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Forecasting Motorcycle Spare Parts Demand Using the Least Squares Method (A Case Study of Teguh Jaya Motor)

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Abstract

Accurate demand forecasting is a critical factor in inventory management, particularly for small and medium-sized automotive workshops where stock shortages may lead to customer loss and operational inefficiencies. This study aims to forecast motorcycle spare parts demand at Teguh Jaya Motor by applying the Least Squares method to historical sales data from January 2020 to December 2024. A quantitative research approach was adopted, utilizing time-series analysis of ten key spare parts, including clutches, engine oil, brake pads, tires, spark plugs, bearings, pistons, starters, and shock absorbers. The forecasting model was evaluated using the Mean Absolute Percentage Error (MAPE) to assess prediction accuracy. Furthermore, the proposed forecasting approach was implemented in a web-based application developed using PHP, HTML, CSS, and MySQL to support practical decision-making. The results indicate that the Least Squares method provides high forecasting accuracy, with MAPE values ranging from 3.97% to 10.21%, categorized as "very good" to "good". These findings demonstrate that the Least Squares approach is suitable for predicting spare parts demand trends and can effectively support inventory planning in motorcycle workshops.

Keywords: *Demand Forecasting, Motorcycle Spare Parts, Least Squares Method, MAPE, Inventory Management*

Introduction

Motorcycle spare parts play a vital role in maintaining vehicle performance, reliability, and rider safety. Components such as clutches, spark plugs, bearings, and brake pads must be replaced periodically to ensure optimal vehicle operation. Consequently, the availability of spare parts is a critical issue for motorcycle workshops, as insufficient stock can lead to service delays, customer dissatisfaction, and lost revenue.

Demand forecasting has become an essential tool for inventory management, enabling businesses to anticipate future needs based on historical data patterns (Adekunle et al., 2021; Hyndman & Athanasopoulos, 2018). Among various time-series forecasting techniques, the Least Squares method is widely used to identify linear trends by modeling the relationship between time and demand variables. This method constructs a trend line that minimizes the sum of squared deviations between observed and predicted values, thereby providing a simple yet effective forecasting approach (Arnorce et al., 2023; Wang et al., 2018).

For Teguh Jaya Motor, the absence of a systematic forecasting mechanism has resulted in challenges related to stock availability and inventory control. Implementing a computerized forecasting system is expected to enhance operational efficiency, reduce storage costs, and improve customer satisfaction. Therefore, this study aims to (1) forecast motorcycle spare parts demand using the Least Squares method, (2) develop a web-based forecasting system to support inventory decision-making, and (3) evaluate forecasting accuracy using the Mean Absolute Percentage Error (MAPE).

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Methods

Research Framework

This study follows a structured research framework consisting of data collection, data preprocessing, forecasting model development using the Least Squares method, accuracy evaluation using MAPE, and system implementation. Historical demand data serve as the primary input for model construction and validation.

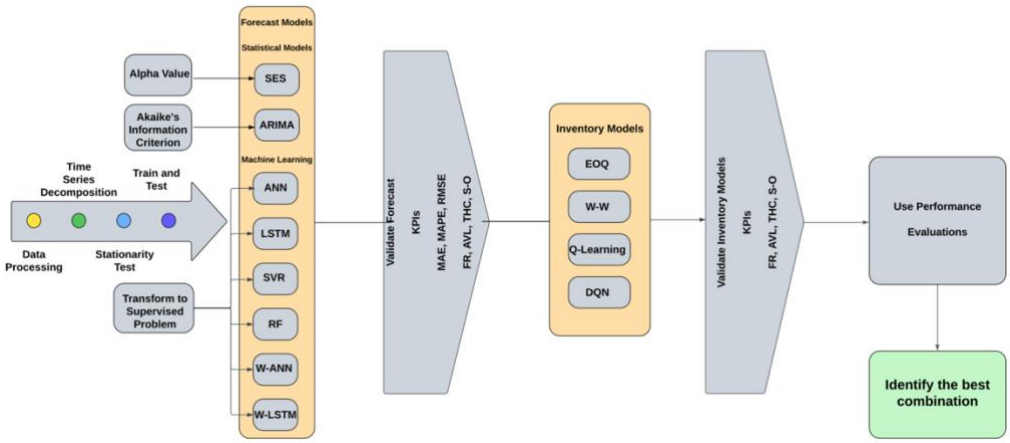

Figure 1. Research Framework

The research framework of this study consists of five sequential stages. The process begins with data collection, where historical monthly sales data of motorcycle spare parts from January 2020 to December 2024 are gathered. The collected data are then subjected to data preprocessing, including data validation, normalization of time periods, and identification of demand trends.

Subsequently, the Least Squares method is applied to construct a linear time-series forecasting model for each spare part category. The forecasting results are then evaluated using the Mean Absolute Percentage Error (MAPE) to assess prediction accuracy and model reliability (Makridakis et al., 2018). Finally, the validated forecasting model is implemented into a web-based decision support system, enabling practical inventory planning and managerial decision-making at Teguh Jaya Motor.

Data Collection

The dataset comprises monthly sales data of motorcycle spare parts at Teguh Jaya Motor from January 2020 to December 2024. Ten types of spare parts were analyzed: clutch, engine oil, brake pads, inner tires, outer tires, spark plugs, bearings, pistons, starters, and shock absorbers.

Data were collected through:

1. Documentation: Monthly sales records maintained by the workshop.
2. Interviews: Direct interviews with the workshop owner to identify unmet demand due to stock shortages, providing complementary qualitative insights.

Least Squares Forecasting Method

The Least Squares method estimates a linear trend model expressed as:

$$Y = a + bX$$

where:

Y represents the forecasted demand,

X denotes the time period,

a is the intercept,

b is the slope coefficient.

The parameters a and b are calculated using:

$$a = \frac{\sum Y}{N}$$

$$b = \frac{\sum XY}{\sum X^2}$$

where N is the number of observations.

Forecast Accuracy Measurement

Forecast accuracy was evaluated using the Mean Absolute Percentage Error (MAPE):

$$MAPE = \frac{1}{n}\sum \left|\frac{Y_t - F_t}{Y_t}\right| \times 100\%$$

MAPE values were interpreted based on standard criteria:

- < 10% (Very Good),
- 10 – 20% (Good),
- 20 – 50% (Fair),
- > 50% (Poor)

Results and Discussion

Forecasting Results Using the Least Squares Method

The Least Squares forecasting model was applied to monthly sales data of ten motorcycle spare parts collected over a five-year period (January 2020–December 2024). The model estimated linear demand trends for each spare part category and generated demand forecasts for the 2025 period.

The forecasting results indicate a general upward demand trend across most spare parts, particularly engine oil, brake pads, and spark plugs. This pattern reflects increasing motorcycle usage intensity and regular maintenance cycles, which are consistent with prior findings in spare parts demand forecasting literature. Engine oil exhibited the highest average monthly demand, confirming its role as a fast-moving consumable item with relatively stable replacement intervals.

In contrast, components such as pistons and starters showed more moderate growth trends, suggesting that these items are associated with corrective maintenance rather than routine servicing. The ability of the Least Squares model to capture these differentiated demand patterns demonstrates its effectiveness in modeling linear trends for both high-frequency and low-frequency spare parts.

Forecast Accuracy Evaluation

Forecast accuracy was evaluated using the Mean Absolute Percentage Error (MAPE), which is widely adopted in demand forecasting studies due to its interpretability and scale independence. The MAPE values obtained ranged from 3.97% to 10.21%, indicating high predictive accuracy across all spare part categories.

Engine oil achieved the lowest MAPE value (3.97%), classified as very good forecasting performance. This result can be attributed to the relatively stable and predictable consumption pattern of engine oil, which aligns well with the assumptions of linear trend-based forecasting. Conversely, pistons recorded the highest MAPE value (10.21%), although this value still falls within the good accuracy category. The higher error level may be explained by the irregular replacement nature of pistons, which is often influenced by unexpected engine failures rather than routine schedules.

Overall, the accuracy evaluation confirms that the Least Squares method is sufficiently robust for operational forecasting in small-to-medium motorcycle workshops, particularly when historical demand data exhibit clear trend characteristics.

Discussion of Demand Patterns and Managerial Implications

The forecasting results provide valuable insights into the demand behavior of motorcycle spare parts at Teguh Jaya Motor. High-demand items such as engine oil, brake pads, and spark plugs should be prioritized in inventory planning due to their frequent turnover and direct impact on service continuity. Maintaining adequate stock levels for these items can significantly reduce service delays and customer dissatisfaction.

Meanwhile, lower-demand and higher-variability items, such as pistons and starters, require a more cautious inventory strategy. Overstocking such components may increase holding costs without proportional benefits. The forecasting outputs generated by the model enable workshop managers to differentiate inventory policies between fast-moving and slow-moving spare parts, supporting more efficient resource allocation.

From a methodological perspective, the results demonstrate that despite its simplicity, the Least Squares method can deliver competitive forecasting accuracy when applied to structured historical data. This finding is consistent with previous studies that highlight the practicality of linear forecasting models in environments with limited data availability and computational resources.

Web-Based System Implementation and Practical Validation

To enhance practical usability, the validated forecasting model was implemented into a web-based decision support system developed using PHP and MySQL. The system allows users to input historical sales data, perform automated forecasting calculations, and visualize results through tables and graphical representations.

Figure 2. Web-Based System Implementation

The integration of forecasting functionality into a web-based platform transforms the model from a purely analytical tool into a real-time operational support system. This implementation enables workshop managers to conduct demand forecasting without requiring advanced statistical expertise, thereby increasing adoption potential in small business settings.

Figure 3. Demand Forecasting Graph by the System

The system also facilitates periodic data updates, allowing forecasts to be recalibrated as new sales data become available. This dynamic capability supports continuous inventory planning and aligns with modern decision support system principles.

Comparison with Related Studies

Compared with prior studies on spare parts demand forecasting, the results of this research demonstrate comparable or superior accuracy levels. Previous research often emphasizes complex forecasting models such as ARIMA or machine learning approaches; however, these methods typically require larger datasets and higher computational complexity. In contrast, the Least Squares method applied in this study achieved satisfactory accuracy with lower implementation complexity, making it more accessible for small-scale enterprises.

Furthermore, while many existing studies focus on manufacturing or large distribution networks, this research extends the application of demand forecasting to the operational level of motorcycle workshops. This contextual contribution strengthens the relevance of the findings, particularly for service-oriented businesses in developing economies.

Conclusion

This study demonstrates that the Least Squares method is an effective and reliable approach for forecasting motorcycle spare parts demand at Teguh Jaya Motor. The forecasting results indicate increasing demand trends, with engine oil emerging as the most frequently required spare part. The MAPE evaluation confirms that the proposed model achieves high accuracy, making it suitable for inventory planning and stock control. The web-based implementation further supports practical decision-making by providing an accessible and user-friendly forecasting tool. Future research may explore hybrid or nonlinear forecasting models to further improve prediction performance.

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