International Journal on Science and Technology (IJSAT)

E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Enhancing Inventory Control Through Sales Forecasting

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Abstract

The study titled "Enhancing Inventory Control through Sales Forecasting for MSMEs in City Commercial Center (C3) Mall, Pagadian City" aimed to develop a computerized POS-integrated system with forecasting capabilities to improve inventory monitoring, sales tracking, and data-driven decision-making among MSMEs. Anchored on Knowledge Management Theory, Demand Forecasting Theory, and Time Series Forecasting Theory, the system was developed using the Agile Software Development Life Cycle (SDLC) to support iterative improvement and user-centered refinement.

This developmental research involved designing, coding, and testing a POS-integrated inventory system that automates business processes and provides sales forecasting using algorithms such as Moving Average, Linear Regression, Weighted Moving Average, Quadratic Regression, and Holt-Winters seasonal smoothing. The study was conducted at C3 Mall in Pagadian City, where 47 respondents, including MSME owners or managers, cashiers, inventory personnel, and IT professionals, evaluated the system using ISO/IEC 9126 software quality standards.

Results showed that the system achieved excellent performance across key quality parameters, including functionality, reliability, usability, efficiency, maintainability, portability, and security. Respondents confirmed its effectiveness in improving business operations by reducing manual errors, speeding up transactions, and enabling real-time forecasting and inventory monitoring. The system enhanced traditional POS platforms by transforming them into decision-support tools that improve operational efficiency and inventory planning.

This study contributes to Computer Science by demonstrating how forecasting algorithms and knowledge-based system design can support MSMEs in adopting digital transformation, enhancing operational efficiency, and maintaining sustainable and competitive business performance.

Keywords: Expert System, Point-of-Sale (POS), MSMEs, CIPP, Sales Forecasting, Predictive Analytics, Business Intelligence, Digital Transformation, Demand Forecasting, Time Series Forecasting, Knowledge Management, Moving Average, Linear Regression, and Holt-Winters Seasonal Smoothing

1. Introduction

Micro, Small, and Medium Enterprises (MSMEs) play a crucial role in driving local economic development, particularly in provincial hubs like Pagadian City in the Philippines. Despite their economic significance, many local MSMEs—such as those operating within C3 Mall—struggle with operational inefficiencies stemming from traditional and reactive inventory management. Business owners frequently rely on manual logbooks, basic Point-of-Sale (POS) systems, and personal intuition to make stocking decisions. Because these conventional methods lack analytical and forecasting capabilities, MSMEs often face a challenging dichotomy: frequent overstocking of slow-moving products and costly shortages of high-demand items. This reliance on fragmented data rather than strategic planning exposes local enterprises to avoidable risks, including inefficient capital utilization, stock losses, and diminished overall competitiveness in an increasingly data-driven market.

To address this critical gap between basic transaction recording and strategic inventory planning, this study proposes the development of a POS-integrated forecasting system tailored specifically for MSMEs at C3 Mall. By embedding predictive analytics within a standard POS environment, the system leverages historical sales data to forecast future demand, empowering business owners to determine optimal restocking times and quantities. Unlike traditional systems, this locally adapted solution assists MSMEs in identifying sales trends, recognizing seasonal patterns, and predicting peak demand periods. Developed in coordination with the Department of Trade and Industry (DTI) Zamboanga del Sur Provincial Office, this initiative aims to transition local businesses from reactive practices to proactive, data-driven inventory management, ultimately improving profitability and product availability.

The development and evaluation of this system are systematically anchored in the Context–Input–Process–Product (CIPP) Evaluation Model, integrated with Agile Software Development principles. The Context and Input phases are grounded in Demand Forecasting, Time Series Forecasting, and Knowledge Management theories, ensuring that raw sales data is effectively transformed into actionable knowledge. The Process phase utilizes Agile methodologies to iteratively develop, test, and refine forecasting algorithms—including Moving Average, Linear Regression, and Holt-Winters Seasonal Smoothing—based on continuous user feedback. Finally, the Product phase delivers tangible decision-support outputs, such as inventory monitoring dashboards and automated reorder recommendations. Through this robust theoretical triangulation, the study provides a methodologically sound and highly adaptable framework for resolving the distinct inventory challenges faced by MSMEs.

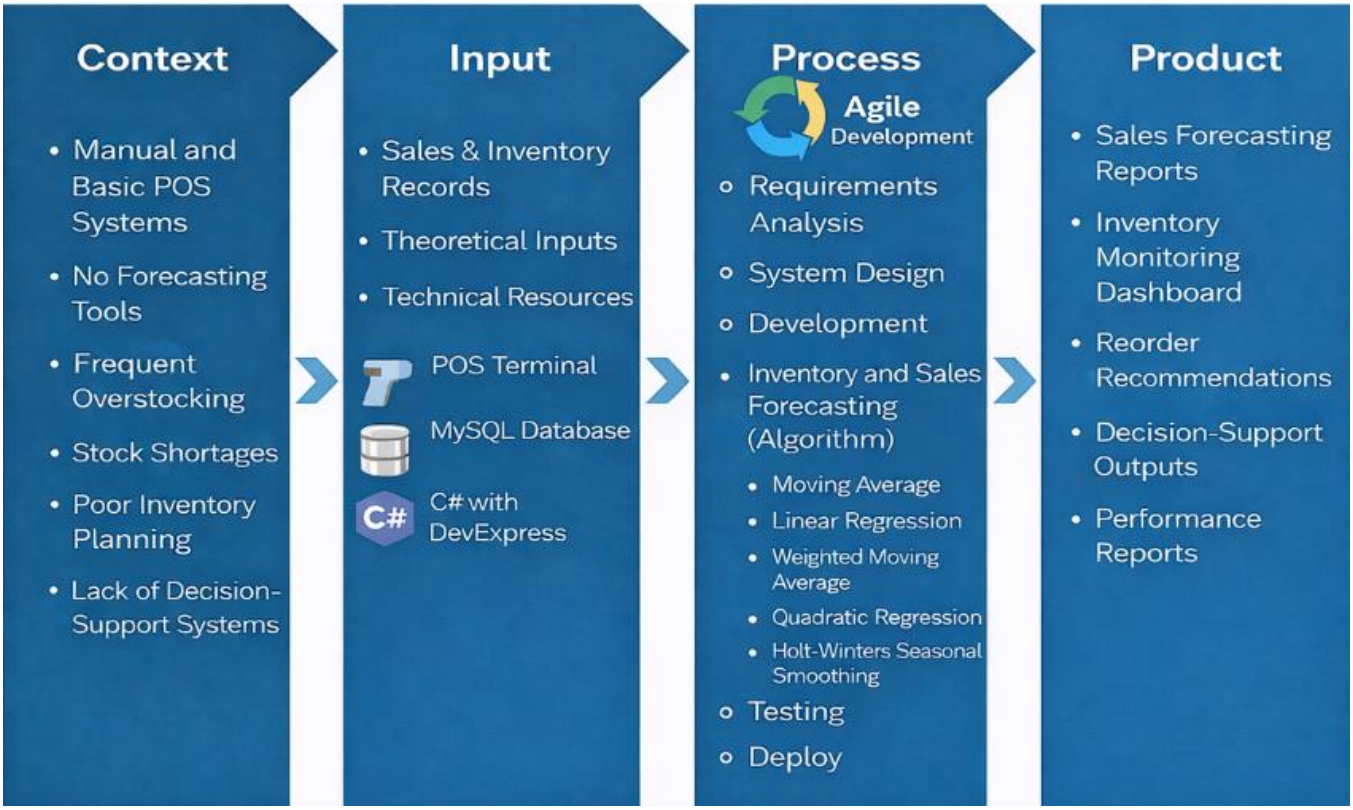

Figure 1: Schema of the Study

The study aimed to develop an Inventory Control through Sales Forecasting system during the calendar year 2025–2026. Specifically, it sought to answer the following questions:

1. What is the current status of the sales and inventory management practices in C3 Mall of Pagadian City?
2. What are the processes involved in the design and development of Inventory Control through Sales Forecasting?
3. What POS-integrated expert system can be developed to assist MSMEs in managing stocks and sales?
4. How do the respondents evaluate the developed Enhancing Inventory Control through Sales Forecasting in terms of the system's:
    4.1.Functionality;
    4.2.Reliability;
    4.3.Usability;
    4.4.Efficiency;
    4.5.Maintainability;
    4.6.Portability; and
    4.7.Security

This will enhance the operational efficiency and decision-making capabilities of Micro, Small, and Medium Enterprises (MSMEs) through the development of a POS-integrated Expert System. By automating routine administrative tasks and delivering intelligent insights—such as sales forecasting and

automated restocking alerts—the system empowers MSME owners to minimize stock-related losses and make accurate, data-driven decisions. Simultaneously, it relieves employees from manual data entry, reducing human error and allowing them to focus on business growth and customer service, which directly benefits consumers by ensuring consistent product availability. Beyond immediate business operations, the research holds broader significance; it equips Local Government Units and the Department of Trade and Industry (DTI) with an evidence-based reference to champion digital adoption, while encouraging the wider local MSME community to embrace technological modernization. Ultimately, this study establishes a strong foundation for future researchers to explore predictive analytics and advanced AI-driven automation in retail environments.

2. Literature Review

Micro, Small, and Medium Enterprises (MSMEs) are recognized as vital drivers of economic development, contributing significantly to employment, industrialization, and resource utilization (Mbugua, Wangoi, Ogada, & Kariuki, 2013). However, these enterprises face substantial barriers to growth, particularly in properly managing market supply and demand (SEPO, 2022). Traditional methods of inventory and sales management, which heavily rely on manual record-keeping and basic Point-of-Sale (POS) systems, are increasingly insufficient to meet dynamic consumer demands and competitive pressures. Consequently, these outdated processes lead to critical operational inefficiencies, including inaccurate reporting, stock shortages, and overstocking. Because effective inventory control and accurate sales forecasting are essential drivers of a company's efficiency and overall profitability, relying on manual processes severely limits an enterprise's potential for sustainable growth (Frye, 2022; Nordmeyer, 2022).

Despite a rapid digital transformation reshaping the global retail industry, a significant technological gap remains for local businesses. While advanced POS platforms have evolved to integrate sales, inventory, and customer relationship management, many MSMEs still utilize traditional transaction-based systems that lack predictive analytics and decision-support capabilities (Santosa & Wirawan, 2019). Research indicates that daily POS transaction data is frequently stored merely for record-keeping and inventory purposes, rather than being utilized to formulate intelligent marketing strategies or derive promotions based on hard evidence (Omorog, 2015). Furthermore, failing to share vital operational and disruption information across the supply chain can lead to high order variability and increased costs, highlighting the need for real-time data utilization (Sarkar & Kumar, 2015). This emphasizes a crucial need for systems that not only record data but also mitigate operational risks by facilitating strategic, data-backed planning.

To address these operational deficiencies, current literature strongly supports the integration of Expert Systems and Decision Support Systems (DSS) within POS platforms. By leveraging techniques like data mining, historical data analysis, and rule-based reasoning, these intelligent systems transform vast amounts of raw sales records into actionable business insights (Omorog, 2015; Sipayung, Cut, & Randy, 2015). This integration empowers MSMEs to accurately forecast demand, optimize restocking schedules, and devise effective promotional activities to minimize potential losses. Studies have shown that utilizing a DSS for inventory management significantly improves operational planning and helps managers make critical decisions regarding stock control (Ferreira et al., 2018). Ultimately, adopting this technology-enhanced, data-driven approach allows local enterprises to transition away from traditional manual processes, ensuring sustainable growth and increased competitiveness in an evolving digital market.

3. Methodology

The study on Enhancing Inventory Control through Sales Forecasting utilized the developmental research method. This method is a systematic approach that involves planning, analyzing, designing, implementing, testing, and maintaining software applications to ensure consistency, functionality, and effectiveness. The developmental research framework is particularly relevant in the field of information and communication technology as it provides a structured process for creating innovative and reliable systems. The developmental research method guided the design and development of a Point-of-Sale (POS)-integrated Expert System aimed at addressing the operational challenges of Micro, Small, and Medium Enterprises (MSMEs). The process included defining system requirements, designing the system architecture, and integrating core components such as the knowledge base, inference engine, and user interface. The product development cycle also incorporated the application of Agile principles, allowing iterative improvements based on user feedback and testing results. To ensure a comprehensive evaluation of the "Enhancing Inventory Control through Sales Forecasting" system, this study utilizes a multi-level assessment involving 47 participants across four distinct categories: IT professionals (n=5, 10.64%), MSME business owners and managers (n=10, 21.28%), cashiers (n=16, 34.04%), and inventory clerks (n=16, 34.04%). This diverse respondent pool guarantees a holistic evaluation from both technical and operational perspectives within the City Commercial Center (C3) of Pagadian City. Using the ISO/IEC 9126 software quality standards, the system is quantitatively assessed for its functionality, reliability, usability, efficiency, maintainability, portability, and security. Simultaneously, management and frontline staff provide critical insights into the system's practical utility, focusing on its ease of integration into existing workflows and its real-world impact on daily sales and inventory operations. By combining technical metrics with user-centric feedback, the study ensures the developed Expert System is not only technically robust but also highly effective and adaptable for day-to-day retail environments.

Respondents	No. of Respondents	%
IT Professional	5	10.64
C3 Mall Business Owners / Managers	10	21.28
Cashiers	16	34.04
Inventory Clerks	16	34.04
Total	**47**	**100**

Table 1. Distribution of Respondents

This study employs a customized, rigorously validated research instrument anchored in the ISO/IEC 9126 software quality standards to evaluate the "Enhancing Inventory Control through Sales Forecasting" system. Adapted from established intelligent Point-of-Sale (POS) research, the tool draws theoretical and structural inspiration from Okofu et al. (2025) and Khan (2020) to comprehensively assess the software across seven key dimensions: functionality, reliability, usability, efficiency, maintainability, portability, and security. To capture both technical and operational perspectives, data is collected from four distinct respondent groups—IT professionals, MSME owners, cashiers, and inventory clerks—and consolidated into structured evaluation tables for clear cross-group comparison and trend identification. The instrument's validity and precision were firmly established through expert reviews and an extensive pilot testing phase. Reliability analyses using the Cronbach's Alpha formula yielded "very good" scores of 0.86 and 0.83 for functional and non-functional aspects, respectively, both comfortably exceeding the standard 0.70 threshold for acceptability (Hulin, Netemeyer, & Cudeck, 2001), alongside an impressive overall pilot

coefficient of 0.90. Ultimately, this multi-faceted evaluation framework guarantees that the collected data is highly trustworthy, ensuring the developed system is not only technically robust but also highly adaptable and effective for the day-to-day operational needs of MSMEs.

Cronbach's Alpha Value	Interpretation
$\alpha \geq 0.90$	Excellent Internal Consistency
$0.80 \leq \alpha < 0.90$	Good Internal Consistency
$0.70 \leq \alpha < 0.80$	Acceptable Internal Consistency
$0.60 \leq \alpha < 0.70$	Questionable Internal Consistency
$0.50 \leq \alpha < 0.60$	Poor Internal Consistency
$\alpha < 0.50$	Unacceptable Internal Consistency

Table 2: Statistical Measure of Internal Consistency and Reliability of Cronbach Alpha

To comprehensively design and evaluate the "Enhancing Inventory Control through Sales Forecasting" system, this study employed a multi-faceted data gathering procedure encompassing document analysis, face-to-face interviews, direct empirical observations, and structured questionnaires. Following formal administrative approval, these instruments were systematically distributed to the respondents to capture critical operational data, user attitudes, and system requirements. Upon retrieval, the raw data was processed using statistical software to draw scientifically significant conclusions through inferential and descriptive statistics. Specifically, frequency counts and percentages were utilized to determine the distribution of respondent groups, identify potential system challenges, and outline expected software features. Furthermore, the weighted mean was computed to accurately gauge respondents' perceptions and rigorously evaluate the overall effectiveness, accuracy, and acceptance of the developed system's functional and non-functional capabilities.

1) Frequency Distribution = n / T * 100%
   Where: n = Number of respondents
   T = Total number of respondents
2) Weighted mean(x) = f (X1 + X2 + …… Xn) n / N
   Where: n = Total numbers of criteria

The development of the proposed system employs the Agile System Development Life Cycle (SDLC) model, an iterative and highly flexible approach that systematically builds upon a foundational version through continuous, user-driven refinements. The cycle initiates with the Planning and Analysis phases, where project objectives, scope, and detailed stakeholder requirements are established to form a clear roadmap. These requirements are then translated during the Design and Implementation phases, where the system's architecture is mapped out and coded using iterative testing and real-time feedback to ensure technical feasibility and prevent major post-development revisions. Following this, the Testing and Integration phase rigorously evaluates the cohesive functionality, performance, and security of all system modules against the initial specifications. Finally, the post-deployment Maintenance phase ensures the system's long-term sustainability and operational efficiency by providing continuous user support, rapid

bug resolution, proactive security monitoring, and progressive feature enhancements driven by ongoing user feedback.

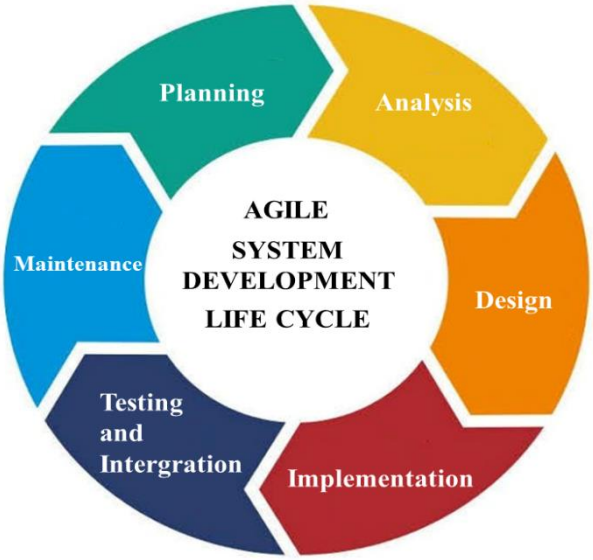

Figure 2: System Development Life Cycle

4. Result and Discussion

Survey results from MSMEs at the City Commercial Center (C3) Mall in Pagadian City highlight severe operational deficiencies in their existing Inventory and Sales Management Systems, reflected by a high overall dissatisfaction mean of 4.48. Respondents frequently reported critical disruptions, including system crashes during transactions (4.6), sluggish processing speeds (4.6), an inability to generate real-time reports (4.6), and consistent failures to update inventory accurately (4.5). Additionally, users noted significant vulnerabilities related to poor interface usability (4.4), inaccurate record-keeping (4.5), a lack of error alerts (4.5), and insecure payment handling (4.3), all of which compound data inconsistencies and financial discrepancies. Ultimately, while these legacy systems remain nominally functional, their pervasive inefficiencies underscore an urgent need to transition to a more advanced, POS-integrated Expert System capable of streamlining daily operations, minimizing system-related losses, and empowering business owners with accurate, data-driven insights.

Current Inventory and Sales Management System used in City Commercial Center (C3) Mall in Pagadian City	MSME's Individual Average Weighted Value
1. How often do you encounter errors or system crashes during sales transactions?	4.6
2. How often does the system process sales and payments slowly or inefficiently?	4.6
3. How often does the system fail to update inventory correctly after each sale?	4.5
4. How often do you experience delays when retrieving stock or sales information?	4.5
5. How often does the system fail to provide real-time reports on stocks and sales?	4.6

6.	How often do you find the system interface confusing or difficult to use?	4.4
7.	How often does the system produce inaccurate or non-transparent sales and inventory records?	4.5
8.	How often do you experience difficulties generating business reports (e.g., stock levels, sales trends, inventory shortages, best-selling products, or daily/weekly sales summaries)?	4.3
9.	How often does the system handle customer payment transactions inaccurately or insecurely?	4.3
10.	How often does the system fail to provide alerts or feedback when incorrect data is entered?	4.5
Mean		**4.48**

Table 3: Current Inventory and Sales Management System Questionnaire

Software Quality Factor	Mean	Descriptive Rating
Functionality	4.50	Excellent
Reliability	4.49	Excellent
Usability	4.61	Excellent
Efficiency	4.53	Excellent
Maintainability	4.37	Excellent
Portability	4.09	Very Satisfactory
Security	4.56	Excellent
Grand Mean	**4.45**	**Highly Acceptable**

Table 4: Software Acceptability

This study successfully developed and evaluated the "Expert System: Stocks and Sales Management" to modernize operations for Micro, Small, and Medium Enterprises (MSMEs) at the City Commercial Center (C3) Mall in Pagadian City. Designed to resolve persistent inefficiencies like manual stock tracking and inaccurate reporting, the platform seamlessly integrates inventory control, sales monitoring, and intelligent forecasting to empower data-driven decision-making. Rigorous evaluation anchored in the ISO/IEC 9126 software quality standards revealed excellent performance across all seven key metrics—functionality, reliability, usability, efficiency, maintainability, portability, and security—exceeding the expectations of business owners, frontline staff, and IT professionals alike. Ultimately, this research holds significant implications for the field of Computer Science, practically demonstrating how the integration of artificial intelligence, forecasting algorithms, and real-time analytics into traditional Point-of-Sale environments can streamline retail workflows, drive digital transformation, and foster sustainable growth for small enterprises.

4.1 Findings

The findings from the study are systematically presented below, structured to directly address the research questions and hypotheses outlined in the study.

1. The current stock and sales management practices of MSMEs in C3 Mall rely heavily on manual recordkeeping and basic POS systems, resulting in frequent delays, errors, and inefficiencies in generating reports and monitoring inventory.
2. The developed system was created using the Agile SDLC, ensuring flexibility, iterative updates, and real-time user feedback throughout the development process.
3. The new system integrates expert reasoning and forecasting algorithms such as Moving Average, Linear Regression, and Holt-Winters methods, which assist MSME owners in predicting demand patterns and preventing overstocking or shortages.
4. The functionality of the system was rated as Excellent, as it effectively performs sales recording, report generation, and data processing with minimal errors.
5. The reliability of the system was rated as Excellent, demonstrating stability and consistency during high-volume transactions and long-term usage.
6. The usability of the system was rated as Excellent, featuring an intuitive and user-friendly interface that allows even non-technical users to operate it with ease.
7. The efficiency of the system was rated as Excellent, showing optimized performance, faster response time, and improved accuracy in managing inventory and sales data.
8. The maintainability of the system was rated as Excellent, as its modular structure allows easy updates and future enhancements without disrupting existing operations.
9. The portability of the system was rated as Very Satisfactory, the system is quite portable. Although there might be minor adjustments required for specific environments, the system can generally be deployed across different platforms with relative ease. It demonstrates good adaptability to varying configurations to MSMEs.
10. The security of the system was rated as Excellent, ensuring data privacy, protection against unauthorized access, and reliability of stored sales and inventory records.
11. The overall system acceptability was rated as Highly Acceptable, confirming that users are satisfied with the system's design, functionality, and contribution to improving business operations.

5. Conclusion and Recommendation

The research undertaken to develop and evaluate the Expert System: Stocks and Sales Management for MSMEs in C3 Mall proves that the system is a highly effective business tool for managing inventory, sales, and forecasting operations. The integration of intelligent algorithms, expert reasoning, and real-time analytics allows business owners to make data-driven decisions that enhance efficiency, accuracy, and profitability. Using the ISO/IEC 9126 evaluation framework, the system demonstrated outstanding performance across all software quality attributes, confirming its reliability, usability, and operational value. The success of this system establishes a strong foundation for MSMEs to transition from manual or basic digital processes toward intelligent, automated solutions that support sustainable growth and competitiveness in a rapidly changing marketplace.

Based on the findings and conclusions, the following key recommendations are proposed:

1. It is recommended that the Expert System: Stocks and Sales Management be implemented among MSMEs within C3 Mall to automate sales reporting, improve inventory tracking, and enhance decision-making through real-time forecasting.

2. Further training and user orientation programs should be conducted to ensure that MSME owners and staff can maximize the analytical and decision-support features of the system.
3. Future researchers are encouraged to enhance the system by incorporating AI-based demand prediction and integration with government databases such as DTI and BIR for easier business compliance.
4. The system can be replicated or adapted for use in other commercial areas or public markets across Zamboanga del Sur to promote digital transformation and technological empowerment among MSMEs.

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