships (Satya Saputra et al., 2024). The literature and industry practice

suggest the use of more complex machine learning algorithms, such as Random Forest, Gradient Boosting, or Neural Networks, to achieve higher prediction accuracy in complex business scenarios.

Research Method

This study uses a quantitative approach to assess the effectiveness of linear regression in predicting sales within the HSR Wheels e-commerce environment. The quantitative method was chosen for its ability to produce measurable data, enabling in-depth statistical analysis of the relationships between variables and allowing for broader generalizations (Siroj et al., 2024). This research involves collecting transaction data from the HSR Wheels e-commerce system, including daily sales records and relevant variables. Linear regression was applied to model the relationship between the independent variable (such as time) and the dependent variables (sales and inventory levels).

a. Problem Identification

This research identifies a critical need for a web-based application capable of accurately predicting sales, profit, and inventory levels. Challenges such as the inefficiencies of traditional recording systems and the risk of human error underscore the importance of developing robust predictive models.

b. Problem Resolution

The proposed solution involves the development and evaluation of a web-based system that facilitates the prediction of sales, profit, and inventory levels using linear regression. The system will be tested to determine its effectiveness in providing accurate predictions over time, contributing to strategic decision-making in e-commerce.

1) Data Collection and Analysis

Data collection will focus on daily transactions from the HSR Wheels database, which includes essential information such as product type, sales volume, price, and transaction date. This data will be systematically analyzed using linear regression to model the relationship between time and the variables of interest.

2) Experimental Procedure

This study uses an experimental approach, applying linear regression to daily transaction data. The model's accuracy will be evaluated through statistical metrics, comparing predictions with actual sales data to determine the model's reliability. Additionally, in this experimental procedure, a system that applies this linear regression prediction was built. The system was developed using the waterfall method. The waterfall method was chosen for its systematic and sequential approach, which includes requirements analysis, system design, implementation, testing, and maintenance (Sri Rahayu et al., 2024). By integrating data collection, analysis, and the application of linear regression into a cohesive methodological framework, this study aims to provide empirical evidence on the

effectiveness of predictive analytics in e-commerce, specifically within the context of HSR Wheels.

Results

1. Data Collection and Analysis

Data collection involved gathering extensive records from the HSR Wheels e-commerce system, which included daily transaction data, product information, pricing details, and sales figures. This dataset provided a comprehensive view of business operations over a significant period, enabling a robust analysis of trends and patterns. The analysis began with Exploratory Data Analysis (EDA) to uncover initial insights, followed by the application of a linear regression model. EDA is a fundamental approach used to summarize the main characteristics of a dataset (Narastu et al., 2025). This EDA involved visualizing data trends and distributions, identifying correlations between variables, and detecting any anomalies or outliers. Linear regression was then applied to model the relationship between time (as the independent variable) and sales, stock, and profit (as the dependent variables). In this study, the data used was sales and profit data from HSR Wheels. This data includes important information about products, sales transactions, prices, and profits. Each attribute in the data has a clear description, which provides an overview of its function in the context of sales and profit analysis.

2. Exploratory Data Analysis (EDA)

EDA is a crucial step in understanding the basic structure of data before applying predictive models. EDA involves using descriptive statistics and data visualization techniques to explore data characteristics and identify potential patterns.

a. Trend Analysis

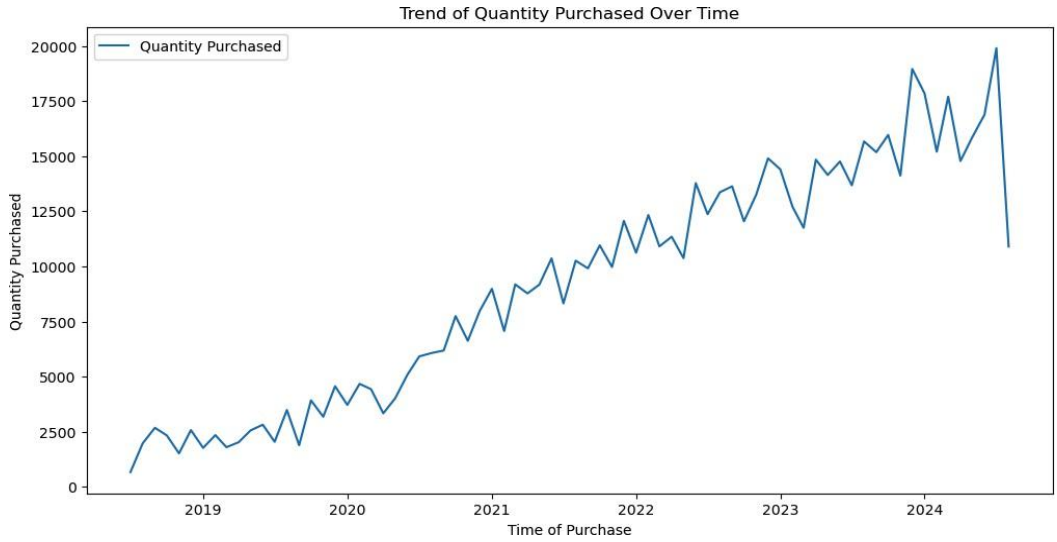

Figure 1. Trend of Quality Purchased

This step involves examining trends in the quantity of sales over time. Trend analysis is a method used to compare data from a specific period with previous periods to identify developing tendencies or patterns over time. Typically expressed as a percentage, this analysis aims to understand the direction of data change, whether it is increasing, decreasing, or stable. By plotting the number of units sold against time, this analysis aims to identify seasonal patterns or significant changes in sales volume, thereby allowing the company to plan more appropriate strategies based on historical trend(Rachmawati et al., 2023).

The "Trend of Quantity Purchased" shown in Figure 1 is the product purchased over a certain time. This graph helps in understanding sales patterns and identifying seasons or periods when sales increase or decrease.

b. Profit Distribution

The profit distribution was analyzed to understand the variability in profitability across different transactions and product categories. This profit distribution analysis is a method used to detect profit spread patterns that can indicate efficiency or inefficiency in profit management. A histogram was used to visualize the profit spread, highlighting any outliers that could indicate unusual sales events (Listyawati & Kristiana, 2021). The Nominal Profit Distribution is shown in Figure 2 in the form of a profit percentage distribution. This histogram helps to understand the distribution of profit obtained from product sales. The profit percentage distribution shows that most of the profit is around a certain value, with some outliers indicating very high or very low profits (Rohman et al., 2021). This can help in evaluating product profitability and provide insights for formulating more effective business strategies.

c. Stock Level Plot

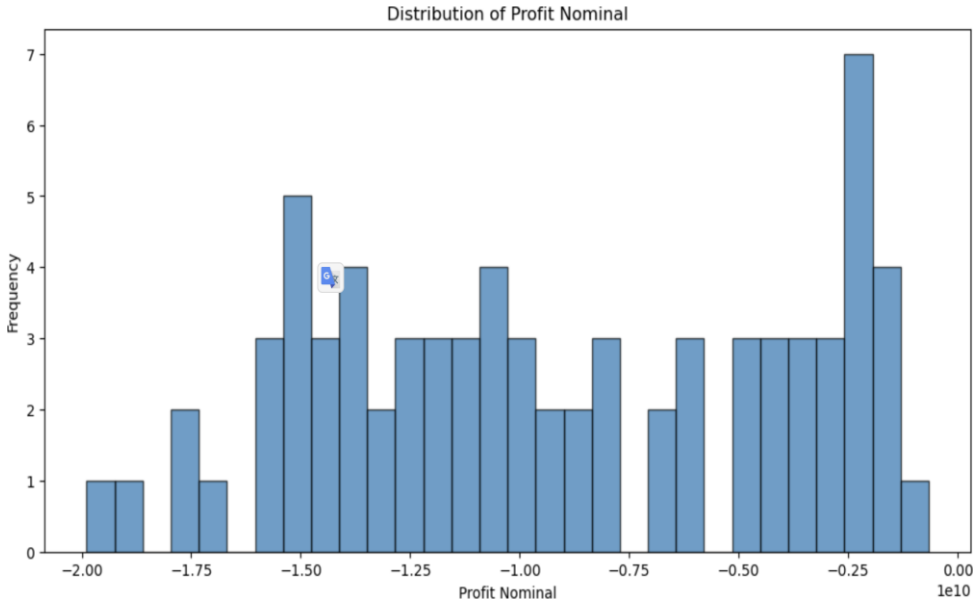

Figure 2. Distribution of Profit Nominal

This analysis also examines stock levels over time, focusing on identifying periods of stock shortages or surpluses. Understanding these patterns is crucial for developing accurate inventory management strategies. The use of box plots in this analysis is effective for identifying outliers that can affect stock management decisions, thus helping the company anticipate unexpected fluctuations (Sihombing et al., 2022).

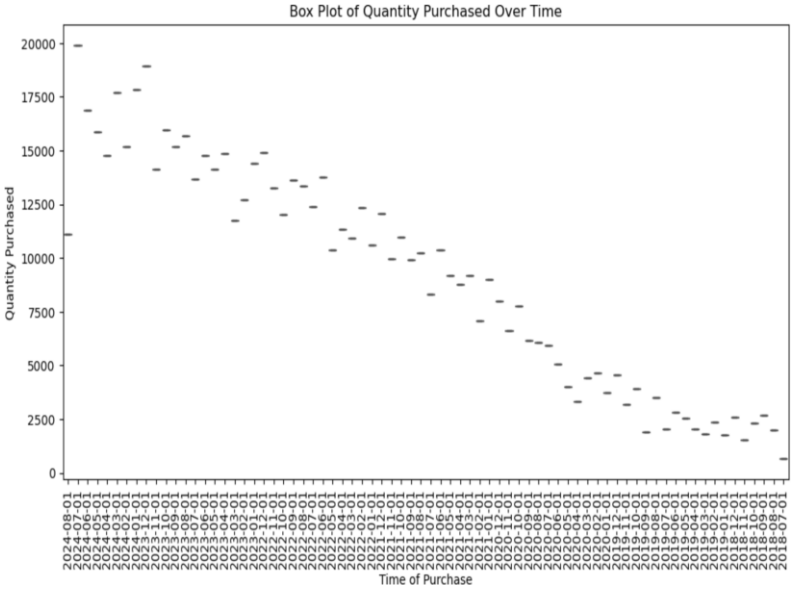

Figure 3. Box Plot of Quantity Purchased Over Time

The "Box Plot of the Quantity Purchased Over Time" shown in Figure 3 illustrates the number of products purchased over time. This box plot provides an overview of the median, quartiles, and outliers of the product purchase quantity (Dwi Cahaya Putra et al., 2023). From this box plot, variations in the number of product purchases can be seen. Some periods show large variations with many outliers, while other periods show smaller and more consistent variations. This analysis is important in identifying potential anomalies that can have a significant impact on inventory management and stock distribution efficiency (Sihombing et al., 2022), (*Mengenal Box-Plot (Box and Whisker Plots) – Accounting*, n.d.).

d. Linear Regression Implementation

A linear regression model was developed to predict sales, stock levels, and profit based on historical data. This process involved several key steps:

1) **Data Cleaning and Normalization**: The raw data was cleaned to remove inconsistencies or errors that could distort the analysis. The data cleaning process was carried out to identify and correct invalid, missing, or duplicate data, thereby improving the quality of the dataset to be used in the analysis (Nurahman & Ernawati, 2024). After the cleaning process, normalization was applied to ensure that all variables were on a comparable scale, which is crucial for linear regression models (Syahputra et al., 2020). Data normalization helps to avoid the dominance of variables with larger scales, so the model can be more effective in identifying relationships between variables (Choong et

al., 2021). This process can also improve prediction accuracy in numerical data analysis, especially when dealing with datasets that have variables with different value ranges (Nurahman & Ernawati, 2024) (Satya Saputra et al., 2024).

2) **Model Training**: The dataset was divided into training and testing subsets. The training set was used to develop the model, while the testing set was reserved for evaluating its performance. The linear regression model was trained on historical data, with time as the main independent variable.
3) **Performance Metrics**: The model's performance was evaluated using Mean Absolute Error (MAE) and R^2 Score, both of which are standard metrics in evaluating the performance of regression models. MAE measures the average of the absolute differences between the predicted and actual values, providing an idea of how far the model's predictions are from the true values (Nurahman & Ernawati, 2024). The R^2 Score, or coefficient of determination, measures the proportion of variance in the dependent variable that can be explained by the independent variables in the regression model (Syahputra et al., 2020). Previous research shows that the use of MAE can provide a clearer indication of model accuracy in situations where large errors need to be identified more significantly (Satya Saputra et al., 2024). In addition, the R^2 Score is often used to assess how well the observed data fits the developed predictive model (Rohman et al., 2021). In the context of linear regression analysis, the combination of MAE and R^2 Score can provide a more comprehensive evaluation of the model's performance (Listyawati & Kristiana, 2021). A lower MAE value indicates that the model has more accurate predictions, while a high R^2 Score indicates that the model is able to explain most of the variability of the observed data.

MAE is calculated as follows:

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i|$$

where *yi* is the actual value, *y^i* is the predicted value, and n is the number of observations.

The R^2 score indicates how well the model's predictions fit the actual data. It is calculated as follows:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

Where y is the mean of the actual values. The data was cleaned, normalized, and divided into training and testing sets to apply the linear regression model. The model was trained on historical data, and its performance was evaluated using metrics such as Mean Absolute Error (MAE) and R^2 Score.

e. Application Implementation and Evaluation

The research culminated in the development of a web-based application designed to provide predictive analysis for products on the HSR Wheels e-commerce platform. A key

feature of this system is the 'Analyst Product' interface, which presents a clear and concise summary of prediction results for a selected product, forecasted for the upcoming year.

This output provides actionable insights to facilitate business decision-making regarding inventory management and sales strategies. For example, the analysis for the product as shown in Figure 6. Figure 6 shows that the product "BOROKO TJH HSR R18X8 H8X100-114.3 ET45 SANDY GREY" has a current selling price of Rp. 1,925,000 with a predicted selling price of Rp. 2,023,724. The projected turnover is Rp. 8,638,822 with a minimum daily stock of 4 products. The profit per product is estimated at Rp. 337,266 with a profit percentage of 4.38%, which is considered quite profitable.

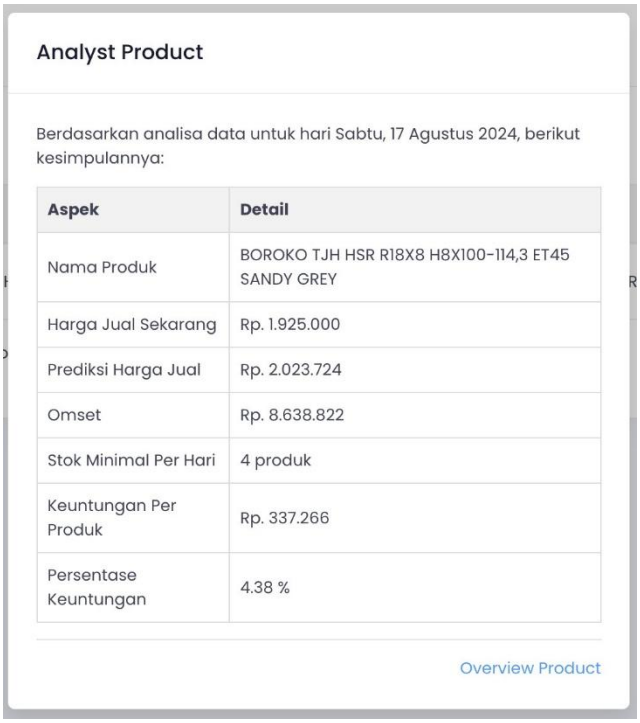

Figure 4. Result Prediction of the application

Table 1 summarizes the results of the prediction evaluation using the linear regression model for several products on the HSR Wheels platform. The evaluation results show that the linear regression model did not perform well in predicting key variables such as selling price, profit percentage, and stock level.

Table 1. Evaluation Metrics Prediction

Product	Variable	MAE	R^2 Score
SUTORE L1805	Sale Price	227,675.617	0.012
	Profit	11.994	0.002
	Stock	0.978	0.037
FE01 HSR R17X75	Sale Price	72,788.041	0.013
	Profit	4.182	0.005
	Stock	0.552	0.002

BOROKO TJH	Sale Price	2,071,435.850	0.012
	Profit	11.994	0.002
BOROKO TJH	Stock	0.978	0.037

The linear regression model showed significant limitations in its ability to predict sales, stock levels, and profit margins. The low R^2 scores across all products and variables indicate that the model could not account for most of the variance in the data, suggesting that the relationships between variables are more complex than what a linear approach can capture.

1) **Sales and Profit Prediction**: The high MAE values for selling price predictions indicate that the model's predictions were far from the actual values, especially for products like BOROKO TJH, where the error exceeded two million. Similarly, the profit percentage predictions were unreliable, with low R^2 scores indicating that the model did not adequately explain the variability in profit margins.
2) **Stock Prediction**: The stock prediction results were also unsatisfactory, with low R^2 scores indicating that the model could not effectively predict stock levels. These findings highlight the need for more sophisticated models that can capture the nuances of stock management in an e-commerce setting.

These results indicate that while linear regression can provide some basic insights, it is insufficient for accurate prediction in the context of HSR Wheels' e-commerce operations. The complexity of the relationships between selling price over time, stock over time, and profit over time requires more sophisticated predictive models, possibly incorporating machine learning techniques or non-linear approaches.

f. Strategies for Model Improvement

Based on the evaluation results above, several strategies can be considered to improve prediction accuracy. Given the limitations of the linear regression model, several strategies can be used to enhance prediction accuracy.

1) Adding more relevant features, such as marketing expenditure, seasonal indicators, or customer segmentation data, could improve the model's ability to capture underlying patterns in the data.
2) Tuning the model's hyperparameters through techniques like grid search can optimize its performance and increase prediction accuracy.
3) Exploring more complex models, such as ensemble methods (e.g., Random Forest, Gradient Boosting) or neural networks, can better capture non-linear relationships in the data.
4) Increasing the size and diversity of the dataset through data augmentation techniques can provide more robust training data for the model, leading to better generalization on unseen data.

Conclusion

This study aimed to evaluate the effectiveness of a linear regression model in predicting selling prices, stock levels, and profit margins on the HSR Wheels e-commerce platform. However, the model showed significant limitations in accommodating the complexity of e-commerce sales data.

The model evaluation using Mean Absolute Error (MAE) and R^2 Score metrics showed that linear regression has low performance. The highest MAE value was found in the selling price prediction of the BOROKO TJH product, which was Rp 2,071,435.85, indicating a large deviation between the actual and predicted price. Meanwhile, the R^2 Score on the selling price prediction of the SUTORE L1805 product only reached 0.012, which means only about 1.2% of the variability could be explained by the model. Profit prediction also showed unsatisfactory results, with an MAE value of Rp 11,994 for the BOROKO TJH product and an R^2 Score of 0.002, which indicates the model's inability to capture the variability patterns of the profit data. Stock level prediction was no better, with an MAE of 0.978 and an R^2 Score of only 0.037, signaling a significant weakness in predicting daily stock fluctuations.

Data visualization through Box Plots revealed significant fluctuations in the quantity of products purchased, with some periods showing large variations marked by many outliers. The distribution of nominal profit showed an uneven spread pattern, where most of the profit was concentrated at a certain value, while some outliers showed very high or very low profits.

Based on these findings, the linear regression model is unable to explain the complexity that occurs in predicting key variables on the HSR Wheels e-commerce platform. Therefore, it is recommended to implement more advanced predictive approaches, such as machine learning algorithms, including Random Forest Regression, Gradient Boosting, or Neural Networks, which are more capable of capturing non-linear relationships in the data. This research is expected to be a basis for the development of more effective inventory and sales management strategies, with more accurate predictions to support strategic decision-making in the e-commerce environment.

Declaration of conflicting interest

The authors declare that there is no conflict of interest regarding the publication of this article entitled “Evaluation of the Use of Linear Regression to Predict Profit, Selling Price, and Stock on the HSR Wheels Platform.”

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