Forecast Demand and Optimize Inventory System Through Predictive Inventory for MKJ Pineda Autoparts Shop

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***Abstract*— Inventory mismanagement is one of the primary challenges faced by small businesses, resulting in stockouts, overstocking, and operational inefficiency. This study investigated the development of a Forecast Demand and Optimize Inventory System through Predictive Inventory for MKJ Pineda Auto Parts Shop. The system leverages predictive analytics and machine learning techniques—specifically linear regression—to forecast product demand based on historical sales data. The objective is to optimize inventory levels, reduce excess stock, and minimize stockouts. Data were gathered through interviews, surveys, and observations from 30 respondents, including business owners, inventory managers, sales staff, and IT experts. The proposed system was evaluated using ISO 25010 quality standards in terms of functional suitability, performance efficiency, reliability, compatibility, and interaction operability. Findings revealed that the system significantly improved inventory, streamlined business processes, and enhanced customer satisfaction. The study highlights the importance of predictive inventory systems in addressing inventory management issues, offering a valuable contribution to small and medium-sized businesses seeking to enhance operational efficiency through data-driven decision-making. By incorporating a demand forecasting module using linear regression, this research empowers MKJ Pineda Auto parts Shop to predict future demand for auto parts based on historical sales data. This predictive capability facilitates informed decision-making regarding inventory replenishment, minimizing losses due to overstocking or stockouts. Furthermore, this project aligns with SDG 9 (Industry, Innovation, and Infrastructure) and SDG 8 (Decent Work and Economic Growth) by enhancing operational efficiency through data-driven insights and optimized inventory management. This contributes to sustainable resource utilization and supports the adoption of innovative technologies within small businesses, fostering economic growth and responsible consumption patterns.**

Keywords— Demand Forecasting, Predictive Inventory, Inventory Optimization, Linear Regression

I. INTRODUCTION

Automobile part retailers, including those in the Philippines, are businesses that sell automotive parts and accessories to both individual customers and professional repair businesses through physical stores and online platforms. Some of these retailers also offer customer support, car maintenance, and repair services. The domestic car parts industry in the Philippines is currently composed of 256 businesses, manufacturing approximately 330 unique parts and components. With the presence of four Japanese automakers, the industry represents a burgeoning economic sector, particularly in the provinces of Laguna and Cavite.

The National Capital Region of the Philippines, specifically the "Banawe" area, is also recognized for its thriving auto parts industry, primarily due to its cost-effectiveness compared to Casa. MKJ Pineda Auto parts, a prominent auto parts business situated in Quezon City, Philippines, has been managing its inventory using paper-based records for several years. However, in the contemporary commercial landscape, such methods can be laborious, susceptible to errors, and inefficient.

This study proposes to explore the potential advantages of implementing a streamlined inventory management system equipped with real-time data capabilities at MKJ Pineda Auto parts. The objective of the study is to enhance operational efficiency, boost sales, and foster business growth by integrating technologies such as point-of-sale (POS) systems and real-time inventory management. The study aims to forecast demand and optimize the inventory system through predictive inventory management.

II. RELATED WORKS

These insights provide a foundation for developing a predictive inventory model from some related literature and studies.

[1] Inventory management defines as a framework for monitoring stock levels, forecasting demand, and optimizing replenishment processes. Inefficient inventory practices, such as overstocking, lead to high costs and waste, while understocking results in operational disruptions and diminished customer satisfaction.

[3] Anderson, underscores the importance of accurate demand forecasting in his case study on automotive aftermarket inventory. He advocates for metrics aligned with customer service levels, such as fill rates and stock-out costs, to improve inventory control.

[4] Nazarenko, demonstrates how AI and machine learning improve forecasting accuracy, helping businesses minimize overstocking and stockouts while reducing costs. Integrating short-term demand forecasting with stock control policies ensures inventory levels meet actual demand, enhancing efficiency.

[5] Makarova, highlights the importance of synchronizing supply chain processes and leveraging proactive demand forecasting for inventory planning. Georgiev et al. (2024) recommend strategies such as precise demand forecasting, robust tracking systems, and lean inventory principles to streamline operations and reduce costs.

[6] Introduce a new deep learning approach to improve inventory management and demand forecasting, with a particular focus on identifying anomalies in complex supply chains. Their innovative framework combines a Convolutional Neural Network (CNN) to extract features and a Long Short-Term Memory (LSTM) network to model sequences, effectively capturing both spatial and temporal patterns in inventory data.

[7] Research conducted by Torculas et al. (2023) utilizes machine learning algorithms, including linear regression, to predict energy consumption in the Philippines. Their work demonstrates the effectiveness of these algorithms in handling large datasets and providing accurate predictions. By integrating multiple data sources, they provide a comprehensive model that can be used for energy planning and policy-making. This approach is particularly valuable in the context of the Philippines, where energy consumption patterns are influenced by various socio-economic factors.

[8] The study titled "A Comparative Study of Machine Learning Algorithms for Regression in Predicting the Academic Performance of Students in General Mathematics" by Mary Christine Ontolan, Redeemtor Sacayan, and Bernadette Tubo (2024) explores the application of various predictive modeling techniques to forecast student performance in General Mathematics at Notre Dame of Midsayap College. The researchers evaluated three machine learning algorithms: multiple linear regression (MLR), random forest regression (RFR), and support vector regression (SVR). They found that multiple linear regression outperformed the other models in terms of predictive accuracy, achieving a 97.29% accuracy rate based on metrics such as Root Mean Square Error (RMSE) and Mean Absolute Error (MAE).

[9] The application of the random forest regression algorithm in this study underscores the importance of using machine learning techniques to analyze complex agricultural data. Linear regression, a simpler yet powerful tool, can also be applied to such data to understand relationships between exogenous variables and rice production. Linear regression is particularly relevant for its ease of use, interpretability, and ability to handle large datasets. By comparing the performance of linear regression with more advanced techniques like random forest, researchers can gain insights into the strengths and limitations of each method. This approach provides valuable guidance for agricultural planning and policy-making, ensuring that strategies are based on robust, data-driven insights.

[10] Magallanes et al., introduce an inventory management system for LJJG Motor Parts, addressing inefficiencies in manual record-keeping. The system enhances stock monitoring, restocking notifications, and sales reporting, reducing errors and improving operational efficiency. This study underscores the value of integrating technology into inventory management to optimize processes and meet customer needs effectively.

[11] The application of linear regression and machine learning in predictive modeling, as explored in studies like "When Machine Learning Meets Econometrics: Can it Build a Better Measure to Predict Multidimensional Poverty and Examine Unmeasurable Economic Conditions?" by Onsay and Rabajante (2024), can provide valuable insights in the study of Forecast Demand and Optimize Inventory System through Predictive Inventory for MKJ Pineda Autoparts Shop. This study utilized linear regression to establish relationships between socio-economic indicators and poverty outcomes, which can be analogously applied to forecast demand in inventory management. By using linear regression, you can predict sales and market demand, allowing for optimized inventory levels to reduce stockouts and excess inventory. This approach enhances the efficiency of inventory management and profitability by leveraging predictive analytics similar to those used in socio-economic research.

[12] Seyedan and Mafakheri (2020) conducted a survey investigating the predictive BDA applications in supply chain demand forecasting. They proposed a classification of these applications and identified gaps for future research, providing valuable insights for the application of predictive inventory.

[13] Linear regression is a statistical technique used to analyze and model the relationship between a dependent variable and one or more independent variables by fitting a linear equation to observed data. It serves as a foundational method in machine learning for predicting outcomes and understanding variable associations, making it a widely utilized tool in various predictive tasks.

[14] A chapter on "Time Series Forecasting with Statistical, Machine Learning, and Deep Learning Methods", Spiliotis discusses various forecasting methods, including linear regression, and their application in inventory systems. The study compares the performance of different techniques in predicting future demand and optimizing inventory levels. Additionally, the research highlights the importance of selecting the appropriate forecasting method based on the specific needs and data characteristics of the inventory system. This chapter provides a detailed analysis of the strengths and weaknesses of each method. Such insights are invaluable for developing more precise and effective forecasting models.

[15] Linear regression is a foundational statistical tool used in predictive modeling and inventory management. Studies demonstrate its reliability in forecasting demand by identifying relationships between historical data and future trends. The formula $y = \beta_0 + \beta_1 x + \varepsilon$ quantifies how independent variables (e.g., sales trends, seasonal factors) influence dependent variables (e.g., inventory levels.

III. METHODOLOGY

A. Methodology

The research will employ Agile methodology for research, focusing on small, incremental updates, continuous collaboration, and flexibility to create a reliable, adaptable solution.

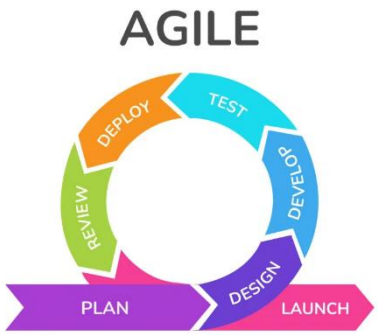

Fig. 1. Agile Methodology

Figure 1 illustrates that the method used in this study is the Agile methodology, which is defined by its iterative and adaptive nature in system development. The methodology is appropriate for the project since it emphasizes continuous feedback, rapid testing, and flexibility in managing changing requirements. The Agile model supports incremental improvements and maintains the system in sync with the changing needs of MKJ Pineda Auto parts Shop.

B. Population, Sample Size, and Sampling Techniques

1. The study examines the key stakeholders at MKJ Pineda Auto Parts Shop, including the business owner and employees engaged in inventory management and sales operations. This group was selected to offer valuable insights and feedback on the existing inventory system and possible enhancements through predictive inventory management.
2. The research features a sample size of 30 respondents, which comprises 20 individuals from various automotive shops, including one business owner, two inventory managers, and two sales staff from MKJ Pineda Auto Parts Shop. Additionally, the sample includes 14 other business owners and one sales staff from other auto shops. Notably, the study also includes responses from 10 IT experts.
3. The study utilizes purposive sampling to select participants. Purposive sampling is a non-probability sampling method where the researcher selects participants based on their knowledge, relationships, and experience related to the research topic. This method ensures that the sample includes individuals with significant insights into the inventory management practices and challenges at MKJ Pineda Auto Parts Shop. [2] Purposeful sampling is effective when specific individuals are best suited to provide the necessary information due to their expertise and involvement in the subject matter.

C. Research Instrument

The research instrument used in this study was a set of structured interview questions designed to gather qualitative data on the current inventory management practices at MKJ Pineda Auto Parts Shop. The interview questions were crafted to extract detailed insights into the methods employed by the shop for tracking inventory, the challenges faced with the existing manual system, and the expectations from an automated inventory management system.

D. Statistical Treatement of Data

1. Weighted Mean. The researchers used weighted Mean to assess the perception of evaluators about the system.

Formula: The formula for weighted mean is:

$$W.M. = \frac{\sum wx}{n}$$

Eq. 1 Weighted Mean Formula

Where:

w = number of respondents who answered specific scale/item
x = values of Likert scale
n = sample size

Likert Scale. The results to the provided variables' questions were evaluated using the "5-point-scale" or Likert Scale system and weighted as follows:

Table 1. Interpretation of Weighted Mean

Point	Range	Verbal Interpretation	Symbol
5	4.50 – 5.0	Strongly Agree	SA
4	3.50 – 4.49	Agree	A
3	2.50 – 3.49	Minimally Agree	MA
2	1.50 – 2.49	Disagree	D
1	1.0 – 1.49	Strongly Disagree	SD

Table 1. Displays the interpretation of weighted mean that is used in the research.

E. Forecasting Demand and Predictive Inventory Using Linear Regression Formula

Linear regression, as a statistical tool, helps establish a relationship between independent variables (predictors) and a dependent variable (outcome). Its forecasting formula is:

$$y = \beta_0 + \beta_1 x + \varepsilon$$

Eq. 2 Linear Regression Formula

where:

y is the predicted value,

β_0 is the intercept (the starting value of y when x is 0),

β_1 is the slope (rate of change in y per unit of x),

x is the independent variable, and

ε is the error term (unexplained variation).

In Eq. 2, the linear regression formula, "$y = \beta_0 + \beta_1 x + \varepsilon$", is a fundamental tool for demand forecasting. In this equation, 'y' represents the forecasted demand, which is what we're trying to predict. 'β_0' is the intercept, indicating the baseline demand when the independent variable is zero. 'β_1' is the slope, showing how much the demand changes for every unit increase in the independent variable. The 'x' is the independent variable, which can be any factor influencing demand, such as price, time, or season. Finally, 'ε,' which accounts for the unexplained variation in demand. By analyzing historical data

and identifying the relationship between demand and these independent variables, businesses can use this formula to predict future demand and make informed decisions about inventory, pricing, and production. It acknowledges that the linear equation isn't a perfect predictor, and other factors not included in the model can influence demand. These factors might be things like unexpected events, changes in consumer preferences, or competitor actions. The error term ensures that the regression model reflects the real-world complexities of demand forecasting.

IV. Results and Discussion

The proposed system is evaluated based on ISO 25010:2011 software quality characteristics, including functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

Table II. Summary Assessment of Respondents on System Features Performance

Indicators	IT Experts		Employees		Composite		Rank
	WM	VI	WM	VI	WM	VI	
Functional Suitability	4.53	SA	4.40	SA	4.60	SA	**1**
Performance Efficiency	4.13	A	4.18	A	4.16	A	**8**
Compatibility	3.90	A	4.03	A	3.97	A	**9**
Interaction Operability	4.34	SA	4.30	SA	4.32	SA	**2**
Reliability	4.17	A	4.18	A	4.18	A	**7**
Security	4.29	SA	4.31	SA	4.30	SA	**3**
Maintainability	4.36	SA	4.17	A	4.25	SA	**6**
Flexibility	4.40	SA	4.20	A	4.29	SA	**4**
Safety	4.50	SA	4.10	A	4.28	SA	**5**
General Weighted Mean					**4.74**	**SA**	

Table 2 summarizes respondents' assessments of system features, the overall weighted mean of the composite score stands at an impressive 4.74, which falls under the category of "Strongly Agree." This indicates a high level of satisfaction among the respondents. The highest-ranking factor was Functional Suitability, with a numerical value of 4.60, which is also interpreted as "Strongly Agree." This suggests that the system meets the necessary functional requirements exceptionally well.

V. Conclusions and Recommendation

A. Conclusions

The results of the evaluation carried out were obtained by considering the concerns stated in the study objectives:

1. That the integration of the predictive inventory system has been specifically created to meet the needs of MKJ Pineda Auto parts Shop. Its characteristics include:
    a. Capability to manage user roles for super admin, admin, and cashier.
    b. Capability to generate comprehensive reports and analytics.
    c. Capability to integrate real-time data for predictive inventory and demand forecasting.
    d. Capability to support system settings and configurations for super admin.
2. The integration of real-time data for predictive inventory, demand forecasting, and dynamic inventory management has been successfully implemented, ensuring accurate and timely decisions. This is supported by comprehensive graphs and tables, which illustrate the system's effectiveness in maintaining optimal stock levels, reducing stockouts and overstock situations, and responding promptly to market demand.
3. The MKJ Pineda Auto parts Shop system has undergone User Acceptance Testing and has passed all the test cases. As a result, the system could support all the features required for the shop's processes.

That the following were the results of the evaluation of the eight criteria as shown in the evaluation:

a) On Functional Suitability, the system received a "Strongly Agree" rating from the respondents, with a numerical value of 4.60. This implies that the system can handle all the tasks and objectives set by the user and delivers accurate outcomes with the required level of accuracy.

b) On Interaction Operability, the system received a "Strongly Agree" rating from the respondents, with a score of 4.32. This reflects that the system is user-friendly and easy to operate.

c) On Flexibility, the system received a "Strongly Agree" rating from the respondents, with a score of 4.29. This highlights the system's ability to adapt to different situations and requirements.

d) On Safety, the system received a "Strongly Agree" rating from the respondents, with a score of 4.28. This indicates that the system is perceived as secure and safe to use.

e) On Maintainability, the system received a "Strongly Agree" rating from the respondents, with a score of 4.25. This shows that the system is easy to maintain and keep in good working condition.

f) On Reliability, the system received a "Strongly Agree" rating from the respondents, with a score of 4.18. This signifies that the system performs consistently well over time.

g) On Performance Efficiency, the system received an "Agree" rating from the respondents, with a score of 4.16. This suggests that while the system performs efficiently, there might be some room for improvement.

h) On Compatibility, the system received an "Agree" rating from the respondents, with a score of 3.97. This indicates that the system is generally compatible with other systems, though there may be some limitations.

4. The system has easy-to-use interfaces and clear reporting tools designed for simplicity and efficiency. The layout is intuitive, allowing users to quickly find and use the features they need. Charts and graphs in the reports help make the data easy to understand and use for decision-making. This blend of simplicity and effective functionality ensures the system meets the needs of all its users.

B. Recommendation

To maximize the benefits of the current system and prepare for future growth, several key recommendations should be implemented. Firstly, ongoing staff training is crucial to ensure optimal system usage and to gather valuable feedback for continuous improvement. Secondly, enhancing the system's predictive capabilities through advanced analytics like machine learning will significantly improve demand forecasting accuracy. As the business expands, it's

essential to ensure system scalability by accommodating new product lines, users, and integrations with other business tools. Regular maintenance and software updates are vital for maintaining system reliability and security. Furthermore, a robust data backup and recovery plan should be implemented to prevent data loss and ensure business continuity. To gain deeper insights, reporting and analytics features should be improved to provide granular data and visual dashboards. Finally, the system's performance should be regularly evaluated and optimized based on ISO 25010 standards, focusing on functional suitability, performance efficiency, reliability, and security, to ensure the system consistently meets the highest quality standards.

REFERENCES

[1] G. M. B. Napa, "Inventory Management System of Seasonal Raw Materials of Feeds at San Jose Batangas through Integer Linear Programming and VBA," Lipa City, Batangas, Philippines, Mar. 2023. Accessed: Feb. 21, 2025. [Online]. Available: https://doi.org/10.46254/AN13.20230628.

[2] M. Q. Patton, "Qualitative-Research-Evaluation-Methods," 2002, Accessed: Feb. 23, 2025. [Online]. Available: https://aulasvirtuales.wordpress.com/wp-content/uploads/2014/02/qualitative-research-evaluation-methods-by-michael-patton.pdf

[3] C. Anderson, "Forecasting Demand for Optimal Inventory with Long Lead Times: Forecasting Demand for Optimal Inventory with Long Lead Times: An Automotive Aftermarket Case Study An Automotive Aftermarket Case Study," Nov. 2021. [Online]. Available: https://irl.umsl.edu/dissertation/1105

[4] A. Nazarenko, "Inventory management system combining short-term demand forecasting and stock control policy: An Automotive Industry Use-Case," Nov. 2024. [Online]. Available: https://ssrn.com/abstract=5036298

[5] O. V. Makarova, "Predictive method of inventory optimization in industrial manufacturer performance," in *E3S Web of Conferences*, EDP Sciences, Apr. 2021. doi: 10.1051/e3sconf/202124701066.

[6] C. Deng and Y. Liu, "A Deep Learning-Based Inventory Management and Demand Prediction Optimization Method for Anomaly Detection," *Wirel Commun Mob Comput*, vol. 2021, 2021, doi: 10.1155/2021/9969357.

[7] E. Torculas, E. J. Rentillo, and A. A. Ambita, "Forecasting of Energy Consumption in the Philippines Using Machine Learning Algorithms," in *Communications in Computer and Information Science*, Springer Science and Business Media Deutschland GmbH, 2023, pp. 424–435. doi: 10.1007/978-3-031-42430-4_35.

[8] M. G. Christine Ontolan, R. R. Sacayan, and B. F. Tubo, "The Mindanawan Journal of Mathematics A Comparative Study of Machine Learning Algorithms for Regression in Predicting the Academic Performance of Students in General Mathematics," Online, 2024.

[9] V. E. Montano and M. Teresa S. Bulao, "Random Forest Analysis of Exogenous Variables Impacting Rice Production in the Philippines," *JOURNAL OF ECONOMICS, FINANCE AND MANAGEMENT STUDIES*, vol. 07, no. 01, Jan. 2024, doi: 10.47191/jefms/v7-i1-13.

[10] C. A. Magallanes *et al.*, "ANALYSIS AND DESIGN OF A SALES AND INVENTORY MANAGEMENT INFORMATION SYSTEM FOR A MOTORCYCLE PARTS AND ACCESSORIES STORE," *International Journal of Scientific Research and Engineering Development*, vol. 4, Jul. 2021, [Online]. Available: https://www.researchgate.net/publication/352978619

[11] E. A. Onsay and J. F. Rabajante, "When machine learning meets econometrics: Can it build a better measure to predict multidimensional poverty and examine unmeasurable economic conditions?," *Science Talks*, vol. 11, p. 100387, Sep. 2024, doi: 10.1016/j.sctalk.2024.100387.

[12] M. Seyedan and F. Mafakheri, "Predictive big data analytics for supply chain demand forecasting: methods, applications, and research opportunities," *J Big Data*, vol. 7, no. 1, Dec. 2020, doi: 10.1186/s40537-020-00329-2.

[13] D. H. Maulud and A. M. Abdulazeez, "Linear Regression Comprehensive in Machine Learning," 2020, Accessed: Feb. 23, 2025. [Online]. Available: https://jastt.org/index.php/jasttpath/article/view/57/20

[14] E. Spiliotis, "Time Series Forecasting with Statistical, Machine Learning, and Deep Learning Methods: Past, Present, and Future," 2023, pp. 49–75. doi: 10.1007/978-3-031-35879-1_3.

[15] M. Stojiljkovic, "Simple Linear Regression Multiple Linear Regression Polynomial Regression Underfitting and Overfitting Implementing Linear Regression in Python Python Packages for Linear Regression Simple Linear Regression With scikit-learn Multiple Linear Regression With scikit-learn Polynomial Regression With scikit-learn Advanced Linear Regression With statsmodels Beyond Linear Regression Conclusion," Apr. 2019. [Online]. Available: https://realpython.com/linear-regression-in-python/1/21