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Determinants of Operational Performance Through Green Warehouse Implementation in Food and Beverage Distributors in Indonesia

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ABSTRACT

Despite the fact that powerful useful resource utilization and operational control are vital for warehousing operations within the meals and beverage distribution enterprise, there's nonetheless a dearth of empirical information concerning the factors that affect green warehouse adoption in Indonesia. further to trying out the mediating position of inexperienced warehouse implementation, this have a look at seems at how management commitment, human useful resource competency, warehouse infrastructure, law, and digitization have an effect on green warehouse implementation and operational effectiveness. a total of 246 members from Indonesian meals and beverage distribution organizations engaged in a go-sectional survey using a confirmatory quantitative technique. Structural Equation Modeling the usage of Partial Least Squares (SEM-PLS) was hired to research the records. each one of the 16 theories become validated. inexperienced warehouse implementation had the best direct impact on operational overall performance (β = zero.255), while law became the exceptional predictor of green warehouse implementation (β = 0.236). 72,5% of operational overall performance and 58,5% of the variance in green warehouse implementation have been defined by means of the model. With VAF values ranging from 19.48% to 27.26%, all five indirect consequences had been vast and showed complementing mediation. The results spotlight the unique roles that organizational commitment, regulatory strain, and green warehouse skills play in improving operational effects and display that the factors that maximum strongly have an impact on inexperienced warehouse implementation are not always people who maximum strongly influence operational overall performance.

Keywords : *Green Warehouse Implementation, Management Commitment, Human Resource Competence, Warehouse Infrastructure, Regulation, Digitalization, Operational Performance.*

INTRODUCTION

Considered one of the largest structural demanding situations of the twenty-first century is climate change, which impacts now not simply worldwide temperatures however additionally food security, financial balance, and the dependability of transportation systems. in step with the Intergovernmental Panel on weather change's synthesis document, worldwide greenhouse gasoline emissions are nevertheless growing due to unsustainable patterns of manufacturing and consumption, and human activity has warmed the earth's floor via approximately 1.1°C between 2011 and 2020 while in comparison to the baseline length of 1850–1900 (IPCC, 2023). As a result, in preference to being a strategic preference, sustainable improvement is now an operational want for nearly each industry

The logistics sector occupies a dual position in this problem. On the one hand, logistics is a victim of climate related disruption through distribution delays, infrastructure damage, and rising operating costs. On the other hand, logistics

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contributes to emissions through electricity consumption, fossil fuel use, warehousing, material handling, and waste management. Tetteh et al. (2024) present a bibliometric and comprehensive methodological evaluation revealing a substantial rise in academic interest in green logistics techniques since 2019, influenced by escalating stakeholder demands for the environmental performance of logistics enterprises.

There is a right away necessity to overtake meals structures. The United international locations environment program reports that 1.05 billion tons of food had been discarded worldwide in 2022. This constitutes 19% of the food available for customers at retail, meals provider, and household ranges, except for an additional 13% lost all through the deliver chain from post-harvest to retail. among eight and ten percentage of worldwide greenhouse gasoline emissions are attributed to food loss and waste (UNEP, 2024). those figures suggest that distribution and garage functions are critical areas for intervention instead of merely supplementary obligations

At the national level, Indonesia faces the challenge of balancing industrial growth with environmental sustainability. The manufacturing industry continues to be the predominant contributor to the national gross domestic product, representing 18.98 percent in 2024, an increase from 18.67 percent in 2023, despite a deceleration in its growth rate to 4.43 percent (Badan Pusat Statistik, 2025). The food and beverage industry is the largest subsector within non oil and gas manufacturing, contributing 40.31 percent of non oil and gas manufacturing gross domestic product, equivalent to 6.92 percent of national gross domestic product, with annual growth of 5.90 percent, while realised investment in the sector reached IDR 110.57 trillion in 2024 (Kementerian Perindustrian Republik Indonesia, 2025). Production, storage, and distribution volumes are therefore expected to continue expanding, at the same time as the national decarbonisation agenda targets net zero emissions by 2060 or sooner.

The warehousing function is critical for food and beverage operations. Most products have a limited shelf life, require temperature control, follow First Expired First Out and First In First Out principles, and exhibit high inventory turnover. Errors in storage, inventory control, and material handling increase damaged and expired products and, in turn, total logistics costs. At the same time, cooling systems, lighting, forklifts, battery charging areas, and conveyors consume substantial energy. Green warehousing emerged from these conditions as an approach that combines more efficient resource use and layout, waste reduction, and digital technology in order to lower environmental impact without sacrificing operational efficiency.

Empirical evidence suggests that the efficacy of green warehousing necessitates a mix of internal and outside factors. Perotti and Colicchia (2023) formulated a conceptual framework for inexperienced warehousing that integrates power efficiency techniques with solutions for minimizing environmental effect, based on a scientific evaluation of sixty guides published from 2008 to 2022. They

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highlighted organizational demanding situations to adoption, including price, complexity, verbal exchange, knowledge and capability, government regulatory pressure, technological boundaries, and insufficient inner dedication to sustainability guidelines. Modica et al. (2021) assert that organizational factors play a crucial role in the implementation of power-green fabric handling apparatus, indicating that solely technical grounds can't justify investments in sustainable generation. two classes of drivers have been found in a scientific evaluate of 90-5 articles posted among 2016 and 2024: outside drivers, which encompass institutional strain, and internal drivers, which are dominated by using pinnacle control commitment to setting strategic direction, allocating resources, and riding organizational change (Tetteh et al., 2024). Perotti et al. (2024) explain how enterprise four.0 technologies, together with statistics analytics, automation structures, and the internet of factors, sell sustainable warehousing.

However, there are still three gaps. The first is significant. Green warehouse implementation as a mediating mechanism and the structural relationships between internal organizational factors, regulation, warehouse infrastructure, and digitalization and operational performance are still poorly supported by empirical research. Contextual is the second. Previous research has focused on manufacturing, e-commerce, and third-party logistics providers, mostly in Europe (Perotti & Colicchia, 2023). However, food and beverage distributors exhibit unique operational features like high inventory turnover, First Expired First Out application, cold chain requirements, expired product control, and high material handling intensity, which restrict the applicability of findings from other industries. Methodological is the third. Even tho organizational resources may enhance operational performance thru two parallel mechanisms general work process improvement and the adoption of sustainable warehousing practices prior research typically tested either direct effects between green practices and firm performance or mediation paths, without estimating both simultaneously. This reasoning corresponds with the herbal resource-primarily based View, which perceives environmentally orientated skills as a aggressive gain (Hart, 1995), and the useful resource-based View, which asserts that competitive benefit arises from a appropriate amalgamation of organizational resources and abilities (Barney, 1991).

Therefore, this look at develops a partial mediation version that estimates direct and indirect paths simultaneously. The methodological foundation for this decision is that the type of mediation, whether or not complete, complementary partial, aggressive partial, or no mediation, can most effective be determined whilst the direct route from the exogenous to the endogenous variable is covered inside the version (Hair et al., 2021). Omitting the direct course dangers specification bias due to the fact the mediated direction coefficient could absorb part of the direct impact that virtually exists. The examine therefore tests sixteen hypotheses along with five direct paths in the direction of inexperienced warehouse implementation, six direct

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paths towards operational performance, and 5 oblique paths thru green warehouse implementation.

Taking these factors into account, the study aims to examine how management commitment, human resource proficiency, warehouse infrastructure, regulatory measures, and digitalization influence the adoption of green warehouses and the operational performance of Indonesian food and beverage distributors, as well as to evaluate the mediating role of green warehouse implementation in these relationships. By analyzing green warehouse implementation as an empirically validated construct instead of a theoretical discussion, the study enhances the theoretical framework surrounding sustainable warehousing. Practically, the outcomes are expected to guide businesses, warehouse management, and policymakers in prioritizing strategies that improve both operational and environmental results.

METHOD

This research adopts an explanatory-confirmatory studies framework and makes use of a quantitative technique. the selection of a quantitative approach stems from the goal to appraise current assumptions approximately causal relationships informed by using theoretical insights and earlier studies. because the model became predetermined consistent with the useful resource-primarily based View, the natural resource-primarily based View, Institutional principle, and Dynamic functionality idea, it famous a confirmatory element. The objective of data evaluation is to evaluate the version's alignment with empirical data (Sekaran & Bougie, 2020).

Data was gathered all at once using a cross sectional survey design. The food and beverage distribution company is the unit of analysis, and the person who represents the company that is, employes who have control over and knowledge of warehouse operations is the unit of observation. The population is made up of Indonesian food and beverage distribution businesses that either own or run warehouses. Non-probability purposive sampling was used since the population size cannot be precisely ascertained because no single sampling frame includes these businesses along with the features of their warehousing facilities.

Inclusion criteria required that respondents work for a company engaged in food and/or beverage distribution in Indonesia, have direct involvement in and adequate knowledge of warehousing, logistics, inventory, distribution, or warehouse facility management at either managerial or operational level, carry a minimum of twelve months of practical exposure to warehouse or logistics work, work for a company that owns and or operates its own or leased warehouse facilities, and be willing to complete the questionnaire fully. The minimum sample target was set at 245 respondents, equal to seven times the number of indicators; after completeness and quality screening, 246 usable responses remained, a figure that sits comfortably inside the indicator multiple of five to ten suggested by Hair et al. (2021).

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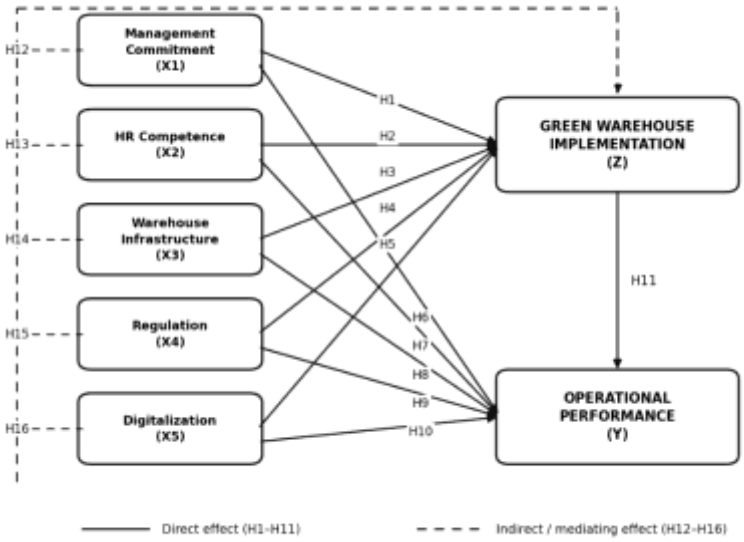
A two-part structured questionnaire serves as the research tool. The second has 35 statement items assessing seven constructs, each represented reflectively by five indicators, scored on a five-level agreement scale anchored at 1 (completely disagree) and 5 (completely agree). The first documents respondent and company characteristics. Management commitment (X1) was measured through environmental policy, budget and resource support, direct leadership involvement, sustainability targets, and evaluation and follow-up. Human resource competence (X2) was measured through green warehousing knowledge, technical operational skills, training and development programs, employee environmental awareness, and adaptability to technology. Warehouse infrastructure (X3) covered building design and envelope, energy-efficient lighting, refrigeration and cold chain systems, energy-efficient material handling equipment, and waste management facilities. Regulation (X4) covered compliance with environmental rules, policy clarity and consistency, government support and incentives, environmental standards and certification, and supervision and reporting obligations. Digitalization (X5) covered Warehouse Management System adoption, automatic identification technology, sensor- and IoT-based energy monitoring, data integration and inventory visibility, and data-driven decision making. Green warehouse implementation (Z) covered energy efficiency practices, waste management and reduction, layout and space optimization, environmentally friendly materials and packaging, and environmentally oriented operating procedures. Operational performance (Y) covered warehouse productivity, delivery timeliness, inventory accuracy, operational cost efficiency, and reduction of damaged and expired products.

Data were collected through online questionnaire distribution. Each questionnaire was preceded by an explanation of the research objective, a guarantee of data confidentiality, and a statement of voluntary consent. This approach was selected due to the research aim being predictive and explanatory concerning the dependent variables, rather than assessing the overall theoretical model fit, given the model's complexity with seven latent constructs and sixteen proposed pathways, and because SEM-PLS does not necessitate normality assumptions (Hair et al., 2021).

Analysis proceeded in two ranges. The outer model changed into judged from 4 angles: indicator loadings needed to attain zero.70, extracted variance needed to attain zero.50, discriminant validity become checked in opposition to the Fornell–Larcker rule, and internal consistency became study from three coefficients (alpha, rho_A, rho_c) with zero.70 as the ground. R-rectangular and the importance of path coefficients received through bootstrapping were utilized to evaluate the structural version (internal version), with importance determined at $p < 0.05$ and t-records exceeding 1.96. to categorise the mediation type, the significance of both indirect and direct pathways turned into integrated with the Variance Accounted For (VAF) as an indicator of impact size. A comprehensive collinearity evaluation became conducted to investigate commonplace method bias and control it systematically.

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Based on the phenomena, research gaps, and novelty outlined above, the study develops the conceptual framework presented in Figure 1.



Source: Processed by the author, 2026

Figure 1. Conceptual Framework

The characteristics of the 246 respondents are presented in Table 1. The profile shows that data were obtained from personnel who are directly involved in warehouse operations, across companies distributing food, beverages, or both, and across companies that own, lease, or combine both forms of warehouse ownership.

Table 1. Respondent Characteristics (n = 246)

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	187	76.0
	Female	59	24.0
Age	< 25 years	1	0.4
	25–34 years	98	39.8
	35–44 years	86	35.0
	45–55 years	61	24.8
Highest education	Diploma	3	1.2
	Senior/vocational high school	126	51.2
	Bachelor's degree	96	39.0
	Master's degree	21	8.5
Current position	Staff	151	61.4
	Supervisor	60	24.4
	Manager	35	14.2

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Characteristic	Category	Frequency	Percentage (%)
Length of service	1–3 years	96	39.0
	3–5 years	77	31.3
	> 5 years	73	29.7
Product type distributed	Food	72	29.3
	Beverages	78	31.7
	Food and beverages	96	39.0
Number of employees	> 50 employees	87	35.4
	> 100 employees	159	64.6
Warehouse ownership	Company-owned (asset)	108	43.9
	Leased	74	30.1
	Company-owned and leased	64	26.0
Total		246	100.0

Source: Primary data processed, 2026. Note: percentages are computed on n = 246 and may not sum to exactly 100 because of rounding.

RESULT AND DISCUSSION

Result

Evaluation of the Measurement Model (Outer Model)

The measuring model must be assessed to determine how effectively the indicators represent the latent variables before the relationships between the constructs are examined. Outer loadings were utilized to determine convergent validity at the indicator level; an indicator was regarded valid when its loading was larger than 0.70 (Hair et al., 2021). The results are shown in Table 2.

Table 2. Outer Loading Results

Item	X1	X2	X3	X4	X5	Z	Y
X1.1	0.830						
X1.2	0.817						
X1.3	0.801						
X1.4	0.794						
X1.5	0.823						
X2.1		0.845					
X2.2		0.806					
X2.3		0.773					

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Item	X1	X2	X3	X4	X5	Z	Y
X2.4		0.773					
X2.5		0.759					
X3.1			0.868				
X3.2			0.831				
X3.3			0.846				
X3.4			0.780				
X3.5			0.806				
X4.1				0.839			
X4.2				0.809			
X4.3				0.812			
X4.4				0.773			
X4.5				0.821			
X5.1					0.863		
X5.2					0.782		
X5.3					0.798		
X5.4					0.802		
X5.5					0.752		
Z.1						0.869	
Z.2						0.846	
Z.3						0.833	
Z.4						0.760	
Z.5						0.714	
Y.1							0.841
Y.2							0.835
Y.3							0.840
Y.4							0.819
Y.5							0.797

Source: SEM-PLS output, 2026. Notes: X1 = Management Commitment; X2 = Human Resource Competence; X3 = Warehouse Infrastructure; X4 = Regulation; X5 = Digitalization; Z = Green Warehouse Implementation; Y = Operational Performance.

Table 2 shows that every indicator has an outer loading of at least 0.70, with the lowest value of 0.714 on indicator Z.5 and the highest of 0.868 on indicator X3.1. Convergent validity at the indicator level is therefore satisfied and all 35 indicators represent their latent constructs adequately, so that no indicator needed to be removed from the model.

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Discriminant validity was then examined construct by construct: for each one, the AVE square root was placed against that construct's correlations with the remaining six. Table 3 sets out the comparison.

Table 3. Fornell-Larcker Discriminant Validity Results

	X1	X2	X3	X4	X5	Y	Z
X1	0.813						
X2	0.398	0.792					
X3	0.361	0.303	0.827				
X4	0.376	0.422	0.466	0.811			
X5	0.366	0.330	0.392	0.343	0.800		
Y	0.619	0.546	0.582	0.613	0.587	0.827	
Z	0.540	0.506	0.554	0.574	0.529	0.744	0.806

Source: SEM-PLS output, 2026

Table 3 indicates that the square root of the AVE for each construct regularly exceeds its correlation with the other constructs, with values ranging from 0.792 to 0.827. The execution of green warehouses and their operational efficacy have the most significant correlation (0.744), although this remains below the square root of the AVE for both constructions. Consequently, discriminant validity is achieved.

Table 4. Results of the Heterotrait-Monotrait Ratio (HTMT) Validity Test

Construct	X5	X3	Z	Y	X1	X2	X4
X5 – Digitalization							
X3 – Warehouse Infrastructure	0.440						
Z – Green Warehouse Implementation	0.608	0.627					
Y – Operational Performance	0.669	0.651	0.847				
X1 – Management Commitment	0.420	0.408	0.619	0.701			
X2 – Human Resource Competence	0.385	0.348	0.588	0.627	0.456		
X4 – Regulation	0.396	0.526	0.661	0.697			

Source: SEM-PLS output, 2026

A second discriminant check relied on the HTMT statistic, benchmarked against the conservative 0.85 cut-off proposed by Henseler et al. (2015). The highest HTMT value observed between the green warehouse installation and operational performance was 0.847, but all other values fell below 0.85. Consequently, discriminant validity was established for each construct.

Table 5 next reports construct-level convergent validity alongside three internal-consistency coefficients and the extracted variance for every construct.

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Table 5. Construct Reliability and Average Variance Extracted

Construct	Cronbach's alpha	rho_A	Composite reliability (rho_c)	AVE
X1 – Management Commitment	0.872	0.875	0.907	0.661
X2 – Human Resource Competence	0.851	0.852	0.894	0.627
X3 – Warehouse Infrastructure	0.884	0.894	0.915	0.684
X4 – Regulation	0.870	0.871	0.906	0.657
X5 – Digitalization	0.859	0.863	0.899	0.640
Y – Operational Performance	0.884	0.886	0.915	0.683
Z – Green Warehouse Implementation	0.864	0.871	0.902	0.650

Source: SEM-PLS output, 2026

Table 5 illustrates that each construct meets the reliability criteria. There is no evidence of indicator redundancy, Redundancy among indicators is not indicated: the three consistency coefficients occupy the bands 0.851–0.884, 0.852–0.894 and 0.894–0.915, all clearing 0.70 without approaching 0.95. Extracted variance lies between 0.627 and 0.684, so convergence at construct level holds. Consequently, the measurement model is both valid and reliable, rendering the structural results interpretable.

Evaluation of the Structural Model (Inner Model)

Explanatory power of the inner model was read from R^2, interpreted against the benchmarks in Hair et al. (2021), where figures approaching 0.25, 0.50 and 0.75 mark weak, moderate and strong prediction respectively. Table 6 displays the findings.

Table 6. R-Square Results

Endogenous construct	R-square	R-square adjusted
Y – Operational Performance	0.725	0.718
Z – Green Warehouse Implementation	0.585	0.577

Source: SEM-PLS output, 2026

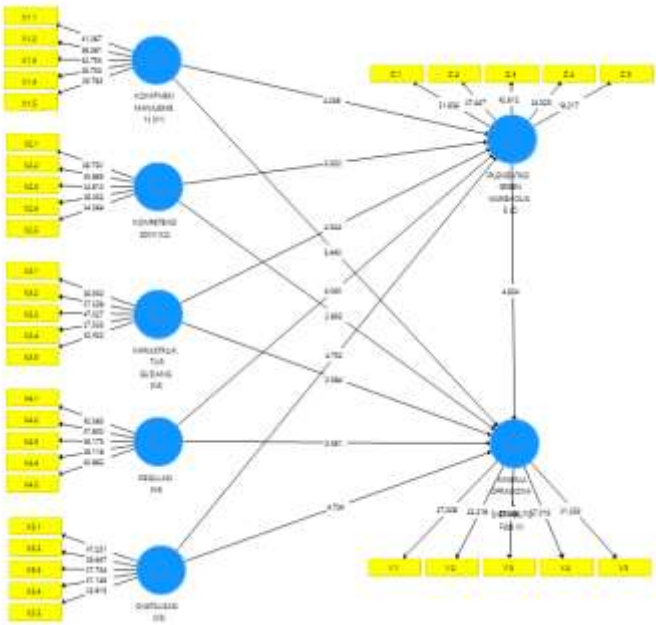
Table 6 demonstrates that operational performance had an R2 of 0.725 with an adjusted R2 of 0.718, indicating that management commitment, human resource competency, warehouse infrastructure, regulation, digitalization, and green warehouse implementation together account for 72.5% of the variance in operational performance. The five exogenous factors account for 58.5% of the

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variance in the green warehouse implementation, which had an R2 of 0.585 and an adjusted R2 of 0.577. The remaining amount can be attributed to factors outside the model, and both values show moderate to strong explanatory power.

Significance of the path coefficients was established through bootstrapping, with a five percent error rate as the decision rule. Table 7 displays the direct effect results, whereas Figure 2 displays the bootstrapping output.



Source: SEM-PLS output, 2026. Note: construct labels appear as named in the original SmartPLS model file, namely Komitmen Manajemen = Management Commitment; Kompetensi SDM = Human Resource Competence; Infrastruktur Gudang = Warehouse Infrastructure; Regulasi = Regulation; Digitalisasi = Digitalization; Implementasi Green Warehouse = Green Warehouse Implementation; Kinerja Operasional Distributor F&B = Operational Performance.

Figure 2. Structural Model Results Using the Bootstrapping Method

Table 7. Direct Effects (H1–H11)

Hypothesis	Path	O	M	STDEV	T statistic	P value	Decision
H1	X1 → Z	0.218	0.217	0.054	4.038	0.000	Supported
H2	X2 → Z	0.179	0.182	0.046	3.920	0.000	Supported
H3	X3 → Z	0.224	0.225	0.050	4.524	0.000	Supported
H4	X4 → Z	0.236	0.235	0.058	4.040	0.000	Supported
H5	X5 → Z	0.222	0.221	0.047	4.752	0.000	Supported
H6	X1 → Y	0.230	0.231	0.042	5.440	0.000	Supported
H7	X2 → Y	0.136	0.137	0.047	2.893	0.004	Supported
H8	X3 → Y	0.152	0.151	0.043	3.584	0.000	Supported

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Hypothesis	Path	O	M	STDEV	T statistic	P value	Decision
H9	X4 → Y	0.184	0.183	0.052	3.561	0.000	Supported
H10	X5 → Y	0.201	0.203	0.043	4.704	0.000	Supported
H11	Z → Y	0.255	0.251	0.052	4.854	0.000	Supported

Source: SEM-PLS output, 2026. Notes: O = original sample; M = sample mean; STDEV = standard deviation; P value 0.000 denotes p < 0.001.

Table 7 shows that all eleven direct paths are positive and significant at the 5 percent level. Within the group of determinants of green warehouse implementation, regulation records the largest coefficient (β = 0.236; t = 4.040), followed by warehouse infrastructure (β = 0.224; t = 4.524), digitalization (β = 0.222; t = 4.752), management commitment (β = 0.218; t = 4.038), and human resource competence (β = 0.179; t = 3.920). Within the group of determinants of operational performance, green warehouse implementation records the largest coefficient (β = 0.255; t = 4.854), followed by management commitment (β = 0.230; t = 5.440), digitalization (β = 0.201; t = 4.704), regulation (β = 0.184; t = 3.561), warehouse infrastructure (β = 0.152; t = 3.584), and human resource competence (β = 0.136; t = 2.893).

Mediation testing was then conducted to assess the role of green warehouse implementation in transmitting the effect of the exogenous variables to operational performance. The type of mediation was determined by combining the significance of the indirect and direct paths, and the magnitude of mediation was quantified through the Variance Accounted For. The results are presented in Table 8.

Table 8. Indirect Effects and Mediation Type (H12–H16)

Hypothesis	Path	O	STDEV	T statistic	P value	VAF (%)	Mediation type
H12	X1 → Z → Y	0.056	0.018	3.163	0.002	19.48	Complementary
H13	X2 → Z → Y	0.045	0.015	3.061	0.002	25.04	Complementary partial
H14	X3 → Z → Y	0.057	0.018	3.153	0.002	27.26	Complementary partial
H15	X4 → Z → Y	0.060	0.020	3.051	0.002	24.60	Complementary partial
H16	X5 → Z → Y	0.056	0.017	3.343	0.001	21.94	Complementary partial

Source: SEM-PLS output, 2026. Notes: VAF = Variance Accounted For, computed as the indirect effect divided by the total effect using unrounded output; all five hypotheses (H12–H16) are supported.

All five indirect paths are significant at the 5 percent level, so green warehouse implementation mediates the effect of every determinant on operational performance. Because the corresponding direct and indirect paths are significant and share the same positive sign, all five cases indicate complementary mediation.

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The VAF values range from 19.48% to 27.26%, indicating that the indirect contribution is relatively modest, while the direct effects remain dominant roughly one-fifth to slightly over one-quarter of the total effect travels through green warehouse implementation, while the majority remains direct. This finding could be obtained only because the model estimates the direct and indirect paths simultaneously.

Combining the direct and indirect effects yields the ranking of total effects on operational performance presented in Table 9.

Table 9. Decomposition of Total Effects on Operational Performance

Determinant	Direct effect	Indirect effect	Total effect	VAF (%)	Rank (total)
X1 – Management Commitment	0.230	0.056	0.286	19.48	1
X5 – Digitalization	0.201	0.056	0.257	21.94	2
X4 – Regulation	0.184	0.060	0.244	24.60	3
X3 – Warehouse Infrastructure	0.152	0.057	0.209	27.26	4
X2 – Human Resource Competence	0.136	0.045	0.181	25.04	5

Source: Processed from SEM-PLS output, 2026. Notes: total effect = direct effect + indirect effect; VAF is computed from unrounded output.

Discussion

1. Determinants of Green Warehouse Implementation (H1–H5)

The willpower of control exerts a huge and memorable influence at the execution of inexperienced warehouse practices (β = 0.218; t = four.038), hence validating H1. The endorsement of regulations and distribution of assets by using senior management propel the implementation of sustainable warehousing practices, in alignment with Tetteh et al. (2024) and Perotti and Colicchia (2023). In theory, this bolsters the aid-based View through framing management commitment as a big and tough-to-replicate intangible asset (Barney, 1991) and affirms that the choice to implement sustainable storage stems from higher management. In application, corporations require documented environmental rules, allotted funds, and quantifiable sustainability goals.

The skillability of human resources exerts a good and great affect at the execution of inexperienced warehouses (β = 0.179; t = 3.920), so validating H2, albeit with the bottom coefficient a number of the 5 pathways. This aligns with the findings of Cheng et al. (2023) and Perotti and Colicchia (2023), who understand insufficient understanding and skills as boundaries to energy efficiency in warehouses. The final results bolsters the human capital viewpoint, emphasizing that competence acts as an enabler instead of a catalyst. training packages should be

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applied after to the establishment of rules and facilities to effectuate changes in practice.

The infrastructure of warehouses exerts a large and useful have an effect on at the execution of green warehouse practices (β = 0.224; t = four.524), representing the second maximum coefficient some of the 5 pathways, as a consequence validating H3. bodily preparedness is a prerequisite for energy efficiency and waste management, as highlighted by means of Perotti and Colicchia (2023), Modica et al. (2021), and Cannava et al. (2024), who underscore the importance of the building envelope, illumination, refrigeration systems, material managing equipment, and renewable strength production. This reinforces the aid-based View regarding the element of exact sources. considering the bloodless chain requirements in food distribution, corporations must emphasize upgrades in refrigeration and illumination.

law exerts a widespread and favorable affect on the execution of inexperienced warehouses, evidenced through the highest coefficient on this category (β = zero.236; t = 4.040), thereby validating H4. The findings align with Tetteh et al. (2024) and bolster Institutional idea approximately the coercive strain mechanism (DiMaggio & Powell, 1983) with Stakeholder principle, for the reason that demands from principals and modern outlets parallel governmental rules. In practice, businesses must regard regulatory compliance as an initial step in preference to a very last destination, as compliance-driven operations frequently stop on the bare minimal.

Digitalization exerts a beneficial and substantial influence on the execution of green warehouses (β = 0.222; t = 4.752), presenting the greatest t-statistic among the five pathways, so validating H5, in alignment with Perotti et al. (2024). In theory, this bolsters Dynamic Capability Theory by framing digitalization as a competency for resource integration and reconfiguration, rather than merely a technology resource (Teece et al., 1997). Sensor-driven energy monitoring is advisable, as assessing energy efficiency measures is challenging without quantification.

2. Determinants of Operational Performance (H6–H11)

H6 is validated as operational performance is favorably and substantially encouraged with the aid of management dedication (β = 0.230; t = five.440; p < 0.001). This final results aligns with the research performed by way of Tetteh et al. (2023), which found out that the operational performance of supply chains is favorably inspired via the environmental dedication of top control, and Soesetyo et al. (2024), who highlighted the significance of pinnacle management's commitment in improving operational performance through deliver chain and technological practices. via imparting managerial dedication as an intangible organizational aid that complements technique area, useful resource allocation, and priority placing, the findings help the resource-based View. Empirically, the final results indicates that management commitment is represented within the distribution of assets, leadership participation, sustainability dreams, and operational pastime-assisting

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evaluation structures. The relatively massive route coefficient additionally means that operational performance in meals and beverage distribution is notably stimulated with the aid of managerial commitment.

H7 is substantiated with the aid of proof indicating that human aid talent exerts a fine and widespread affect on operational overall performance (β = 0.136; t = 2.893; p < 0.01). This finding aligns with the studies carried out through Sitorus et al. (2026), which discovered that human resource competency has a full-size and favorable effect on operational overall performance within Jakarta's logistics area. the discovery also lends credence to the human capital perspective via suggesting that operational efficacy is encouraged with the aid of the know-how, competencies, and adaptability of employes. able employes are greater adept at appropriately acting warehouse sports, running operational structures, responding to troubles, and making sure the reliability of approaches inside the context of meals and beverage distribution. however, the extraordinarily small coefficient shows that competence ordinarily functions as an allowing thing, and its contribution to operational overall performance is contingent upon the availability of good enough work structures and facilities. therefore, training need to be targeted on the improvement of abilities that are straight away applicable to the daily operations of warehouses and distribution facilities.

The speculation H8 is confirmed, indicating that warehouse infrastructure exerts a superb and full-size influence on operational overall performance (β = zero.152; t = three.584; p < zero.001). Rizkyansyah et al. (2021) additionally found a massive high quality impact of warehouse infrastructure on operational performance in the logistics and transportation area, that's consistent with this discovery. further, the invention bolsters the aid-based View by way of organising physical infrastructure as a tangible organizational resource that helps the efficient operation of operational processes. Smoother product movement, reduced choosing mistakes, and minimized product damage and expiration are all facilitated with the aid of the right warehouse architecture, fabric coping with device, storage facilities, and cold-chain infrastructure in meals and beverage distribution. Infrastructure by myself won't absolutely generate operational advantages except it is correctly translated into appropriate operating practices, as evidenced by using the smaller direct coefficient in contrast to the effect of infrastructure on inexperienced warehouse implementation.

Regulation exerts a useful and extensive affect on operational overall performance (β = zero.184; t = three.561; p < zero.001), thereby validating H9. This discovery aligns with the paintings of Ricardianto et al. (2023), who investigated the effect of shipment delivery laws on operational efficacy in Indonesia and illustrated that regulatory frameworks might have an effect on the performance of logistical activities. The finding supports Institutional idea through indicating that regulatory requirements create external pressures that inspire corporations to establish standardized approaches, documentation, and operational controls. In meals and

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beverage distribution, regulatory compliance can improve operational consistency via clarifying requirements for product managing, storage, documentation, and distribution sports. The wonderful however relatively smaller coefficient compared with the impact of regulation on inexperienced warehouse implementation shows that law contributes to operational performance often through establishing standardized running conditions in place of directly improving performance.

H10 is corroborated by means of evidence indicating that digitalization exerts a beneficial and vast impact on operational overall performance (β = 0.201; t = 4.704; p < 0.001). This revelation aligns with the research performed by Aninda and Karyani (2022), which indicated that deliver chain digitization improves operational performance in Indonesian companies. The effects align with the research conducted by using Rahayu et al., which found out that the adoption of technology and digitalization in virtual deliver chains positively impacts operational overall performance aspects which includes price efficiency, productiveness, and nice. the discovery bolsters Dynamic functionality theory through setting up digitalization as an organizational capability that enables firms to contain information, reconfigure tactics, and reply more swiftly to operational modifications. virtual structures, such as warehouse management structures, incorporated inventory statistics, and virtual monitoring, can beautify the accuracy of inventory, the visibility of processes, and the timeliness of deliveries in the food and beverage distribution enterprise. The rather excessive coefficient suggests that digitalization is a massive direct driving force of operational overall performance, no matter its function within the implementation of green warehouses.

The implementation of green warehousing techniques significantly enhances operating performance (β = 0.255; t = four.854; p < 0.001), therefore confirming H11. This finding corresponds with the studies conducted through Bartolini et al. (2019), Kanyepe et al. (2023), and Jayarathna et al. (2024), which together suggest that sustainable storage and logistics methods may want to enhance operational efficiency. Bartolini et al. (2019) highlight the importance of power conservation, the traits of warehouse structure, and environmentally sustainable warehouse control as important additives of sustainable warehousing. The finding bolsters the Triple bottom Line and natural aid-based View with the aid of illustrating that environmental efforts can provide operational benefits rather than being a change-off between ecological sustainability and performance. in the realm of food and beverage distribution, sustainable warehouse practices embody electricity-green operations, waste discount, optimized cloth dealing with, and progressed warehouse architecture to promote higher useful resource usage and operational efficacy. accordingly, funding priorities need to emphasize sustainable strategies that simultaneously improve operational performance and environmental outcomes.

3. The Mediating Role of Green Warehouse Implementation (H12–H16)

The implementation of green warehouse practices drastically moderates the impact of management dedication on operational overall performance (β = 0.056; t =

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three.163; p < 0.01), thereby corroborating H12, with a supplementary mediation effect and a VAF of 19.48%, indicating that the oblique have an effect on thru green warehouse practices is exceedingly minimum, while the direct impact remains dominant. This finding corresponds with Basana et al. (2022), who proved that the commitment of senior control improves operational performance thru sustainable procurement and manufacturing practices. This corresponds with the studies of Adusei et al. (2023), which indicates that the environmental willpower of senior management influences deliver chain operational efficacy, with sustainable supply chain control practices appearing as a mediator. the discovery bolsters the resource-based totally View via demonstrating that managerial determination enhances operational overall performance each as a direct organizational asset and through the cultivation of sustainable warehouse competencies. inside the realm of food and beverage distribution, managerial willpower can show up as operational improvements thru the availability of rules, sources, and leadership backing for green warehousing practices. The VAF of nineteen.48% indicates that the indirect impact of inexperienced warehouse implementation is minimum, however control commitment predominantly impacts operational overall performance thru its direct direction.

The execution of a green warehouse notably mediates the influence of human resource proficiency on operational performance (β = 0.045; t = 3.061; p < 0.01), so supporting H13, with a partial mediation that is complimentary and a VAF of 25.04%. This discovery aligns with the research of Sitorus et al. (2026), which indicated that human resource proficiency enhances operational effectiveness within the logistics sector. The findings endorse the human capital viewpoint, suggesting that employes' expertise, competencies, and flexibility can enhance operational efficiency via sustainable warehousing operations. In the realm of food and beverage distribution, proficient personnel may implement sustainable practices and utilize resources effectively. The VAF of 25.04% signifies that the use of green warehouses offers an alternative route for enhancing human resource proficiency, hence boosting operational performance.

The deployment of green warehouses considerably mediates the have an effect on of warehouse infrastructure on operational performance (β = zero.057; t = 3.153; p < 0.01), consequently supporting H14, with a supplementary partial mediation and a VAF of 27.26%. This end is corroborated via Perotti and Colicchia (2023), who pinpoint construction, utilities, illumination, and cloth control as essential aspects of sustainable garage. This aligns with the findings of Agyabeng-Mensah et al. (2020), which suggest that inexperienced warehousing enhances performance via sustainability-driven techniques. The findings corroborate the natural resource-based totally View, suggesting that warehouse infrastructure can grant the important assets for the adoption of sustainable practices and enhancement of operational performance. The VAF of 27.26% means that the

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adoption of inexperienced warehouse practices gives an alternative way through which warehouse infrastructure complements operational efficiency.

Green warehouse implementation significantly mediates the effect of regulation on operational performance ($\beta = 0.060$; $t = 3.051$; $p < 0.01$), so H15 is supported, with complementary partial mediation and a VAF of 24.60%. This finding supports Institutional Theory, indicating that regulatory requirements can encourage firms to adopt standardized green warehouse practices that subsequently improve operational performance. In food and beverage distribution, regulatory compliance can strengthen waste management, environmental procedures, energy efficiency, and operational controls. Previous research also identifies government regulations as an important driver of green warehousing adoption (Perotti & Colicchia, 2023). The VAF of 24.60% indicates that green warehouse implementation provides an additional pathway through which regulation contributes to operational performance.

Green warehouse implementation significantly mediates the effect of digitalization on operational performance ($\beta = 0.056$; $t = 3.343$; $p < 0.01$), so H16 is supported, with complementary partial mediation and a VAF of 21.94%. This finding supports Dynamic Capability Theory, indicating that digitalization enables firms to develop green warehouse capabilities while improving operational performance. Digital systems such as WMS, integrated inventory information, and digital monitoring can improve process visibility, resource efficiency, and operational accuracy. This finding is consistent with Šateikienė and Kovalevskaja (2026), who found that digitalization and WMS support green logistics practices by improving warehouse processes and resource efficiency. The VAF of 21.94% indicates that green warehouse implementation provides an additional pathway through which digitalization contributes to operational performance.

The novelty of this examine lies in demonstrating that the determinants of inexperienced warehouse implementation aren't always the same as those who most strongly affect operational performance. regulation is the most powerful predictor of inexperienced warehouse implementation, while control dedication has the most important overall impact on operational performance. Warehouse infrastructure ranks 2nd in predicting green warehouse implementation but has a decrease overall effect on operational performance. those findings endorse that law broadly speaking acts as an adoption driving force, while management dedication performs a stronger position in translating organizational resources into operational consequences. green warehouse implementation offers a complementary but partial pathway via which these determinants contribute to operational performance.

CONCLUSION

This research investigated the influence of management dedication, human resource proficiency, warehouse facilities, regulatory frameworks, and digital transformation on the execution of green warehouses and operational efficacy,

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alongside the mediating function of green warehouse implementation, utilizing data from 246 participants. All sixteen propositions were validated.

1. All five determinants have positive and significant effects on green warehouse implementation. Regulation is the strongest predictor (β = 0.236), followed by warehouse infrastructure (β = 0.224), digitalization (β = 0.222), management commitment (β = 0.218), and human resource competence (β = 0.179). Together, these variables explain 58.5% of the variance in green warehouse implementation.
2. Management commitment, human resource competence, warehouse infrastructure, regulation, digitalization, and green warehouse implementation positively and significantly affect operational performance. Green warehouse implementation has the strongest direct effect (β = 0.255), while the model explains 72.5% of operational performance.
3. Green warehouse implementation significantly mediates the effects of all five determinants on operational performance. All mediation paths are complementary partial mediation, with VAF ranging from 19.48% to 27.26%. Warehouse infrastructure has the highest mediation contribution, while management commitment has the lowest.
4. Based on the total effects, management commitment has the strongest overall influence on operational performance (0.286), followed by digitalization (0.257), regulation (0.244), warehouse infrastructure (0.209), and human resource competence (0.181). These findings confirm that the strongest determinant of green warehouse implementation is not necessarily the strongest determinant of operational performance.

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