

WAREHOUSE MANAGEMENT SYSTEM AND PERFORMANCE OF DOWNSTREAM OIL AND GAS COMPANIES IN PORT HARCOURT

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Abstract

This study investigated the correlation between warehouse management system (WMS) and performance of downstream oil and gas companies in Port Harcourt, focusing on how WMS relates to cost reduction, productivity and safe production. Founded on Technology Acceptance Model, the study adopted correlational research design with a cross-sectional approach. The population of the study comprised 23 downstream oil and gas companies. All the companies were studied because the population is small. However, 81 respondents provided data for the study through a semi-structured questionnaire designed in 5-point Likert scale. Pearson Product Moment Correlation Analysis was conducted and the results of the analysis revealed that WMS relates positively and significantly to cost reduction, productivity and safe production. Thus, the study concluded that a positive and significant correlation exists between WMS and performance of downstream oil and gas companies operating in Port Harcourt; and recommends downstream oil and gas companies should prioritize acquisition and integration of robust WMS platforms that align with their operational scale and complexity.

Keywords: Cost reduction, organizational performance, productivity, safe production warehouse management system

Introduction

In today's dynamic and technology-driven business environment, the ability of firms to manage their warehouses efficiently has become a key determinant of performance and competitiveness. Thus, firms are adopting technology to facilitate their warehousing operations. Warehouse management system (WMS) is one of such technological solutions commonly adopted. WMS is an integrated software solution that optimizes the control, coordination, and monitoring of warehouse operations, including inventory tracking, order processing, material handling, and logistics scheduling (Richards, 2017). WMS enhances visibility, accuracy, and efficiency in supply chain processes by automating routine operations and providing real-time data for decision-making. It is therefore, not just a technological tool but a strategic necessity for performance improvement (Adebayo & Alao, 2020).

The downstream oil and gas industry encompasses refining, distribution, storage, and marketing of petroleum products. Companies in this industry face persistent challenges relating to inventory inaccuracies, product losses, stockouts, redundant handling, and delays in distribution (Onoh & Nwokah, 2019). These operational inefficiencies often result in higher logistics costs, reduced customer satisfaction, and revenue losses. Despite the sector's critical role in Nigeria's economy, many downstream firms in the region still rely on manual or semi-automated systems for warehouse operations, which limits their ability to achieve real-time visibility and control over inventory (Amah & Worlu, 2021).

The problem, therefore, lies in inadequate adoption and integration of modern WMS that streamline operations, reduce waste, and enhance organizational performance. Existing studies on operational performance in Nigeria's oil and gas industry have focused primarily on supply chain integration, logistics performance, and procurement efficiency (Okeke & Eze, 2018; Eze, 2020), with limited attention given to specific impact of WMS on organizational outcomes such as cost efficiency, productivity and customer satisfaction. Thus the relationship between WMS and organizational performance in Nigeria's downstream oil and gas sector is largely underexplored.

This study therefore sought to complement literature by examining the influence WMS on performance of downstream oil and gas companies in Port Harcourt. Specifically, the study sought to determine whether adoption of WMS contributes to improved inventory accuracy, reduced operational cost, enhanced productivity, and superior service delivery. By empirically establishing this relationship, the study provide evidence-based insights that can guide managers to optimize warehouse operations for greater organizational performance in Nigeria's downstream oil and gas sector. The study is underpinned by Technology Acceptance Model (TAM).

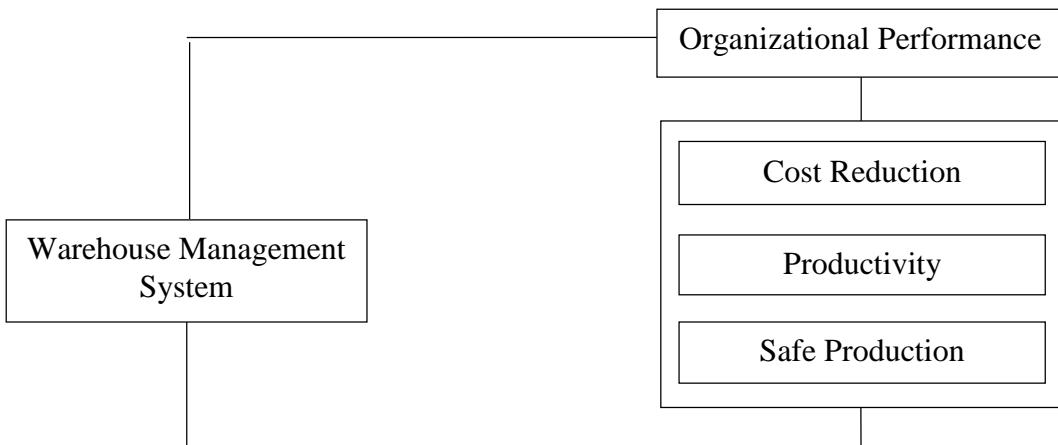


Fig. 1: Conceptual framework of relationship between warehouse management system and performance of downstream oil and gas companies in Port Harcourt.

Source: Adapted from Fujii et al. (2020); Oloruntoba and Gray (2006).

Theoretical Framework

Technology Acceptance Model (TAM) was adopted to underpin this study. TAM (Davis, 1986, 1989) is one of the most widely used frameworks for explaining user acceptance of technology. TAM posits perceived usefulness (PU) and perceived ease-of-use (PEOU) are two primary factors that influence users' adoption of innovation. PU reflects the belief that using a system will enhance job performance, while PEOU reflect the degree to which using the system is free from effort (Davis, 1989).

In the context of warehouse automation, PU represents how operators perceive that WMS as an advanced inventory technology can improve efficiency and enhance productivity. PEOU, on the other hand, involves the ease of learning, operating and integrating these technologies into existing workflows. Together, PU and PEOU influence technology acceptance and utilization, which are critical for realizing automation benefits in industrial environments.

Extensions such as TAM2 (Venkatesh & Davis, 2000) and UTAUT (Venkatesh et al., 2003) have enriched TAM by including social influence, facilitating conditions, and performance expectancy, yet the original model remains valuable for understanding user adoption behavior. Empirical studies demonstrate TAM's applicability in logistics and supply chain settings, showing that PU and PEOU significantly predict adoption of automation technology (Chao et al., 2019; Zhou et al., 2021).

In the downstream oil and gas industry where operations depend on precision, safety and efficiency, TAM provides a lens for understanding the human factors behind automation adoption. Despite the availability of advanced WMS, user resistance, low digital literacy and fear of change often impede effective utilization. This study adopts TAM to explain how users'

perceptions of usefulness and ease of use PU and PEOU influence successful implementation of WMS to improve organizational performance through cost reduction, productivity and safe production.

While TAM has faced criticism for oversimplifying adoption behavior (Bagozzi, 2007), it remains instrumental to identifying behavioral enablers of technological success. By integrating TAM with performance outcomes, this study bridges a critical gap in understanding how technology acceptance predicts the relationship between WMS and organizational performance.

Concept of Warehouse Management System

WMS has become essential tools for achieving operational excellence in modern logistics and supply chains. They automate inventory operations, streamline order fulfillment, and enhance decision-making through real-time data visibility (Frazelle, 2018). In complex sectors such as downstream oil and gas, where precision, safety and efficiency are critical, WMS adoption is a strategic necessity for sustained performance (Richards, 2017).

WMS is a software solution designed to optimize warehouse operations, including receiving, storing and dispatching goods. Modern WMS integrate technologies like barcoding, Radio Frequency Identification (RFID), and the Internet of Things (IoT) to ensure inventory accuracy and efficient space utilization (Sharma et al., 2020). Core functions of WMS include inventory and order management, layout optimization, labor allocation, and real-time analytics (Bartholdi & Hackman, 2014). These capabilities minimize stockouts, reduce handling time, and support informed managerial decisions, thereby improving overall productivity.

In the downstream oil and gas sector, WMS enhances inventory accuracy, ensures regulatory compliance, and strengthens workplace safety (Ejiogu & Okonkwo, 2021). Real-time tracking of hazardous or perishable materials through RFID reduces errors and promotes accountability (Palšaitis & Bazaras, 2016). However, challenges persist. High implementation costs, limited infrastructure, and resistance to technological change hinder adoption among indigenous firms (Obi et al., 2022; Shet & Pereira, 2021).

TAM emphasizes that perceived usefulness and ease of use determine successful adoption (Davis, 1989). Similarly, dynamic capabilities theory (Teece, 2007) suggests that firms leveraging WMS can adapt rapidly to operational disruptions. Effective WMS deployment promises cost reduction, improved efficiency, and enhanced competitiveness. As infrastructure and digital literacy improve, WMS will become a standard for operational efficiency and safety in Nigeria's energy logistics landscape.

Concept of Organizational Performance

Organizational performance represents a firm's ability to achieve its strategic and operational objectives effectively and efficiently. It reflects how well companies manage complex logistics, ensure safety and maintain profitability amid regulatory and infrastructural challenges (Agyabeng-Mensah et al., 2020). As warehouse operations form the backbone of supply chain efficiency, automation technologies have become instrumental to improved efficiency, productivity and safety - three key dimensions of organizational performance.

Efficiency involve minimizing storage, handling, and labor costs while maintaining service quality (Hervani et al., 2005). Through automation tools like WMS, automated guided vehicles (AGVs), and real-time inventory tracking, firms can lower operational expenses and reduce

human error (Waller & Fawcett, 2013). In Port Harcourt, these benefits are particularly vital due to rising logistics costs and economic volatility (Olumide & Abass, 2021).

Productivity reflects effective conversion of resources into outputs. In warehousing, automation improves throughput, order fulfillment accuracy, and space utilization (Gunasekaran et al., 2001). Technologies such as AI-driven analytics and human-machine collaboration enhance workflow planning and operational continuity, ensuring reliable fuel and material distribution (Guan & Zhao, 2011). Safe production emphasizes maintaining output levels while ensuring compliance with health, safety, and environmental (HSE) standards. Automation minimizes human exposure to hazardous conditions through IoT sensors, robotic systems, and predictive safety technologies (Ali et al., 2020).

In the downstream oil and gas sector, warehouse automation enhances organizational performance by promoting agility, regulatory compliance, and stakeholder confidence. Despite challenges such as high capital requirements, infrastructure limitations, and change resistance (Obi et al., 2022), automation remains a critical enabler of sustainable organizational growth and competitiveness in Nigeria's evolving energy logistics environment.

While cost reduction, productivity, and safe production are critical indicators of warehouse performance examined in this study, several additional performance measures provide a more comprehensive view of operational effectiveness. These include inventory accuracy, order fulfillment rate, lead time, customer satisfaction, asset utilization, and environmental sustainability. Inventory accuracy refers to the degree to which recorded inventory matches the actual physical stock in the warehouse. It is vital for ensuring order accuracy, minimizing stockouts, and avoiding overstocking (Frazelle, 2002).

Automation tools such as RFID and barcoding systems significantly improve inventory tracking and data integrity (Kumar & Saini, 2020; Gunasekaran et al., 2004; Christopher, 2016; Mentzer et al., 2001; Lambert et al., 2006; Hervani et al., 2005). Incorporating these additional measures of performance allows downstream oil and gas firms to gain deeper insights into their warehouse operations. These metrics align closely with strategic goals such as customer satisfaction, regulatory compliance, and sustainable growth. Leveraging warehouse automation enables more accurate tracking, real-time reporting, and faster decision-making across all these performance domains.

Cost reduction

Ability to control costs is an imperative to business survival and growth (Ateke et al., 2025). Cost reduction is thus fundamental to profitability and sustainability in any business environment. In the capital-intensive and competitive downstream oil and gas sector, minimizing operational costs while maintaining safety is crucial (Hendricks & Singhal, 2003). Warehousing plays a vital role in this process, as it supports movement, storage and handling of materials and finished products.

Warehouse cost reduction involves minimizing expenses related to labor, storage, inventory handling, transportation, and energy use without compromising service quality (Liker, 2004). Automation technologies such as WMS, AGVs, and Robotic Process Automation (RPA) have become key enablers of this goal (Stern, 2007; Hernandez et al., 2019). WMS improves inventory visibility, order accuracy, and operational efficiency, thereby reducing labor and storage costs (Waller & Fawcett, 2013). Similarly, AGVs and robotics automate material handling and picking, lowering human errors and repetitive labor costs (Coyle et al., 2003). RPA streamlines administrative tasks, minimizes overheads and accelerates workflows (Avasarala et al., 2018).

Ultimately, cost reduction in warehouse operations extends beyond minimizing direct costs. It involves continuous process optimization, workforce efficiency, and technological integration. In the downstream oil and gas sector, these strategies collectively enhance operational performance, ensure regulatory compliance, and strengthen competitiveness in a volatile market environment.

Productivity

Productivity is a key determinant of operational success in warehouse management, particularly in the downstream oil and gas industry where materials must be handled efficiently to sustain profitability. In this context, productivity reflects how effectively resources such as labor, space, and capital are used to achieve outputs like order fulfillment, inventory accuracy, and timely deliveries (Hitt et al., 2001; Chopra & Meindl, 2016). Enhancing productivity reduces operational costs, improves customer satisfaction, and strengthens competitiveness.

Warehouse automation technologies WMS, AGVs, and robotic picking systems play a transformative role in improving productivity. These technologies streamline processes, reduce human error, and increase throughput. A WMS optimizes order fulfillment and inventory tracking, providing real-time visibility that enhances efficiency (Barros et al., 2018). Similarly, AGVs automate material transport, reducing handling time and increasing operational speed (Kumar & Saini, 2020). Robotic picking systems further improve accuracy and reduce order processing time (Van den Berg et al., 2020).

Human-machine collaboration also contributes to higher productivity. Collaborative robots (cobots) assist workers in repetitive tasks, enabling staff to focus on higher-value activities (Ramaswamy et al., 2020). Studies show that automation can increase warehouse productivity by 20–40%, depending on the degree of integration (Hussain et al., 2020). Effective inventory control strategies, such as Just-in-Time (JIT) systems and demand forecasting, also enhance productivity by reducing excess stock and minimizing movement inefficiencies (Mangan et al., 2016; Christopher, 2016).

However, automation adoption faces barriers such as high implementation costs, system integration challenges, and maintenance demands (Avasarala et al., 2018). Despite these obstacles, downstream oil and gas firms in Port Harcourt can achieve significant performance gains by investing strategically in warehouse automation, fostering employee training, and aligning technology with operational needs.

Safe production

Safe production is vital to industrial operations, particularly in the downstream oil and gas sector, where hazardous materials, flammable substances, and heavy machinery are routinely handled. In warehouses, safety ensures not only the protection of workers but also operational continuity and environmental protection (Kapp, 2019). Safe production encompasses all preventive measures, procedures, and technologies aimed at minimizing accidents, injuries, and exposure to harmful materials.

Key determinants of safe production include safety culture, warehouse design, personal protective equipment (PPE), and regulatory compliance. A strong safety culture, supported by management commitment, continuous training and communication significantly reduces workplace incidents (Ehsan et al., 2020). Proper warehouse design, including organized layouts, adequate lighting, and clear safety signage, helps reduce accidents related to equipment movement and material handling (Chong et al., 2016). PPE use, such as helmets, gloves, and goggles, remains fundamental in minimizing injuries and chemical exposure (Lutz et al., 2018). Compliance with

occupational and fire safety standards, such as OSHA and NFPA regulations, ensures adherence to established safety protocols and emergency preparedness (Jha & Soni, 2017).

Warehouse automation technologies now play a pivotal role in enhancing safety. WMS automate inventory control and flag hazardous materials requiring special handling, reducing human error (Yuan et al., 2020). AGVs minimize direct human involvement in material movement, thereby lowering injury rates (Park & Lee, 2021). Robotic systems for picking and sorting also reduce worker exposure to toxic substances and physical strain (Pinto et al., 2018).

However, challenges such as high implementation costs, resistance to change, and maintenance demands persist, particularly in developing contexts. Overcoming these barriers through training, investment, and strong safety governance will enable warehouses in the oil and gas sector to achieve safer, more efficient, and sustainable operations.

Warehouse Management System and Organizational Performance

Several studies have explored the influence of WMS on the performance of the oil and gas sector. Sharma et al. (2020) investigated how WMS enhances supply chain performance in India's oil and gas industry. Using structural equation modeling, the study found that WMS significantly improved inventory accuracy, reduced lead times, and enhanced order fulfillment rates. The integration of WMS also lowered operational costs and increased productivity, providing firms with a competitive advantage through optimized warehouse operations.

Similarly, Khan et al. (2021) examined the relationship between WMS implementation and operational performance in Pakistan's industrial sector. Through regression and correlation analyses, the study revealed that WMS adoption improved inventory control, storage optimization, and cost reduction. It concluded that WMS directly contributes to higher efficiency and cost-effectiveness by minimizing waste and improving resource utilization.

In Nigeria, Ogunyemi (2019) focused on barriers to WMS adoption in the oil and gas sector and its effect on performance. Using a qualitative case study approach, the research found that while WMS improved efficiency and cost management, adoption was limited by factors such as high implementation costs, poor infrastructure, and lack of skilled personnel. The study emphasized that addressing these barriers could significantly enhance operational efficiency and safety.

Sarkis and Zailani (2018) evaluated WMS effects on logistics and supply chain performance in Malaysia's oil and gas industry. Their findings showed that WMS implementation reduced material handling time, improved stock visibility, and optimized order fulfillment processes, leading to cost savings and improved responsiveness. In addition, Tajbakhsh and Alam (2020) investigated WMS adoption in the United Arab Emirates and found that it fostered supply chain collaboration, enhanced inventory turnover, and improved decision-making. This ultimately led to better operational efficiency, delivery accuracy, and lead time performance.

Collectively, these studies confirm that WMS is instrumental to improved operational efficiency, and performance of firms. However, there remains a research gap regarding how these relationships manifest among downstream oil and gas companies, where infrastructural and environmental challenges are unique. Therefore, the following hypotheses are formulated:

H₀₁: There is no significant relationship between warehouse management system and cost reduction of downstream oil and gas companies in Port Harcourt.

H₀₂: There is no significant relationship between warehouse management system and safe production of downstream oil and gas companies in Port Harcourt.

H₀₃: There is no significant relationship between warehouse management system and productivity of downstream oil and gas companies in Port Harcourt.

Methodology

This study adopted correlational research design with a cross-sectional approach. The study's population comprised 23 downstream oil and gas companies in Port Harcourt. The entire universe was surveyed. 81 respondents comprising warehouse manager, operations supervisors, IT specialists, supply chain manager, logistics personnel, procurement manager and finance manager of the 23 downstream oil and gas companies in Port Harcourt provided data for the study through a semi-structured questionnaire.

The instrument was designed in 5-point Likert scale. Its reliability was determined using Cronbach's Alpha test with a threshold of 0.70 set by Nunally (1978); while its construct validity was determined through Exploratory Factor Analysis (EFA). To establish the relationship between the predictor variable and the criterion variables, Pearson Product Moment Correlation was used to test the 3 hypotheses formulated for the study. The analysis was done with the aid of Statistical Package for Social Sciences (SPSS) version 25.

Table 1: Results of Reliability and Validity Tests

S/N	Variables	Number of Items	Cronbach's Alpha Coefficients	Factor Loadings
1	Warehouse Management Systems	4	0.803	0.759
2	Cost Reduction	4	0.769	0.860
3	Productivity	4	0.780	0.690
4	Safe Production	4	0.807	0.829

Source: SPSS Output (2025).

Table 1 revealed that all the variables in the study produced high Cronbach's Alpha coefficients. This is an evidence to show that, there is inter-item consistency among the variables in the study. In other words, if this study is conducted again in a similar condition the results will be similar to the results of this study. Again, all the variables have high factor loadings greater than 0.4, indicating that the items and variables in the questionnaire measured what they were supposed to measure. These loadings indicated that there is no cross-loading hence there is discriminant validity.

Test of Hypothesis

Table 2: Pearson correlation between Warehouse Management System and Cost Reduction

		Warehouse Management System	Cost Reduction
Warehouse Management System	Pearson Correlation	1	.768**
	Sig. (2-tailed)		.000
	N	81	81
Cost Reduction	Pearson Correlation	.768**	1
	Sig. (2-tailed)	.000	
	N	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS Output (2025).

Table 2 displays the result of Pearson Correlation on the link between WMS and cost reduction of downstream oil and gas companies in Port Harcourt. Using a sample of 81 respondents, drawn from 23 downstream oil and gas companies in Port Harcourt, the analysis revealed that, WMS

has a strong, positive and significant relationship with cost reduction of downstream oil and gas companies in Port Harcourt. This result is evident in the correlation coefficients of 0.768 and a probability value of $0.000 < 0.05$. In view of this result, the researcher rejects the null hypothesis which deny the existence significant correlation between WMS and cost reduction of downstream oil and gas companies in Port Harcourt.

Table 3: Pearson correlation between Warehouse Management System and Productivity

		Warehouse Management System	Productivity
Warehouse Management System	Pearson Correlation	1	.509**
	Sig. (2-tailed)		.000
	N	81	81
Productivity	Pearson Correlation	.509**	1
	Sig. (2-tailed)	.000	
	N	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS Output (2025).

A Pearson Correlation Analysis was run to assess the correlation between WMS and productivity of downstream oil and gas companies in Port Harcourt. Using a sample of 81 respondents, drawn from 23 downstream oil and gas companies in Port Harcourt, the analysis revealed as shown in Table 3 that, WMS has a moderate, positive and significant relationship with productivity of downstream oil and gas companies in Port Harcourt. This result is evident in the correlation coefficient of 0.509 and probability value of $0.000 < 0.05$. In view of this result, the researcher rejects the hypothesis which negate the existence of significant correlation between WMS and productivity of downstream oil and gas companies in Port Harcourt.

Table 4: Pearson correlation between Warehouse Management System and Safe Production

		Warehouse Management System	Safe Production
Warehouse Management System	Pearson Correlation	1	.548**
	Sig. (2-tailed)		.000
	N	81	81
Safe Production	Pearson Correlation	.548**	1
	Sig. (2-tailed)	.000	
	N	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS Output (2025).

Pearson Correlation Analysis was run to assess the relationship between WMS and safe production of downstream oil and gas companies in Port Harcourt. Using a sample of 81 respondents, drawn from 23 downstream oil and gas companies in Port Harcourt, the analysis revealed as shown in Table 4 that, WMS has a moderate, positive and significant relationship with safe production of downstream oil and gas companies in Port Harcourt. This result is evident in the correlation coefficients of 0.548 and a probability value of $0.000 < 0.05$. In view of this result, the researcher rejects the hypothesis which states that there is no significant relationship between WMS and safe production of downstream oil and gas companies in Port Harcourt.

Discussion of Findings

This study examined the correlation between WMS and performance of downstream oil and gas companies in Port Harcourt. The results of the analyses conducted, shows that WMS has strong positive correlation with cost reduction and moderate positive correlation with productivity and safe production. More so, all the correlations were found to be statistically significant.

These findings support the findings of previous studies. For instance, the findings agree with the finding of Sharma et al. (2020) who investigated how WMS improve supply chain performance in the oil and gas industry, and found that WMS significantly enhanced inventory accuracy, reduced lead times, and improved order fulfillment rates, demonstrating that integration of WMS contribute to reduction of operational costs and increases productivity.

Our findings also align with the findings of Khan et al. (2021) who examined the relevance of WMS to operational performance of oil and gas companies; and highlighted that WMS play a key role in improving inventory accuracy and resource allocation. It also found a significant reduction in operational costs due to optimized warehouse processes and better inventory management.

Also, results of this study further confirmed the results of Ogunyemi (2019) who examined how barriers to adoption of WMS could be overcome in developing economies. The study found that while WMS had a positive effect on performance by improving efficiency and reducing costs, adoption was hindered by factors like high implementation costs, inadequate infrastructure, and lack of skilled labor. Hence the study concluded that overcoming the barriers to WMS adoption in the oil and gas sector could lead to substantial improvements in operational efficiency and safety.

The results of the current study are also in agreement with the results of Sarkis and Zailani (2018) who investigated the impact of WMS on supply chain performance of oil and gas sector firms in Malaysia and found that WMS contribute to significant reduction in material handling time, improved stock visibility, and optimized the order fulfillment process. These improvements directly led to cost savings and enhanced supply chain responsiveness.

Furthermore, the current findings confirm the results of Tajbakhsh and Alam (2020) who examined the impact of WMS adoption on operational efficiency in the oil and gas sector in United Arab Emirates. The study demonstrated that WMS adoption led to increased collaboration between supply chain partners, enhanced inventory turnover, and more effective decision-making. This, in turn, improved operational efficiency and performance metrics such as delivery accuracy and lead time.

Conclusion and Recommendations

Based on the findings of this study, it is concluded that there is a positive significant correlation between WMS and performance of downstream oil and gas companies operating in Port Harcourt. The empirical evidence particularly demonstrates that WMS significantly contribute to improved inventory accuracy, streamlined workflows, and better resource allocation, all of which lead to tangible cost savings and productivity gains.

Based on the findings and conclusion of the study, it is recommended that downstream oil and gas companies should prioritize the acquisition and integration of robust WMS platforms that align with their operational scale and complexity. These systems should support real-time tracking, order processing, and inventory visibility to enhance accuracy, reduce operational delays, and support data-driven decision-making.

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