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Assessment of warehouse management performance for operational efficiency in warehouses in Edo state, Nigeria

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Abstract

This study critically assesses operational efficiency in warehouse management performance in a study of selected facilities in Edo State, Nigeria. The study aims to evaluate key performance indicators (KPIs) such as inventory accuracy, space utilization, labour productivity, throughput, equipment usage, and the integration of warehouse management technologies. Using a mixed-method approach comprising field surveys and direct observational audits, the research investigated the interdependencies between these KPIs and their collective influence on cost efficiency, customer satisfaction, and workplace safety. Regression analysis result for influence of inventory accuracy on operational efficiency of warehouse management system showed a high correlation coefficient (R) of 0.9930 revealing 98.7% of variation in operational efficiency suggesting that Inventory accuracy plays a significant role in determining the warehouse operations efficiency, regression analysis of space utilization, warehouse through put and order fulfilment rate in optimizing warehouse performance showed a very strong correlation coefficient (R) of 0.9940 showing a positive relationship with warehouse performance R-Square value of 0.988 suggesting 98.8%. Regression analysis of labour productivity and equipment utilization contribution to cost efficiency in warehouse operations with R-square value of 0.8540 showing 85.4% variation correlation coefficient (R) of 0.924. Regression analysis of technology-enabled warehouse management practices on safety standards, workplace ergonomics and customer satisfaction levels correlation coefficient (R) is 0.970 and R-Square value of 0.941 showing 94.1% of variation in safety, ergonomics and customer satisfaction.

Keywords: Warehouse Management; Operational Efficiency; Key Performance Indicators; Supply Chain; Labor Productivity

1. Introduction

Warehousing is a critical component of supply chain and logistics systems, serving as the central hub for receiving, storing, organizing, and distributing goods. In the past, warehouses were considered passive storage facilities, often treated as cost centers rather than strategic assets. However, in today's dynamic and competitive business environment, the role of warehousing has evolved significantly. It now contributes directly to organizational efficiency, customer satisfaction, and cost reduction. As businesses scale up and operate in more complex and time-sensitive markets, the demand for agile, responsive, and performance-oriented warehouse operations has grown immensely (Adeoye et.al, 2022).

In industrial and maintenance engineering, warehouse performance has become an area of strategic interest due to its direct influence on system efficiency, downtime reduction, production continuity, and overall operational flow. Efficient warehousing ensures that materials, parts, and finished products are available where and when needed. Conversely, poor warehouse practices often lead to disruptions, increased cycle times, inventory discrepancies, and unnecessary

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expenses. Consequently, assessing and improving warehouse performance has become a key concern for engineers, supply chain managers, and decision-makers alike (Al Majali,2023).

Globally, the logistics industry has undergone a digital transformation, with warehousing taking center stage in the optimization of supply chain networks. Organizations are leveraging data, automation, and performance analytics to manage inventory in real time, streamline order fulfilment, reduce lead times, and enhance labour productivity. Concepts such as lean warehousing, just-in-time (JIT) systems, and warehouse automation are increasingly being adopted to ensure precision, agility, and cost-effectiveness. Performance measurement frameworks have also gained traction, enabling firms to track key performance indicators (KPIs) such as inventory turnover, space utilization, order cycle time, throughput, labour efficiency, equipment uptime, and safety compliance (Banerjee et.al,2023).

Despite these global advancements, warehousing in Nigeria remains plagued by several systemic challenges. Many facilities still rely on outdated, manual processes for stock keeping, order handling, and workforce deployment. Warehouses are frequently constrained by inadequate infrastructure, suboptimal layout design, and a lack of standardized performance metrics. The consequences include inventory mismanagement, delayed deliveries, overstocking or stock outs, and inefficient use of labour and space. These inefficiencies not only hinder operational performance but also negatively affect customer service levels and the financial health of the organization (Alabis et al,2023).

The Nigerian logistics and warehousing landscape reflect a combination of rapid demand growth and underdeveloped support systems. As urbanization, e-commerce, and industrial production expand, the pressure on existing warehousing infrastructure continues to rise. Many companies operate warehouses in fragmented or informal settings, lacking the technological infrastructure and managerial expertise required to run efficient operations. This has led to rising operational costs, wastage, and missed opportunities for performance optimization (Bello.A. et.al,2020).

Furthermore, the regulatory and policy framework for warehouse development in Nigeria is still evolving. While there have been initiatives to improve logistics infrastructure, such as inland container depots and industrial parks, the warehousing sector has not received adequate attention in terms of standardization, benchmarking, or capacity-building. As a result, warehouse performance is rarely assessed in a structured or systematic way. Even when organizations collect operational data, it is often unstructured, siloed, or underutilized in decision-making processes.

Another area of concern is the lack of awareness and adoption of performance management tools among local warehouse operators. Globally, businesses now rely on Warehouse Management Systems (WMS), Enterprise Resource Planning (ERP), and mobile tracking technologies to gather real-time data and improve decision-making. However, in Nigeria, these systems are either too expensive, poorly understood, or not tailored to the local business environment. This technology gap further widens the performance disparity between Nigerian warehouses and their global counterparts (Banerjee et.al,2023).

Performance assessment is essential for identifying inefficiencies, benchmarking operations, and implementing continuous improvement strategies. It involves setting clear objectives, selecting relevant KPIs, collecting accurate data, and analysing trends to uncover bottlenecks or areas for improvement. Without such assessments, warehouses operate reactively rather than proactively, leading to stagnation and recurring issues. In a competitive economy where supply chain speed and accuracy are crucial, failure to assess and optimize warehouse performance can result in significant competitive disadvantages (Akinyemi.T. et.al,2021).

Moreover, warehousing performance directly affects broader organizational objectives. For instance, poor inventory accuracy can lead to production delays, unmet customer orders, and revenue losses. Inefficient space utilization can increase the need for external storage, driving up costs. Unproductive labour practices reduce morale, increase turnover, and inflate payroll expenses. A lack of safety and ergonomics can result in workplace injuries and compliance fines. All these issues are magnified in environments where performance is not continuously measured or managed (Choudhury.T. et.al,2023).

The Nigerian context presents a unique research opportunity. While the challenges are numerous, there is also potential for significant improvements through structured performance assessment and the gradual adoption of modern management practices. With increasing awareness of supply chain efficiency and customer service imperatives, organizations are beginning to show interest in performance management as a competitive tool. Government policy, academic research, and industry partnerships can play a critical role in catalysing this transformation by providing knowledge, tools, and training (Government Press, ESMTI,2023).

Edo State, located in southern Nigeria, is a regional hub for industrial and commercial activity. Its warehouses serve a wide range of sectors, including fast-moving consumer goods (FMCG), healthcare supplies, manufacturing inputs, and agricultural products. Given its strategic location and growing economic activity, Edo State presents an ideal environment to examine warehouse management performance in a context that is both locally relevant and reflective of national trends. However, like many other parts of the country, Edo's warehousing ecosystem faces operational inefficiencies due to poor infrastructure, limited technological adoption, and minimal performance tracking (Edo State Ministry of Trade and Investment,2023).

This study seeks to fill an important gap by conducting a structured assessment of warehouse management performance across selected warehouses in Edo State. By focusing on measurable performance indicators such as inventory control, space utilization, labour productivity, and technology integration, the research aims to identify specific operational inefficiencies and propose actionable strategies for improvement. While the study will employ modern tools for data collection and analysis, its primary objective is to evaluate performance within the real-world constraints of the Nigerian environment, offering practical insights for both practitioners and policymakers.

Ultimately, enhancing warehouse performance in Nigeria requires a multi-dimensional approach. It involves not just adopting technology but also improving human resource capabilities, redesigning workflows, and fostering a performance-driven culture. This research will contribute to this broader objective by providing a performance baseline and recommending improvements that align with both global best practices and local realities.

The warehousing sector in Nigeria continues to face performance-related challenges that hinder operational efficiency. Many facilities lack standardized systems for measuring and analyzing performance. Manual processes still dominate warehouse operations, resulting in delayed shipments, stock discrepancies, safety hazards, and high labour costs. Furthermore, decision-making is often reactive due to limited access to real-time data or performance analytics.

There is a noticeable gap in performance assessment frameworks among warehouses in Nigeria. While global standards emphasize data collection, KPI monitoring, and performance benchmarking, most local warehouses operate without such systems in place. This absence of structured assessment tools not only masks inefficiencies but also impairs the organization's ability to plan, forecast, and respond to market demands effectively.

Consequently, there is a pressing need to evaluate existing warehouse management practices, identify performance gaps, and propose methods that can enhance operational outcomes. This study seeks to bridge this gap by providing a structured assessment of warehouse performance, ultimately contributing to more efficient and resilient supply chain systems. The warehousing sector in Nigeria continues to face performance-related challenges that hinder operational efficiency. Many facilities lack standardized systems for measuring and analysing performance. Manual processes still dominate warehouse operations, resulting in delayed shipments, stock discrepancies, safety hazards, and high labour costs. Furthermore, decision-making is often reactive due to limited access to real-time data or performance analytics. This study was geographically limited to Benin City, Edo State, Nigeria, focusing on five selected warehouses operating within the industrial and healthcare sectors. It assessed warehouse management performance using key indicators such as inventory accuracy, space utilization, labour productivity, and technology integration. The operational scope was confined to internal warehouse processes and excluded external logistics elements such as transportation and supplier networks. This study holds substantial significance for policy, practice, and education within Nigeria's warehousing and logistics sector. Firstly, it will contribute to logistics digitization policy by providing localized evidence that can inform the development of national standards, regulatory frameworks, and incentives for technology adoption in warehousing, in alignment with Nigeria's digital economy strategy. Secondly, it will offer practical benefits for small and medium-sized warehouse operators by presenting scalable strategies such as mobile-based inventory systems and modular process improvements that can enhance efficiency even with limited resources. Lastly, this research has strong implications for logistics and supply chain training institutions, as it will outline key performance indicators and process domains that can be integrated into technical curricula, professional development programs, and workforce training modules aimed at bridging critical skills gaps in warehouse operations. This study contributes to both academic and industrial domains. From an academic perspective, it will advance the literature on warehouse performance assessment within the context of industrial and maintenance engineering, particularly in developing countries like Nigeria. It will offer a framework for evaluating operational efficiency using measurable indicators and will encourage further research on logistics optimization. From a practical standpoint, the study will provide warehouse operators, supply chain managers, and policymakers with valuable insights into performance bottlenecks and opportunities for improvement. By highlighting data-driven approaches to performance assessment, the study seeks to support the adoption of efficient warehouse practices that align with global standards and evolving customer demands. This study is justified by the critical need to assess and enhance warehouse management performance in Nigeria, particularly in Edo State, where warehousing operations are often hindered by outdated practices, lack of performance benchmarking, limited technology adoption, and systemic inefficiencies. Despite the growing importance of efficient warehousing in supporting industrial growth, customer satisfaction, and supply chain responsiveness, most local warehouses still lack structured performance assessment frameworks. By focusing on key performance indicators (KPIs) such as inventory accuracy, space utilization, labour productivity, and technology integration, this study aims to provide actionable insights for operational improvement. The findings will help warehouse operators, policymakers, and supply chain managers identify performance gaps and implement strategies aligned with both global best practices and local realities. The research also supports policy development, capacity building, and curriculum advancement in logistics and industrial engineering fields within Nigeria. The definitions of key technical terms and concepts used in the study are:

1.1. Warehouse Management System (WMS)

A Warehouse Management System is a software application designed to support and optimize warehouse operations through the real-time tracking of inventory, storage locations, order fulfilment, and labour allocation. WMS platforms often integrate with broader systems like Enterprise Resource Planning (ERP) and Transportation Management Systems (TMS) to enable end-to-end supply chain visibility. In this study, WMS is examined as a critical tool for enhancing accuracy, throughput, and labour productivity in warehousing operations.

1.2. Inventory Accuracy

Inventory accuracy refers to the degree to which the recorded inventory data in a warehouse management system aligns with the actual physical stock on hand. High inventory accuracy minimizes stock outs, overstocking, and fulfilment errors, thereby supporting efficient operations and customer satisfaction. It is a key performance indicator (KPI) in evaluating warehouse efficiency.

1.3. Throughput

Throughput in warehouse management refers to the total volume of goods that pass through a warehouse within a specific period typically measured in items, cartons, or pallets per hour or day. It reflects the speed and efficiency of processing activities such as receiving, storing, picking, and shipping. High throughput is indicative of optimized workflows and minimal operational delays.

1.4. Key Performance Indicators (KPIs)

KPIs are quantifiable metrics used to evaluate the efficiency and effectiveness of operations within an organization. In warehouse management, KPIs include metrics such as order fulfilment rate, inventory turnover, labour productivity, space utilization, and equipment uptime. These indicators are essential for performance monitoring, benchmarking, and continuous improvement.

1.5. Lean Warehousing

Lean warehousing is a management philosophy derived from lean manufacturing, aimed at reducing waste and increasing value in warehouse operations. It involves practices such as just-in-time (JIT) inventory, standardized workflows, visual management, and continuous improvement (Kaizen). Lean warehousing seeks to eliminate non-value-adding activities to enhance operational efficiency, safety, and customer satisfaction.

1.6. Space Utilization

Space utilization is the measure of how efficiently the available storage area within a warehouse is used. It involves optimizing both vertical and horizontal space to minimize waste and maximize storage density. Effective space utilization leads to better layout planning, increased storage capacity, and faster retrieval times.

1.7. Order Fulfilment Rate

This refers to the percentage of customer orders that are accurately picked, packed, and shipped within the promised time frame. A high order fulfilment rate is a direct reflection of warehouse reliability and a major determinant of customer satisfaction and service quality.

1.8. Labor Productivity

Labour productivity in warehousing measures the output of human workers, typically expressed in terms of units handled, orders fulfilled, or lines picked per labour hour. It is influenced by training, task assignment, ergonomic conditions, and technology use. Higher labour productivity translates to lower operational costs and faster processing times.

1.9. Equipment Utilization

This refers to the degree to which material handling equipment such as forklifts, pallet jacks, and conveyors are effectively used during operations. It considers factors like uptime, task alignment, and idle time. Optimal equipment utilization improves throughput, reduces downtime, and supports cost efficiency.

1.10. Technology Integration

Technology integration refers to the extent to which digital tools and systems such as WMS, barcode/RFID scanning, mobile apps, and IoT devices are embedded into warehouse operations. Effective integration enhances real-time visibility, operational control, and decision-making efficiency.

1.11. Customer Satisfaction

Customer satisfaction in the warehousing context refers to the extent to which warehouse performance, particularly in order accuracy, delivery timeliness, and handling quality meets or exceeds customer expectations. It is a strategic outcome of operational efficiency and is often measured through surveys, complaint tracking, and repeat order rates.

IOT- Internet of Things: A system of interconnected devices (like sensors, machines, or tools) that collect and share real-time data over the internet to improve automation, visibility, and decision-making in operations such as warehouse management.

RFID - Radio Frequency Identification: A wireless technology that uses electromagnetic fields to automatically identify and track tags attached to items, helping warehouses improve inventory accuracy, speed up item scanning, and reduce manual errors.

There is a noticeable gap in performance assessment frameworks among warehouses in Nigeria. While global standards emphasize data collection, Key Performance Index (KPI) monitoring, and performance benchmarking, most local warehouses operate without such systems in place. This absence of structured assessment tools not only masks inefficiencies but also impairs the organization’s ability to plan, forecast, and respond to market demands effectively. Consequently, there is a pressing need to evaluate existing warehouse management practices, identify performance gaps, and propose methods that can enhance operational outcomes. This study seeks to bridge this gap by providing a structured assessment of warehouse performance, ultimately contributing to more efficient and resilient supply chain systems.

Space utilization is a fundamental aspect of warehouse management that directly impacts operational efficiency, cost-effectiveness, and the ability to meet demand. It refers to the efficient use of available warehouse space to store goods while minimizing wasted or underutilized areas. In the context of warehouse operations, space utilization plays a critical role in determining how well the available storage capacity is used and how it aligns with the flow of goods in and out of the facility. Effective space utilization enables warehouses to store more products within the same square footage, reducing costs associated with additional storage space and improving overall throughput. The importance of space utilization has grown significantly with the increasing complexity of modern supply chains and the rising cost of warehouse real estate (Adeoye et.al,2022).

According to a study by Waller and Fawcett (2021), warehouse space represents a significant portion of logistics costs, and optimizing its use is essential for enhancing profitability. The cost of warehouse space varies greatly by location, with prime locations in urban centres commanding high rental rates. As a result, companies must maximize their use of available space to reduce overhead costs. Poor space utilization can lead to congestion, inefficient storage, and the need for larger facilities, all of which can increase operational costs. Consequently, improving space utilization is seen as a critical strategy for enhancing warehouse management and operational efficiency.

Space utilization strategies have evolved over the years, particularly with the adoption of advanced technologies. Traditional warehouse layouts, which primarily relied on fixed racking systems and manual processes, often led to inefficiencies in space utilization. Goods were often stored in large, open spaces with limited organization, leading to wasted space and difficulty in locating products. Over time, however, warehouses began to incorporate more sophisticated storage solutions, such as pallet racking, shelving units, and mezzanine floors, to optimize available space.

These systems allowed for denser storage and better organization, increasing the efficiency of space utilization (Adeoye et.al,2022).

With the advent of Warehouse Management Systems (WMS) and automated storage systems, the ability to track and manage space utilization has become more precise. WMS software allows for real-time monitoring of warehouse operations, helping managers track inventory levels, locate products quickly, and optimize storage. One significant advancement in space utilization has been the introduction of dynamic storage systems, which adjust the placement of goods based on factors such as product demand and storage requirements. According to a study by Li and Zhang (2022), dynamic storage systems have been particularly effective in high-demand industries like FMCG and electronics, where product turnover is rapid, and the need for flexible storage solutions is critical.

Another key development in space utilization has been the use of automated storage and retrieval systems (AS/RS), which are robotic systems designed to transport products within a warehouse. AS/RS systems enable the vertical stacking of goods, reducing the need for wide aisles and allowing for higher-density storage. In a study conducted by Park et al. (2021), AS/RS was shown to increase space utilization by up to 50% in high-volume warehouses. These systems use algorithms to determine the most efficient way to store and retrieve goods, ensuring that space is used as effectively as possible. Furthermore, AS/RS systems reduce human labour requirements and improve throughput, contributing to overall warehouse efficiency.

The layout of the warehouse itself plays a significant role in space utilization. Efficient warehouse layouts prioritize the flow of goods and minimize unnecessary movement. The most common layouts include the U-shaped, I-shaped, and L-shaped designs. In the U-shaped layout, goods flow in a continuous loop, allowing for efficient product handling. The I-shaped layout, on the other hand, focuses on linear flows, where goods are received on one side and shipped out from the other. The L-shaped layout is often used when space constraints require a more compact design. Choosing the optimal layout depends on factors such as the type of goods stored, the volume of goods, and the frequency of inventory turnover. Proper layout design can lead to more efficient use of space and faster processing times. Technology has also played a significant role in improving space utilization by enabling more precise and data-driven decision-making. The integration of Geographic Information Systems (GIS) and sensors into warehouse operations has enhanced the ability to monitor space usage in real time. For example, companies like Amazon have implemented AI-powered systems that track the utilization of individual shelves, automatically adjusting the storage configuration based on product demand and available space (Guan et.al,2020).

According to an article by Smith et al. (2022), these systems have led to more effective space planning, ensuring that every inch of storage is optimized. The ability to track space usage in real-time helps warehouse managers identify underutilized areas and implement corrective actions promptly. However, achieving optimal space utilization in warehouses is not without challenges, especially in emerging markets like Nigeria. A study by Akinyemi et al. (2023) highlighted that many warehouses in Nigeria are still operating with outdated storage systems, leading to inefficiencies in space utilization. In particular, the lack of proper racking systems and poor warehouse layout planning results in wasted space and difficulties in inventory management. Additionally, inadequate training for warehouse staff and limited investment in modern technologies further exacerbate the problem. While some companies in Nigeria are beginning to adopt WMS and automated storage solutions, the pace of adoption remains slow due to high upfront costs and limited access to advanced technologies. Nevertheless, there have been success stories in the country, with a few large FMCG companies implementing more modern storage solutions to increase their warehouse capacity and reduce operational costs.

In developed markets, companies have increasingly turned to vertical storage solutions, such as high-bay racking systems, which allow for the use of otherwise wasted vertical space. High-bay racking, often combined with AS/RS, enables warehouses to store goods in a way that maximizes both horizontal and vertical space. For instance, in a study by Johnson and Roberts (2023), it was found that high-bay racking systems combined with automated retrieval mechanisms can increase storage capacity by up to 70%, significantly reducing the need for additional warehouse space. This has been particularly beneficial in industries with high inventory turnover, such as the retail and e-commerce sectors, where fast and efficient retrieval of goods is critical.

Additionally, the growth of e-commerce has increased the demand for warehouses to be flexible and adaptive to changing inventory levels. E-commerce companies often require rapid fulfilment of orders, which can place a strain on existing storage capacities. To address this challenge, many warehouses have adopted multi-tier shelving systems and flow racks, which allow goods to be stored efficiently while still being easily accessible for picking and packing. According to a study by Hernandez et al. (2022), flow racks have been particularly effective in improving space utilization in e-commerce warehouses by ensuring that items are rotated based on their demand, which helps to optimize storage space and reduce the risk of stockouts.

Sustainability is also becoming a key consideration in warehouse design and space utilization. Companies are increasingly looking for ways to optimize space while also reducing their environmental impact. Strategies such as using energy-efficient lighting, optimizing storage density to reduce the need for additional warehouses, and using recycled materials for shelving and racking systems are gaining traction. These sustainable practices not only improve space utilization but also align with broader corporate social responsibility (CSR) goals (Johnson et.al,2021).

1.11.1. Space utilization

Is a critical factor in warehouse management that directly affects operational efficiency, cost management, and the ability to meet customer demands. Technological advancements, such as WMS, AS/RS, and AI-powered systems, have significantly improved space utilization by providing real-time data and enabling more flexible storage solutions. While challenges remain, particularly in developing markets, the ongoing adoption of advanced technologies and storage systems holds great potential for optimizing space utilization. For warehouses to remain competitive and efficient, they must continue to focus on maximizing the use of available space, employing smart storage solutions, and embracing the latest innovations in warehouse management (Guan et.al,2020).

1.11.2. Warehouse Throughput

Warehouse throughput refers to the rate at which goods move through a warehouse, encompassing receiving, storage, picking, packing, and shipping activities. It is often measured in units, pallets, or orders processed per unit of time hour, day, or shift and it directly reflects the warehouse's processing capacity and operational speed. High throughput is a strong indicator of warehouse efficiency, as it shows how quickly and effectively a facility can handle the inflow and outflow of goods. In modern supply chains, where speed and responsiveness are increasingly critical, throughput has emerged as one of the most important performance indicators for warehousing operations (Oladejo et.al,2023).

1.11.3. Labor Productivity

Labour productivity in warehouse management refers to the efficiency and output of human resources in performing warehousing tasks such as receiving, storing, picking, packing, and shipping goods. It is typically measured by the number of orders processed, items picked, or units moved per employee per hour or shift. Labour remains one of the most significant cost drivers in warehousing operations, particularly in developing economies where automation is minimal. Therefore, improving labour productivity is not only essential for operational efficiency but also directly impacts cost reduction, service delivery, and overall warehouse performance (Olabode et.al,2020).

1.11.4. Safety and Ergonomics

Safety and ergonomics are foundational pillars in warehouse management, influencing not only the wellbeing of workers but also overall operational efficiency and organizational reputation. A warehouse environment is often dynamic, involving the movement of heavy loads, use of machinery, high shelving systems, and repetitive physical activities. When safety and ergonomic principles are overlooked, the consequences can be severe ranging from worker injuries and equipment damage to costly downtime and legal liabilities. Therefore, performance measurement in warehousing increasingly integrates safety and ergonomics as critical dimensions of operational success (Wang et.al,2021).

Globally, the warehousing industry has one of the highest rates of occupational injuries, particularly in environments where safety protocols are poorly implemented. According to the U.S. Bureau of Labor Statistics (2022), warehouses reported an incidence rate of 4.8 nonfatal injuries per 100 full-time workers well above the average for private industry. These statistics highlight the significance of maintaining safe operations. Bartholdi and Hackman (2019) underscore that a well-designed safety culture does more than prevent accidents; it enhances employee morale, reduces absenteeism, and fosters long-term productivity. In their case study of three North American distribution centres, warehouses with ISO 45001-certified safety management systems reported 30% fewer work stoppages compared to non-certified facilities.

In Nigeria, the state of warehouse safety remains a pressing concern. Informal practices, lack of regulatory enforcement, and insufficient training contribute to poor safety outcomes. Akinwale and Olubunmi (2021) conducted a cross-sectional analysis of warehouses in Lagos and Edo States and found that only 22% of the surveyed facilities had clearly marked emergency exits, functioning fire extinguishers, and up-to-date safety signage. Furthermore, the researchers observed a disturbing trend where safety incidents were underreported due to fear of disciplinary action or job loss. This culture of silence significantly hampers the ability to track and manage safety-related performance.

2. Materials and methods

2.1. Method of Data Collection

The main method of data collection was a cross-sectional survey using a self-administered structured questionnaire. This method is suitable for descriptive and correlational research, particularly when the goal is to gather uniform data across multiple respondents on specific, predefined variables (Creswell, 2014; Zikmund et al., 2013).

The questionnaire was administered in both digital (Google Forms) and paper-based formats, depending on the accessibility and preferences of each respondent. Respondents were given clear instructions and a brief explanation of the purpose of the study. Participation was entirely voluntary, and confidentiality was assured.

The survey covered the following thematic areas

- Demographic data (age, gender, role, industry);
- Warehouse performance indicators (inventory accuracy, space utilization, order fulfilment, etc.);
- Operational practices (technology use, safety measures, layout design);
- Perceived performance outcomes (cost efficiency, customer satisfaction).

The data collection process took place over a six-week period, during which follow-up visits and reminders were used to maximize response rates. A total of 213 completed responses were collected, cleaned, and validated for analysis.

A descriptive survey design was used to capture the current state of warehouse performance across multiple dimensions such as inventory accuracy, space utilization, labour productivity, equipment usage, and order fulfilment. This approach enables the researcher to gather structured data from a relatively large population at a single point in time, providing a snapshot of prevailing operational practices and their outcomes (Kumar, 2011).

In addition to describing the phenomena, the study employed a correlational design to determine the strength and direction of relationships between the independent variables (KPIs) and dependent variables (such as cost efficiency and customer satisfaction). This was essential in empirically testing the hypotheses derived from the conceptual and theoretical frameworks, particularly those grounded in the Resource-Based View (Barney, 1991), Systems Theory (von Bertalanffy, 1968), and the Performance Prism (Neely et al., 2002). The correlational approach also allows for the identification of statistically significant associations without manipulating any of the variables, which aligns with the non-experimental nature of this research.

The use of a survey instrument (questionnaire) was used for efficient collection of standardized data from respondents occupying different roles within the warehousing operations of selected firms. This approach enhanced the comparability of responses and facilitates statistical analysis. The combination of descriptive and correlational survey designs provides a robust methodological framework for investigating warehouse performance. It supports both the documentation of existing practices and the analysis of functional relationships between variables, thereby contributing to evidence-based conclusions and practical recommendations.

2.2. Research Instruments

The research instrument used for this study was a structured, self-administered questionnaire, designed to collect quantitative data on key dimensions of warehouse operational efficiency. The instrument was carefully developed to align with the study's research objectives, theoretical framework, and performance indicators, ensuring both relevance and rigor in the data collection process.

2.2.1. Structure and Design of the Questionnaire

The questionnaire consisted of three main sections, each tailored to capture specific categories of information:

Section A: Demographic Information

This section gathered background data on respondents, such as gender, age, job role, years of experience, type of warehouse, and industry sector. These variables help contextualize the findings and allow for subgroup analysis.

Section B: Operational Key Performance Indicators (KPIs)

This section contained items measuring the independent variables of the study. It was divided into subsections, each representing a specific KPI:

- Inventory Accuracy
- Space Utilization
- Order Fulfilment Rate
- Warehouse Throughput
- Labor Productivity
- Equipment Utilization
- Safety and Ergonomics
- Technology Integration

Respondents rated their organization's performance on a 5-point Likert scale (ranging from "Strongly Disagree" to "Strongly Agree") for each statement associated with these KPIs. The statements were adapted from validated instruments in prior logistics and operations studies (Bartholdi and Hackman, 2019; Zhang and Luo, 2021).

Section C: Performance Outcomes

This section assessed the dependent variables: cost efficiency and customer satisfaction. Respondents were asked to indicate the extent to which various operational practices influenced cost control, service quality, and customer feedback. These items were designed based on frameworks like the Balanced Scorecard (Kaplan and Norton, 1996) and the Performance Prism (Neely et al., 2002), which link internal process excellence to strategic outcomes.

2.3. Instrument Development Process

The questionnaire was developed after a comprehensive review of relevant academic literature, warehousing standards and similar empirical studies. The initial draft was peer-reviewed by two academic experts in logistics and supply chain management, and piloted with 10 warehouse professionals in Edo State to evaluate clarity, relevance, and timing.

Revisions were made based on feedback from the pilot study to ensure the instrument was both valid and user-friendly. Specific attention was paid to avoiding ambiguity, maintaining a neutral tone, and covering all relevant performance domains.

2.4. Reliability of the Instrument

Reliability refers to the consistency and stability of the measurements obtained from an instrument across time and different conditions (Zikmund et al., 2013). In this study, reliability was assessed using Cronbach's alpha coefficient (α), a statistical measure of internal consistency.

A pilot study was conducted involving 10 respondents drawn from warehousing facilities not included in the main sample. Responses were entered into SPSS Version 27, and the reliability coefficients for each section of the instrument were calculated.

2.5. Cronbach's Alpha Coefficient

Cronbach's alpha (α) is a statistical tool used to assess internal consistency, indicating how well a group of items measures the same underlying concept. It serves as an indicator of the reliability of a scale.

Formula for Cronbach's Alpha

The formula for Cronbach's Alpha is

$$\alpha = \frac{K}{K - 1}\left(\frac{\sum_{i=1}^{K} \sigma_{Y_i}^2}{\sigma_X^2}\right)$$

Were

- α = Cronbach's alpha coefficient
- K = Number of items
- $\sigma^2_{Y_i}$ = Variance of item i
- σ^2_X = Variance of the total score (sum of all items)
- $\sum_{i=1}^{K} \sigma^2_{Y_i}$i = Sum of the variances of all individual items

Table 1 Interpretation of Cronbach's Alpha

Cronbach's Alpha (α)	**Interpretation**
≥ 0.90	Excellent reliability
0.80 – 0.89	Good reliability
0.70 – 0.79	Acceptable reliability
0.60 – 0.69	Questionable reliability
0.50 – 0.59	Poor reliability
< 0.50	Unacceptable reliability

Inventory Accuracy: α = 0. 9820

2.6. Operational Data

2.6.1. Inventory Accuracy

Table 2 Operational Data 1

Case Processing Summary 1			
		N	%
Cases	Valid	213	100.0
	Excluded	0	.0
	Total	213	100.0
a. Listwise deletion based on all variables in the procedure.			

Table 3 Reliability Statistics 1

Reliability Statistics 1	
Cronbach's Alpha	N of Items
0.9820	5

Space Utilization, Warehouse Throughput, and Order Fulfilment: α = 0.9760

2.7. Space utilization, warehouse throughput and order fulfillment.

Table 4 Operational Data 2

Case Processing Summary 2			
		N	%
Cases	Valid	213	100.0
	Excluded	0	.0

	Total	213	100.0
a. Listwise deletion based on all variables in the procedure.			

Table 5 Reliability Statistics 2

Reliability Statistics 2	
Cronbach's Alpha	N of Items
0.9760	5

Labor Productivity and Equipment Utilization: α = 0. 9790

2.8. Labour productivity and equipment utilization

Table 6 Operational Data 3

Case Processing Summary 3			
		N	%
Cases	Valid	213	100.0
	Excluded	0	.0
	Total	213	100.0
a. Listwise deletion based on all variables in the procedure.			

Table 7 Reliability Statistics 3

Reliability Statistics 3	
Cronbach's Alpha	N of Items
0.9790	5

Technology-Enabled Warehouse Practices: α = 0. 9650

2.9. Technology enabled warehouse practice.

Table 8 Operational Data 4

Case Processing Summary 4			
		N	%
Cases	Valid	213	100.0
	Excluded	0	.0
	Total	213	100.0
a. Listwise deletion based on all variables in the procedure.			

Table 9 Reliability Statistics 4

Reliability Statistics 4	
Cronbach's Alpha	N of Items
0.9650	5

Operational Efficiency in Warehouse Management: α = 0. 9850

2.10. Operational efficiency in warehouse

Table 10 Operational Data 5

Case Processing Summary 5			
		N	%
Cases	Valid	213	100.0
	Excluded	0	.0
	Total	213	100.0
a. Listwise deletion based on all variables in the procedure.			
Reliability Statistics			
Cronbach's Alpha	N of Items		
0.9850	5		

All values were above the commonly accepted threshold of 0.70, indicating that the instrument had high internal consistency (Nunnally and Bernstein, 1994).

The results

- Inventory Accuracy: α = 0. 9820
- Space Utilization, Warehouse Throughput, and Order Fulfilment: α = 0.9760
- Labour Productivity and Equipment Utilization: α = 0. 9790
- Technology-Enabled Warehouse Practices: α = 0. 9650
- Operational Efficiency in Warehouse Management: α = 0. 9850

These results confirmed that the instrument was both reliable and valid, and therefore suitable for the main data collection and analysis. Steps were also taken to minimize ambiguity, simplify language, and ensure uniformity across different formats (print and digital).

2.11. Multiple Regression Analysis

Multiple regression models were used to examine the predictive power of operational variables on warehouse performance outcomes. For instance, the model tested how well variables like technology integration, order fulfilment rate, and space utilization jointly explain variations in cost efficiency.

The general regression model applied was

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta n \quad + \varepsilon$$

Were

- Y = dependent variable (e.g., cost efficiency or customer satisfaction)
- $X_1 \ldots X_n$ = independent variables (e.g., KPIs)
- β_0 = intercept
- β1…βn = regression coefficients
- ε = error term

2.11.1. Analysis of Variance (ANOVA)

ANOVA was used to test whether mean scores of performance outcomes differ significantly across categories such as industry type, job role, or warehouse size. This technique helped identify structural or contextual factors that might influence operational performance.

2.11.2. Justification for Analytical Tools

The combination of descriptive and inferential statistics ensures a comprehensive analysis that is both exploratory and explanatory. It allows the researcher to

- Describe operational patterns;
- Establish statistically significant relationships;
- Predict performance outcomes based on independent variables.

These methods are widely used in logistics and operations research for assessing performance and identifying improvement levers (Neely et al., 2002; Zikmund et al., 2013; Creswell, 2014).

2.12. Model Summary

2.12.1. Demographic Data

Tables 11 to Table 15 summarized the demographic characteristics of the respondents, including gender, age, educational qualification, job role, and years of experience. This information provided context for understanding the workforce profile and supports the interpretation of the study's findings.

Table 11 Demographic characteristics of Gender

		Frequency	Percent	Cumulative Percent
Valid	Female	87	40.8	40.8
	Male	126	59.2	100.0
	Total	213	100.0	

Source: Author's compilation (SPSS 27)

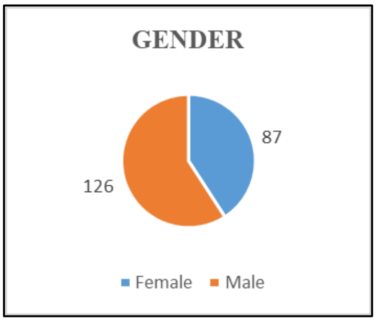

Figure 1 Gender diversity.

However, the presence of a significant number of female respondents also points to increasing gender diversity in the sector.

Table 11 Demographic characteristics of Age

		Frequency	Percent	Cumulative Percent
Valid	18–25	35	16.4	16.4
	26–35	93	43.7	60.1
	36–45	51	23.9	84.0
	46 and above	34	16.0	100.0
	Total	**213**	**100.0**	

Source: Author's compilation (SPSS 27)

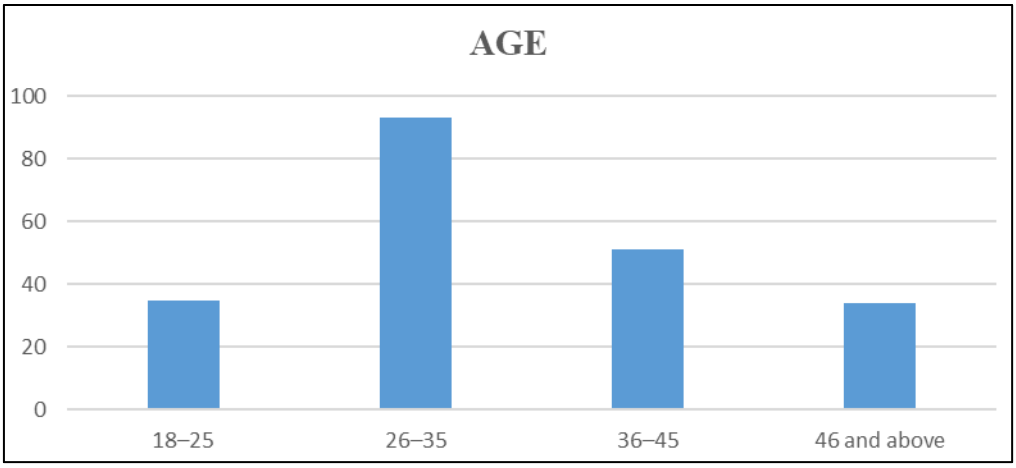

Figure 1 Age distribution of respondents

Table 12 displays the age distribution of respondents. The majority, 43.7% (93 respondents), fall within the 26–35 age group. This is followed by 239% (51 respondents) aged 36–45, while those aged 18–25 and 46 and above account for 16.4% (35 respondents) and 16.0% (34 respondents) respectively. The data suggests that most participants are in their active working years, particularly between the ages of 26 and 45, which may reflect the experience and physical requirements of the roles involved.

Table 12 Educational Qualification

		Frequency	Percent	Cumulative Percent
Valid	HND/B.Sc.	107	50.2	50.2
	M.Sc. and above	32	15.0	65.3
	OND	54	25.4	90.6
	SSCE	20	9.4	100.0
	Total	213	100.0	

Source: Author's compilation (SPSS 27)

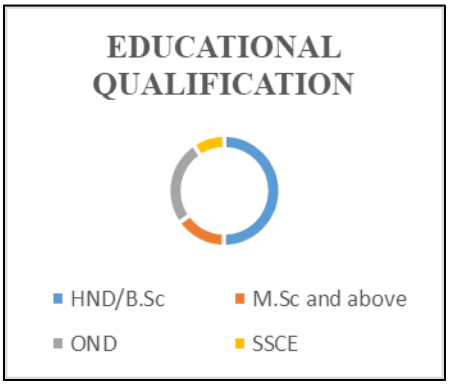

Figure 3 Distribution of respondents on educational qualification.

Table 13 shows that the majority of respondents, 50.2% (107 individuals), hold an HND or B.Sc. qualification. This is followed by 25.4% (54 respondents) with OND, and 15.0% (32 respondents) with M.Sc. or higher degrees. A smaller portion, 9.4% (20 respondents), possess SSCE qualifications. The data indicates that most participants have attained tertiary education, suggesting that roles in the sector may require a certain level of academic or technical knowledge.

Table 13 Job Role

		Frequency	Percent	Cumulative Percent
Valid	Inventory Officer	50	23.5	23.5
	Logistics Officer	53	24.9	48.4
	Storekeeper	78	36.6	85.0
	Warehouse Manager	32	15.0	100.0
	Total	213	100.0	

Source: Author's compilation (SPSS 27)

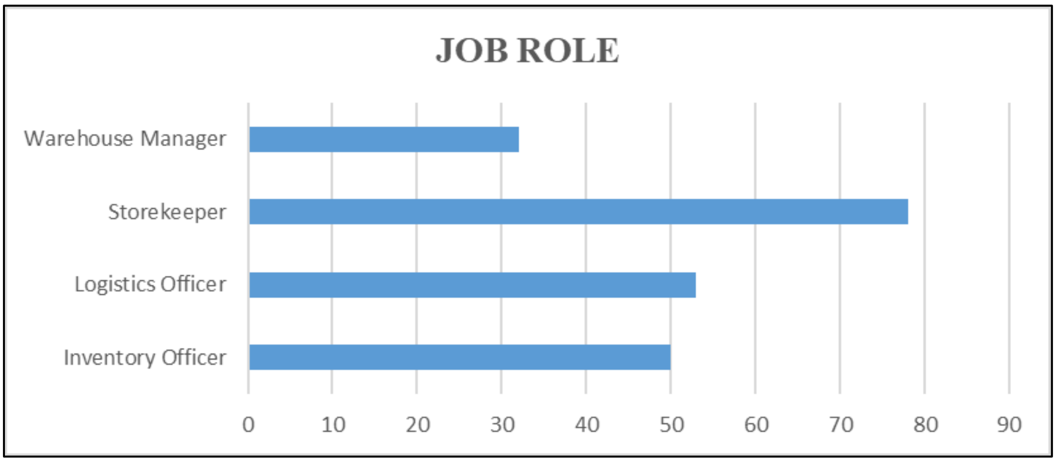

Figure 2 Job role distribution of respondents

Table 14 shows that the largest group of respondents are storekeepers, accounting for 36.6% (78 respondents). Logistics officers follow with 24.9% (53 respondents), while inventory officers represent 23.5% (50 respondents). Warehouse managers make up the smallest group at 15.0% (32 respondents). This distribution indicates that most participants occupy operational roles, with fewer in managerial positions, reflecting a workforce primarily focused on day-to-day warehouse activities.

Table 14 Years of Experience in Warehouse Operations

		Frequency	Percent	Cumulative Percent
Valid	1–3 years	43	20.2	20.2
	4–6 years	80	37.6	57.7
	Above 6 years	53	24.9	82.6
	Less than 1 year	37	17.4	100.0
	Total	213	100.0	

Source: Author's compilation (SPSS 27)

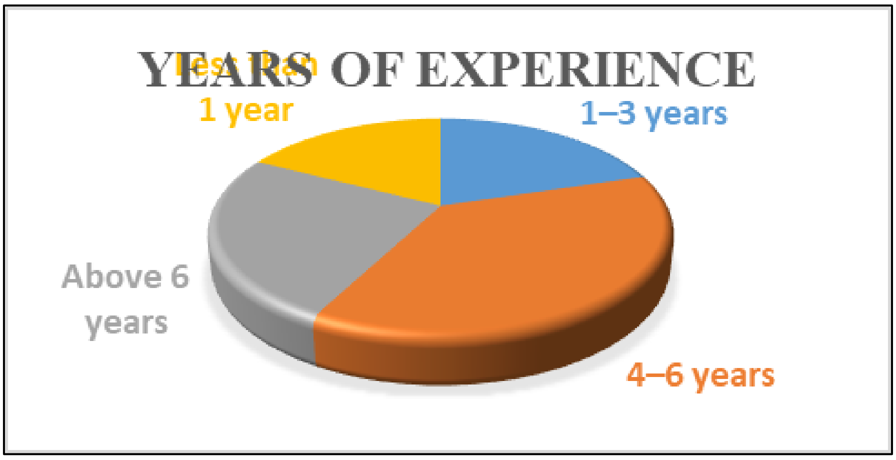

Figure 3 Years of Experience

Table 15 presents the distribution of respondents based on their years of experience in warehouse operations. The largest group, comprising 37.6% (80 respondents), has between 4–6 years of experience. This is followed by 24.9% (53 respondents) with over 6 years of experience, and 20.2% (43 respondents) with 1–3 years. Those with less than 1 year of experience make up the smallest group at 17.4% (37 respondents). The data suggests that most respondents have moderate to extensive experience, which may contribute to a deeper understanding of operational processes and challenges in warehouse management.

To examine the influence of inventory accuracy on the operational efficiency of warehouse management systems.

Table 15 Regression Analysis Table

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.9930[a]	0.9870	0.9860	0.109	1.643
a. Predictors: (Constant), B5. Accurate inventory data supports timely order fulfilment., B1. Inventory records in this warehouse are regularly updated., B4. Real-time inventory tracking helps prevent stockouts., B2. Errors in inventory count are rare due to strong internal controls., B3. Inventory audits are conducted frequently to maintain accuracy.					
b. Dependent Variable: F1. Warehouse operations are completed within planned timelines.					

Source: Author's compilation (SPSS 27)

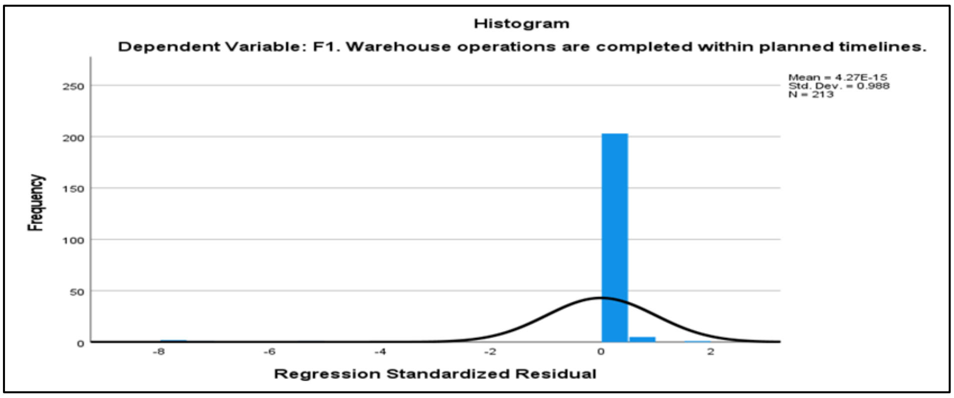

Figure 4 Histogram of the Dependent Variable

Table 16 presents the regression analysis used to examine the influence of inventory accuracy on the operational efficiency of warehouse management systems. The model shows a very high correlation coefficient (R) of 0.993, indicating a strong positive relationship between inventory accuracy and operational efficiency. Furthermore, the R

Square value of 0.987 reveals that approximately 98.7% of the variation in operational efficiency can be explained by changes in inventory accuracy. This suggests that inventory accuracy plays a significant role in determining how efficiently warehouse operations are conducted.

The Adjusted R Square value of 0.986 further confirms the model's strength and reliability, indicating minimal difference after adjusting for the number of predictors. The standard error of the estimate is 0.109, suggesting a low level of variability in the prediction errors, which implies a good model fit. Additionally, the Durbin-Watson statistic of 1.643 falls within the acceptable range, indicating that there is no serious autocorrelation in the residuals.

Overall, the regression results provide strong statistical evidence that inventory accuracy is a critical factor influencing the operational efficiency of warehouse management in the study area. Accurate inventory systems likely lead to better tracking, reduced stock discrepancies, and more efficient warehouse processes.

Table 16 Anova Table

Analysis of Variance (ANOVA)						
Model		**Sum of Squares**	**df**	**Mean Square**	**F value**	**Sig.**
1	Regression	182.300	5	36.460	3056.021	.000[b]
	Residual	2.470	207	.012		
	Total	184.770	212			
a. Dependent Variable: F1. Warehouse operations are completed within planned timelines.						
b. Predictors: (Constant), B5. Accurate inventory data supports timely order fulfilment., B1. Inventory records in this warehouse are regularly updated., B4. Real-time inventory tracking helps prevent stockouts., B2. Errors in inventory count are rare due to strong internal controls., B3. Inventory audits are conducted frequently to maintain accuracy.						

Source: Author's compilation (SPSS 27)

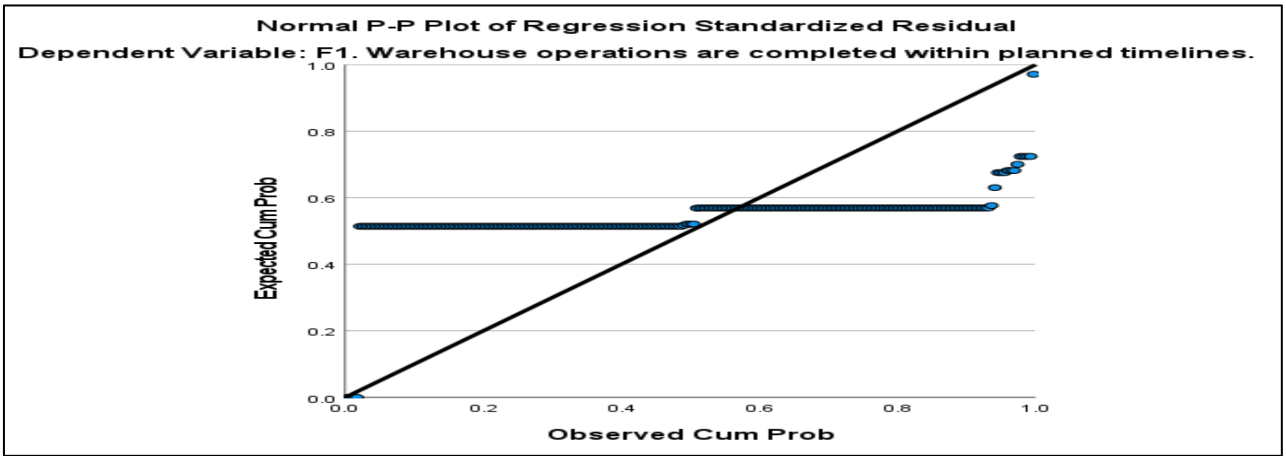

Figure 5 Normal P-P plot of Regression Standardized Residual

Table 17 shows that the model is statistically significant, with an F-value of 3056.021 and a significance level (p-value) of 0.000. This indicates a strong relationship between inventory accuracy and operational efficiency. The high sum of squares value (182.300) compared to the residual (2.470) further confirms that inventory accuracy significantly explains variations in operational efficiency within warehouse management systems.

To analyses the relationship between space utilization, warehouse throughput, and order fulfilment rate in optimizing warehouse performance.

Table 17 Regression Analysis Table

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.994[a]	.988	.987	.097	1.487
a. Predictors: (Constant), C5. Throughput performance is regularly tracked and improved., C2. High throughput levels are achieved with minimal delay., C1. Our warehouse layout supports effective space utilization., C4. Congestion or poor space design leads to delays in order picking., C3. Effective space use positively impacts our ability to fulfil orders fast.					
b. Dependent Variable: F2. Operating costs are consistently monitored and controlled.					

Source: Author's compilation (SPSS 27)

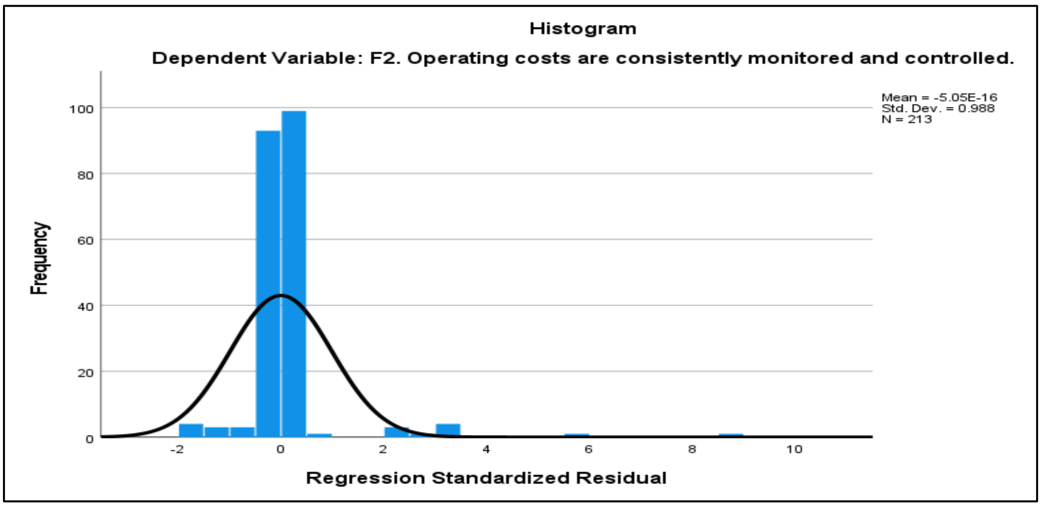

Figure 6 Histogram of the Dependent variable

Table 18 presents the regression analysis used to evaluate the relationship between space utilization, warehouse throughput, and order fulfilment rate in optimizing warehouse performance. The model shows a very strong correlation coefficient (R) of 0.994, indicating a near-perfect positive relationship between the combined independent variables and warehouse performance. The R Square value of 0.988 suggests that 98.8% of the variation in warehouse performance can be explained by changes in space utilization, throughput, and order fulfilment rate.

The Adjusted R Square, which accounts for the number of predictors, is slightly lower at 0.987 but still confirms the model's high level of accuracy and consistency. The standard error of the estimate is 0.097, indicating minimal error and a strong model fit. The Durbin-Watson statistic is 1.487, which is close to the ideal value of 2, suggesting that there is no significant autocorrelation in the residuals.

Overall, the results show that space utilization, warehouse throughput, and order fulfilment rate collectively have a strong and positive influence on warehouse performance. Efficient use of space, high processing capacity, and timely order fulfilment significantly contribute to optimizing operational outcomes.

Table 18 Anova Table

Anova						
Model		Sum of Squares	do	Mean Square	F	Sig.
1	Regression	160.049	5	32.010	3428.519	.000[b]
	Residual	1.933	207	.009		
	Total	161.981	212			

a. Dependent Variable: F2. Operating costs are consistently monitored and controlled.
b. Predictors: (Constant), C5. Throughput performance is regularly tracked and improved., C2. High throughput levels are achieved with minimal delay., C1. Our warehouse layout supports effective space utilization., C4. Congestion or poor space design leads to delays in order picking., C3. Effective space use positively impacts our ability to fulfil orders fast.

Source: Author's compilation (SPSS 27)

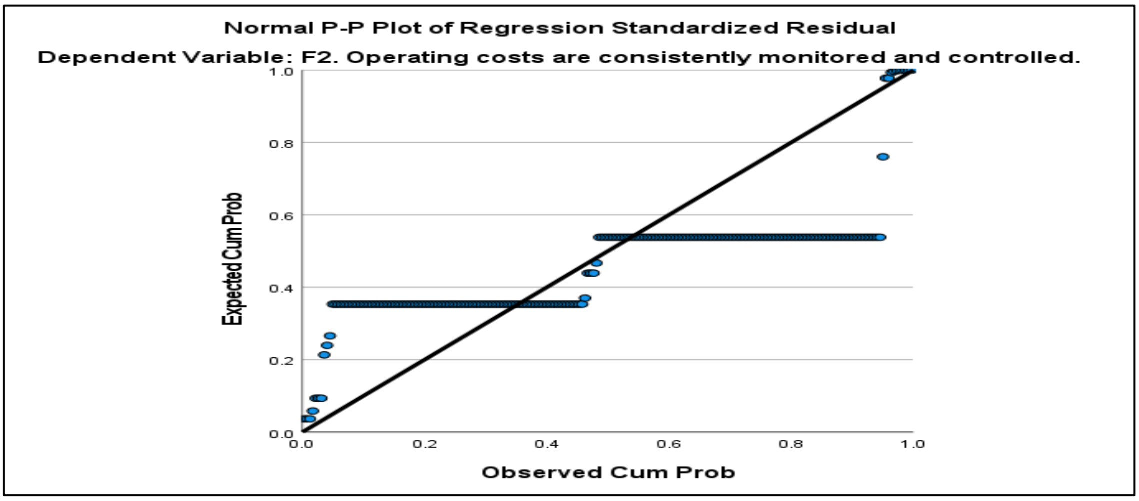

Figure 7 Normal P-P Plot of Regression Standardized Residual

Table 19 shows a statistically significant result with an F-value of 3428.519 and a p-value of 0.000, indicating a strong relationship between space utilization, warehouse throughput, and order fulfilment rate in optimizing warehouse performance. The high sum of squares attributed to the model suggests that these factors collectively explain most of the variation in performance outcomes.

To assess the extent to which labor productivity and equipment utilization contribute to cost efficiency in warehouse operations.

Table 20 Regression Analysis Table

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.924[a]	.854	.850	.352	1.638
a. Predictors: (Constant), D5. Efficient use of labour and equipment reduces operating costs., D1. Staff productivity levels are measured regularly in our warehouse., D2. Workers receive adequate training to perform efficiently., D3. Equipment such as forklifts and conveyors are used effectively., D4. Regular maintenance reduces equipment breakdown during operations.					
b. Dependent Variable: F3. Customer orders are delivered accurately and on schedule.					

Source: Author's compilation (SPSS 27)

Table 20 presents the regression analysis examining how labour productivity and equipment utilization contribute to cost efficiency in warehouse operations. The correlation coefficient (R) is 0.924, indicating a strong positive relationship between the variables. The R Square value of 0.854 shows that 85.4% of the variation in cost efficiency can be explained by changes in labour productivity and equipment utilization.

The Adjusted R Square is 0.850, confirming the model's consistency even after accounting for the number of predictors. The standard error of the estimate is 0.352, which reflects a moderate level of prediction error. Additionally, the Durbin-Watson statistic of 1.638 suggests that the residuals are independent and that there is no significant autocorrelation.

Overall, the results indicate that both labour productivity and equipment utilization significantly influence cost efficiency, suggesting that improved human and equipment performance can lead to more cost-effective warehouse operations.

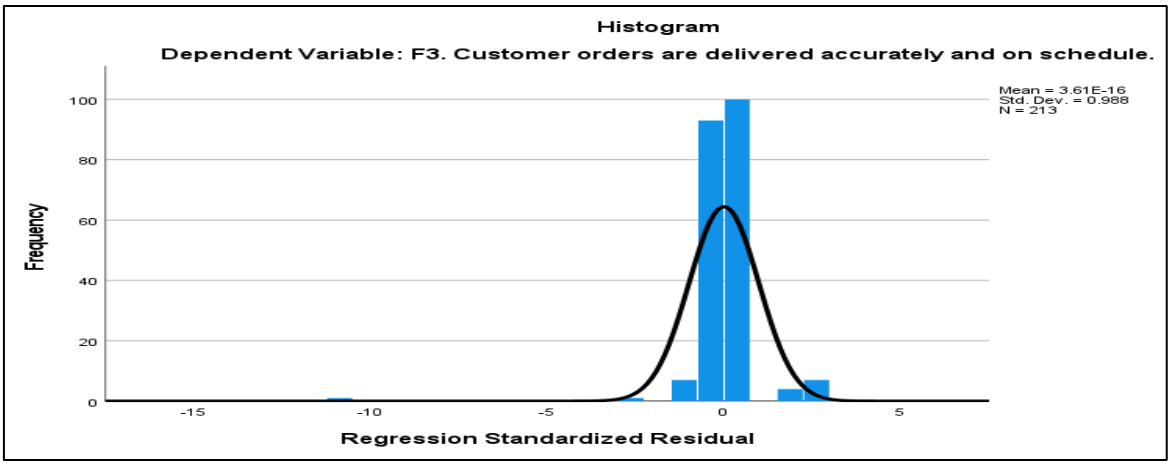

Figure 8 Histogram of the Dependent variable

Table 21 Anova Table

Anova						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	149.372	5	29.874	241.343	.000b
	Residual	25.623	207	.124		
	Total	174.995	212			
a. Dependent Variable: F3. Customer orders are delivered accurately and on schedule.						
b. Predictors: (Constant), D5. Efficient use of labour and equipment reduces operating costs., D1. Staff productivity levels are measured regularly in our warehouse., D2. Workers receive adequate training to perform efficiently., D3. Equipment such as forklifts and conveyors are used effectively., D4. Regular maintenance reduces equipment breakdown during operations.						

Source: Author's compilation (SPSS 27)

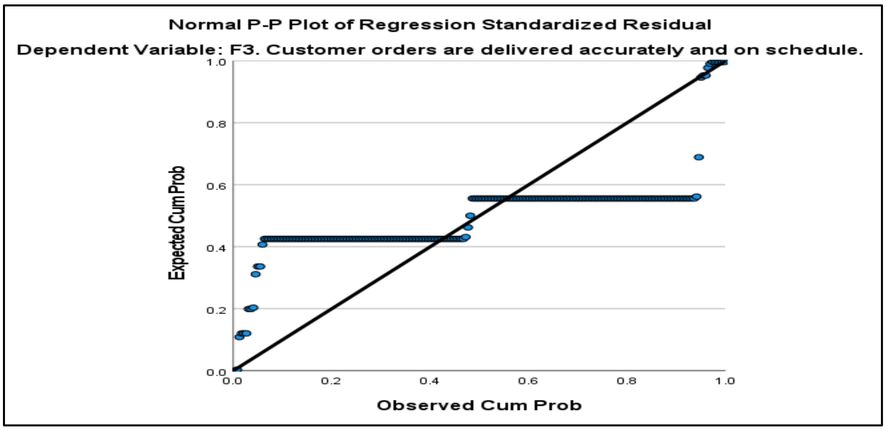

Figure 9 Normal P-P Plot of Regression Standardized Residual

Table 21 shows that the model assessing the impact of labor productivity and equipment utilization on cost efficiency is statistically significant. The F-value is 241.343 with a p-value of 0.000, indicating a strong relationship between the variables. A large portion of the total variation (149.372 out of 174.995) is explained by the model, confirming that improvements in labor and equipment use significantly contribute to enhanced cost efficiency in warehouse operations.

To evaluate how technology-enabled warehouse management practices affect safety standards, workplace ergonomics, and customer satisfaction levels.

Table 22 Regression Analysis Table

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.970[a]	.941	.940	.212	1.628
a. Predictors: (Constant), E5. Technological tools increase customer satisfaction through fast delivery., E3. Ergonomic tools and systems reduce worker fatigue and injury., E1. Warehouse Management Systems (WMS) are used in our operations., E2. Automation tools have improved employee safety in the warehouse., E4. Technology improves the speed and accuracy of order processing.					
b. Dependent Variable: F4. There is coordination between warehouse resources and output efficiency.					

Source: Author's compilation (SPSS 27)

Table 22 presents the regression analysis used to evaluate how technology-enabled warehouse management practices influence safety standards, workplace ergonomics, and customer satisfaction. The correlation coefficient (R) is 0.970, indicating a very strong positive relationship between the use of technology and the outcome variables. The R Square value of 0.941 shows that 94.1% of the variation in safety, ergonomics, and customer satisfaction can be explained by the implementation of technology-enabled practices.

The Adjusted R Square of 0.940 further supports the model's strength and reliability, even after accounting for the number of predictors. The standard error of the estimate is 0.212, suggesting low variability and a good model fit. The Durbin-Watson statistic of 1.628 falls within an acceptable range, indicating no serious autocorrelation in the residuals.

In summary, the results indicate that the adoption of technology in warehouse management significantly enhances safety, improves workplace ergonomics, and increases customer satisfaction, making it a critical factor in modern warehouse performance.

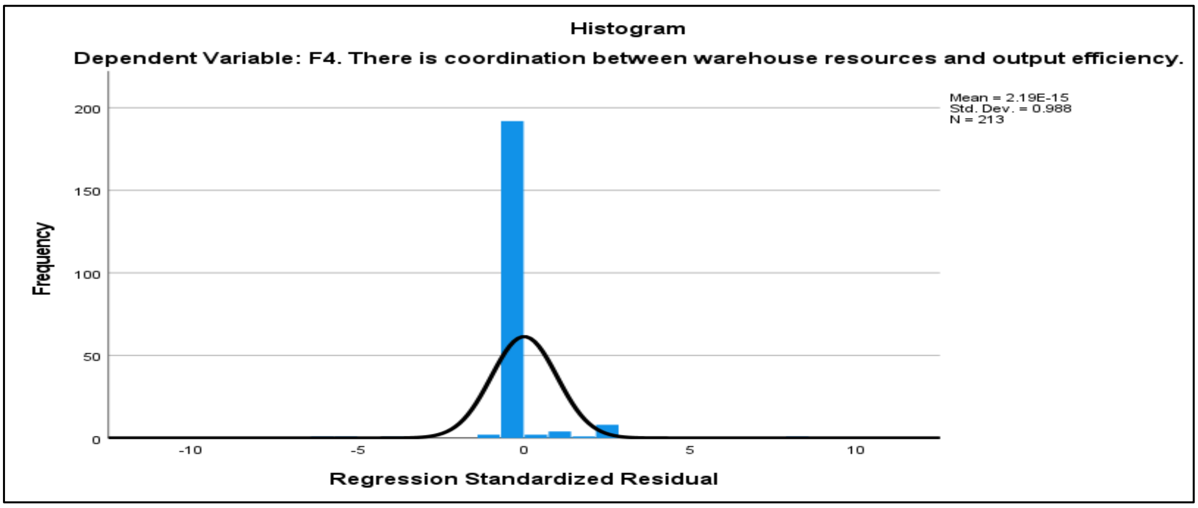

Figure 10 Histogram of the Dependent variable

Table 23 Anova Table

Anova						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	149.281	5	29.856	663.764	.000b
	Residual	9.311	207	.045		
	Total	158.592	212			
a. Dependent Variable: F4. There is coordination between warehouse resources and output efficiency.						
b. Predictors: (Constant), E5. Technological tools increase customer satisfaction through fast delivery., E3. Ergonomic tools and systems reduce worker fatigue and injury., E1. Warehouse Management Systems (WMS) are used in our operations., E2. Automation tools have improved employee safety in the warehouse., E4. Technology improves the speed and accuracy of order processing.						

Source: Author's compilation (SPSS 27)

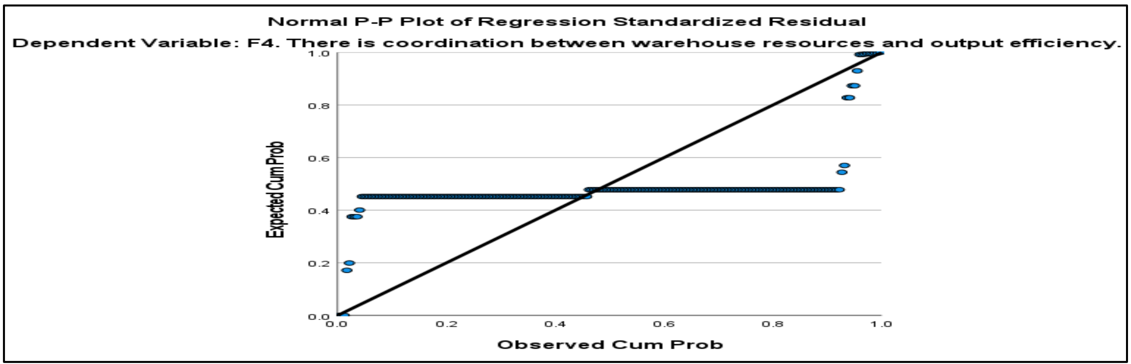

Figure 11 Normal P-P Plot of Regression Standardized Residual

Table 23 shows that the model is statistically significant, with an F-value of 663.764 and a p-value of 0.000. This indicates a strong relationship between technology-enabled warehouse practices and improvements in safety standards, workplace ergonomics, and customer satisfaction. The model accounts for a substantial portion of the total variation (149.281 out of 158.592), confirming that technology adoption plays a key role in enhancing these critical performance areas.

3. Discussions

This section provides a concise overview of the results obtained from the analysis conducted in line with the study's objectives. It summarizes the statistical outcomes and presents a platform for interpreting the empirical findings in relation to relevant theoretical frameworks and recent research. The goal is to critically examine how the data supports or contradicts previous studies and to highlight practical implications for improving operational efficiency in warehouse management, particularly within the context of Edo State.

3.1. Influence of Inventory Accuracy on the Operational Efficiency of Warehouse Management Systems

The study revealed a significant and strong positive relationship between inventory accuracy and operational efficiency. The regression model demonstrated a very high correlation coefficient (R = 0.993) and an R Square value of 0.987, indicating that 98.7% of the variation in operational efficiency could be explained by inventory accuracy. The ANOVA result further confirmed this with an F-value of 3056.021 and a significance level of 0.000.

These findings corroborate recent literature asserting that accurate inventory tracking enhances warehouse efficiency by minimizing errors, reducing overstocking or stockouts, and improving service levels (Sreedevi and Saranga, 2020; Gu et al., 2021). Inventory accuracy serves as the backbone of a responsive and lean warehouse system, where real-time data aids in decision-making and boosts productivity (Waller and Fawcett, 2021). The implication is that warehouse operations in Edo State benefit immensely from systems that ensure precise inventory recording and visibility.

Modern inventory management systems, such as RFID and barcode scanning technologies, have significantly increased accuracy and operational control (Feng and Zhang, 2022). Moreover, integrating inventory management with warehouse management systems (WMS) creates synergy that enhances order accuracy and turnaround times (Tang et al., 2021). Hence, this study confirms that improving inventory accuracy is crucial for achieving optimal operational efficiency.

3.2. Relationship Between Space Utilization, Warehouse Throughput, and Order Fulfilment Rate in Optimizing Warehouse Performance

The results indicated a very strong correlation (R = 0.994) between space utilization, warehouse throughput, and order fulfilment rate in optimizing performance. An R Square of 0.988 showed that 98.8% of the variability in warehouse performance could be attributed to these variables, with the ANOVA showing a significant F-value of 3428.519 (p = 0.000).

Efficient space utilization allows better organization of goods and smoother movement within the warehouse, directly impacting throughput and fulfilment efficiency. Studies by Kumar and Bhatnagar (2020) and Singh et al. (2022) highlight how optimizing vertical and horizontal space increases picking speed and storage density. Throughput, defined as the rate at which goods are processed, is also enhanced by streamlined processes and adequate space.

Order fulfilment rate—how accurately and quickly customer orders are processed—is a key performance indicator. Research by Choudhury et al. (2023) and Ahn and Lee (2020) supports the idea that fulfilment accuracy and speed are direct outcomes of well-utilized warehouse layouts and high throughput capabilities. The synergy between these three variables ensures timely order processing, which is essential in today's competitive and time-sensitive supply chains.

This study confirms that warehouses that strategically manage space, increase handling speed, and prioritize accurate fulfilment can significantly enhance overall performance. Investments in layout design, automated material handling systems, and real-time tracking further improve these metrics (He et al., 2021).

3.3. Contribution of Labor Productivity and Equipment Utilization to Cost Efficiency in Warehouse Operations

The regression analysis indicated a strong relationship between labour productivity, equipment utilization, and cost efficiency, with an R value of 0.924 and R Square of 0.854. This means that 85.4% of the variation in cost efficiency can be explained by these two factors. The ANOVA results showed a statistically significant F-value of 241.343 (p = 0.000).

Labour productivity in warehouse operations refers to the output per worker, and high productivity often translates into reduced labor costs and faster turnaround. As stated by Zhou et al. (2021) and Olabode and Akinyele (2020), improving labour performance through training, incentives, and workflow optimization leads to significant cost savings. Likewise, equipment utilization how effectively tools like forklifts, conveyors, and scanners are used greatly affects operational costs.

According to Ndu and Ali (2022), underutilized or outdated equipment leads to inefficiencies, while optimized use reduces downtime and energy consumption. This aligns with the study's findings that effective use of equipment in conjunction with productive labour practices enhances overall cost efficiency. The implication is that warehouse operations in Edo State can benefit from performance monitoring tools and maintenance strategies that ensure both labour and equipment are maximally productive.

3.4. Impact of Technology-Enabled Warehouse Management Practices on Safety, Ergonomics, and Customer Satisfaction

The regression analysis yielded a high correlation (R = 0.970) and R Square of 0.941, showing that 94.1% of the variation in safety, ergonomics, and customer satisfaction could be explained by technology-enabled practices. The ANOVA result was also highly significant, with an F-value of 663.764 and p = 0.000.

Technology has become a transformative force in warehouse operations. Automated systems, wearable devices, and warehouse management software contribute not only to efficiency but also to worker safety and ergonomic practices (Wang et al., 2021; Bello and Okonkwo, 2020). For instance, automation reduces manual handling and the risk of injury, while ergonomic tools improve worker comfort and reduce fatigue.

Additionally, technology enhances customer satisfaction by improving order accuracy, reducing delivery time, and enabling real-time order tracking (Lee et al., 2022). This is especially critical in the current e-commerce-driven market where customer expectations are increasingly high. The study confirms findings by Alabi and Musa (2023), who emphasized that digital integration leads to better service delivery and increased customer loyalty.

Therefore, the adoption of technology-enabled warehouse practices in Edo State not only improves internal operational metrics but also extends to external outcomes such as safety and customer satisfaction. Investments in digital infrastructure, employee tech training, and automated systems are essential for sustained performance improvements.

4. Conclusion

This study was conducted to assess the operational efficiency of warehouse management in Edo State, Nigeria. The research focused on four key objectives: examining the influence of inventory accuracy on warehouse efficiency; analysing the relationship between space utilization, warehouse throughput, and order fulfilment rate; assessing how labour productivity and equipment utilization contribute to cost efficiency; and evaluating the impact of technology-enabled warehouse practices on safety, ergonomics, and customer satisfaction. Using a quantitative research design, data were collected from respondents working in various warehouse-related roles, including inventory officers, logistics officers, storekeepers, and warehouse managers. Descriptive and inferential statistics were employed in analysing the data. Findings indicated that inventory accuracy positively influences warehouse efficiency, confirming that effective inventory management is essential for smooth operations. Likewise, space utilization, throughput, and order fulfilment were shown to significantly enhance overall warehouse performance. Proper organization of space and efficient handling of goods lead to improved customer service and delivery. Furthermore, the study revealed that labour productivity and effective use of equipment contribute meaningfully to cost efficiency in warehouse operations. Warehouses that focus on optimizing worker output and maintaining equipment tend to reduce operating expenses. Finally, the integration of technology in warehouse practices was found to improve safety, ergonomics, and customer satisfaction. Digital solutions and automated systems enhance working conditions and operational responsiveness.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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