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Evaluating the Impact of Warehouse Management Systems (WMS) Effectiveness, Technology Integration, and Organizational Support on Supply Chain Performance

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Abstract: The impact of technology integration and organisational support on the effectiveness of Warehouse Management Systems (WMS) in manufacturing companies is examined in this study, along with their effect on supply chain performance. A quantitative methodological approach was adopted, employing Structural Equation Modelling–Partial Least Squares (SEM-PLS) with SmartPLS as the analytical tool. The research model consists of four variables: technology integration, organisational support, WMS effectiveness and supply chain performance. The results of the SEM-PLS analysis indicate that technology integration has a significant positive effect on WMS effectiveness ($\beta = 0.478$, $p < 0.001$), as does organisational support ($\beta = 0.452$, $p < 0.001$). Furthermore, WMS effectiveness significantly improves supply chain performance ($\beta = 0.430$, $p < 0.001$) and mediates the effects of technology integration and organisational support on supply chain performance. The model explained 73.0% of the variance in WMS effectiveness and 72.5% of the variance in supply chain performance, indicating substantial explanatory power. The findings demonstrate that successful WMS implementation depends on technological integration and strong organisational support, including management commitment and employee readiness. By improving warehouse operational effectiveness, organisations can achieve better supply chain performance. This research contributes to supply chain management literature, providing practical guidelines for developing effective, integrated WMS implementation strategies.

Keywords: Warehouse, Supply Chain Performance, WMS, Technology Integration, Organizational Support, Digital Transformation.

INTRODUCTION

Manufacturing firms are facing growing pressure to maintain operational efficiency and supply chain responsiveness amid rapid market changes, increasing customer expectations, and intensified global competition. In this environment, the ability to manage the flow of materials, information, and products effectively has become a critical factor influencing organizational

performance and long-term competitiveness (Perotti et al., 2022; Purnomo & Syafranita, 2024). As supply chain activities become more interconnected, companies must ensure the effective flow of materials, information, and products across organizational functions and supply chain partners (A. A. Atieh et al., 2025; Flynn et al., 2010; Masa'deh et al., 2022).

Warehouse management has become a critical component of supply chain operations, influencing inventory visibility, operational efficiency, and supply chain responsiveness (Dzulkifli & Ernawati, 2021; Faber et al., 2013; Purnomo et al., 2025; Tikwayo & Mathaba, 2023; Vaičiūtė & Katinienė, 2025). To improve warehouse performance, organizations increasingly implement Warehouse Management Systems (WMS), which integrate and automate warehouse activities. Effective WMS implementation has been associated with improved inventory accuracy, higher operational efficiency, and enhanced logistics performance (Dzulkifli & Ernawati, 2021; Faber et al., 2013; Purnomo et al., 2025; Tikwayo & Mathaba, 2023; Vaičiūtė & Katinienė, 2025).

The emergence of Industry 4.0 and Logistics 4.0 has accelerated the adoption of digital technologies across supply chain operations. Technologies such as Enterprise Resource Planning (ERP), Radio Frequency Identification (RFID), Internet of Things (IoT), cloud computing, and real-time information systems have enabled organizations to improve operational visibility, information sharing, process synchronization, and decision-making quality. As a result, technology integration has become an important factor in supporting warehouse digitalization and enhancing supply chain performance (Canon et al., 2025; de Vass et al., 2018; Flynn et al., 2010; Jarašūnienė et al., 2023; Kmiecik, 2023; Ngaboyimbere et al., 2021).

The growing importance of warehouse digitalization is reflected in the rapid expansion of logistics and e-commerce activities worldwide. According to the World Bank Logistics Performance Index (LPI) (2023) logistics efficiency has become a critical determinant of national competitiveness, with supply chain reliability, digital visibility, and logistics service quality increasingly influencing economic performance and international trade competitiveness. In response to these challenges, manufacturing organizations have accelerated digital transformation initiatives to improve operational resilience, efficiency, and supply chain responsiveness. Deloitte (2024) highlights that manufacturers are increasingly embracing digital technologies to address ongoing operational and supply chain challenges.

The Indonesian context reflects similar developments. According to Statistics Indonesia (BPS, 2025), the warehousing, freight forwarding, and courier industries continue to expand alongside the growth of digital commerce. This trend has encouraged organizations to invest in modern warehouse systems that support faster, more accurate, and integrated distribution processes. Indonesia's e-commerce logistics market is projected to reach USD 6.7 billion in 2025 (Wibisono, 2025), highlighting the strategic role of warehouse management in supporting supply chain competitiveness. However, logistics efficiency remains a significant challenge, as Indonesia's logistics costs still account for approximately 23% of national GDP (Katadata Databoks, 2026). This condition indicates that many organizations continue to face operational challenges related to system integration, process efficiency, and supply chain visibility despite ongoing digital transformation efforts.

Despite ongoing digital transformation efforts, operational challenges remain evident in many manufacturing warehouses. Observations from A. M. Atieh et al. (2016) at the research revealed inventory discrepancies, delays in data updates, inconsistencies between physical and system records, and limited integration among operational information systems. Although a Warehouse Management System (WMS) had been implemented, its benefits were not

consistently realized due to fragmented technology integration, varying levels of system utilization, and inconsistent managerial support. These findings suggest that technology adoption alone is insufficient to improve operational performance without adequate organizational readiness, management commitment, and employee capability development (Kamble & Gunasekaran, 2019; Suri et al., 2024; Vaičiūtė & Katinienė, 2025).

Existing literature suggests that successful warehouse digitalization depends not only on technological capability but also on organizational readiness (Canon et al., 2025; Erna et al., 2019). However, many organizations continue to experience inventory inaccuracies, process inefficiencies, and limited operational visibility despite substantial investments in digital technologies. This indicates that technology adoption alone is insufficient to improve supply chain performance. Rather, the ability to effectively utilize WMS may serve as a critical mechanism through which technological and organizational resources are translated into operational and supply chain benefits.

To explain this phenomenon, this study adopts the Technology–Organization–Environment (TOE) framework as the primary theoretical foundation and the Resource-Based View (RBV) as a complementary perspective. TOE suggests that technology implementation success is influenced by technological and organizational factors, represented in this study by Technology Integration and Organizational Support (Louis et al., 1990). Meanwhile, RBV explains how these resources can be transformed into organizational value through operational capabilities (Jay Barney et al., 1991). In this context, WMS Effectiveness is viewed as a key capability that converts technological and organizational resources into improved Supply Chain Performance. Therefore, the integration of TOE and RBV provides a comprehensive framework for understanding how warehouse digitalization contributes to supply chain performance improvement.

Although previous studies have investigated warehouse management systems, supply chain digitalization, and technology adoption, several important research gaps remain. First, existing studies predominantly focus on the direct operational impacts of WMS implementation, while providing limited understanding of the mechanisms through which technological and organizational capabilities contribute to broader supply chain outcomes (Kodithuwakku et al., 2022; Saraswati & Amin, 2024). Second, prior research has rarely integrated the Resource-Based View and Technology–Organization–Environment perspectives into a unified empirical framework that explains warehouse digital transformation (Yu et al., 2026). Third, the mediating role of WMS effectiveness in translating organizational and technological resources into supply chain value remains underexplored, particularly within emerging economies where digital transformation maturity is still developing (Perotti et al., 2022; Vaičiūtė & Katinienė, 2025).

The novelty of this study lies in its integrated examination of warehouse digitalization from both technological and organizational perspectives. First, this study combines the Technology–Organization–Environment (TOE) framework and the Resource-Based View (RBV) to explain how technology integration and organizational support contribute to supply chain performance. Second, it positions WMS Effectiveness as a mediating capability that translates technological and organizational resources into operational and supply chain outcomes. Third, this study provides empirical evidence from Indonesian manufacturing companies, an emerging economy context that remains underrepresented in the warehouse digitalization literature. By testing these relationships within a single framework, this study offers a more comprehensive understanding of how digital warehouse initiatives enhance supply chain performance.

METHOD

This study employed a quantitative approach using an explanatory research design to examine the causal relationships among technology integration, organizational support, Warehouse Management System (WMS) effectiveness, and supply chain performance. The quantitative method was selected because the study aimed to empirically test the proposed hypotheses through statistical analysis and evaluate both direct and indirect relationships among latent variables.

Literature Review and Hypothesis development

Resource-Based View and Technology–Organization–Environment Framework

The Technology–Organization–Environment (TOE) framework, developed by Louis et al. (1990), serves as the primary theoretical foundation of this study. The TOE framework explains that the successful adoption and implementation of technology are influenced by three contextual dimensions: technological factors, organizational factors, and environmental conditions. This framework has been widely applied in studies related to digital transformation, information systems adoption, Industry 4.0 implementation, and supply chain digitalization because it provides a comprehensive explanation of how technological and organizational readiness affect the success of technology implementation.

In the context of this research, Technology Integration represents the technological dimension of the TOE framework, reflecting the extent to which digital technologies such as ERP, IoT, RFID, cloud systems, and WMS are interconnected and support organizational operations. Organizational Support represents the organizational dimension, encompassing management commitment, employee readiness, training programs, resource availability, and organizational culture that facilitate technology implementation. Accordingly, the TOE framework provides a strong theoretical basis for explaining how technological and organizational factors contribute to the effectiveness of Warehouse Management Systems (WMS).

To complement the TOE perspective, this study also draws upon the Resource-Based View (RBV) proposed by Jay Barney et al. (1991). RBV argues that superior organizational performance is achieved through the development and utilization of valuable organizational capabilities that are difficult for competitors to imitate. Rather than viewing technology itself as a source of competitive advantage, RBV emphasizes that organizational capabilities derived from the effective deployment of resources are the primary drivers of performance improvement. From the RBV perspective, WMS Effectiveness represents an operational capability through which technological and organizational resources are transformed into supply chain value and performance improvement. Meanwhile, the TOE framework explains how Technology Integration and Organizational Support influence the successful implementation and utilization of WMS. Together, TOE and RBV provide a complementary foundation for understanding how warehouse digitalization contributes to Supply Chain Performance.

Research Population and Sample

This study focuses on manufacturing and logistics companies that have implemented Warehouse Management Systems (WMS) as part of their operations and supply chains. The study focuses on organizations that utilize WMS to improve inventory accuracy, operational efficiency, and supply chain responsiveness. According to John W. Creswell (2009), A group

of individuals or organisations that share common characteristics is known as a population. These characteristics are relevant to the objectives of a study. In this study, the shared characteristic is the implementation of digital warehouse systems and supply chain integration practices.

The respondents involved in this research include logistics managers, warehouse supervisors, inventory controllers, operational managers, and supply chain practitioners who have direct experience with WMS implementation and warehouse operations. The following criteria were used to determine the samples : (1) companies had implemented WMS for at least two years; (2) respondents were involved in logistics, warehouse, or supply chain management activities; and (3) A minimum of two years of work experience in logistics or supply chain functions was held by the respondents. This study used purposive sampling, whereby respondents were selected based on specific criteria related to the research objectives.

Sugiyono (2013) explains that purposive sampling is a sampling technique based on particular considerations, especially when the researcher requires respondents who possess relevant knowledge and experience. Therefore, respondents were selected only if they were actively involved in logistics operations, digital system usage, and supply chain decision-making processes within their organizations.

The purposive sampling approach was considered appropriate because not all employees have sufficient understanding of warehouse digitalization and WMS implementation. By selecting respondents who are directly engaged in operational and managerial logistics activities, the study is expected to generate more reliable and meaningful findings. Sarstedt et al. (2021) also emphasize that in research using Structural Equation Modeling (SEM), respondents should possess adequate knowledge regarding the phenomenon being studied to ensure data quality and analytical accuracy.

The sample size for this study was calculated using the Partial Least Squares–Structural Equation Modeling (PLS-SEM) technique. Based on the findings of Hair et al. (2022), researchers can estimate the minimum sample size using the 10-times rule, by recommending their sample at least 10 times the size of the largest number of structural paths directed towards an endogenous construct. As the Supply Chain Performance variable has three direct relationships, the minimal requirement was a sample size of 30 respondents. Therefore, the total sample size of 100 respondents used in this study exceeds the minimum requirement for a PLS-SEM analysis.

This sample size is also supported by several previous studies. Chin & G. Marcoulides (1998) stated that PLS-SEM is suitable for studies with relatively small sample sizes as long as validity and reliability requirements are fulfilled. Marcoulides & Saunders (2006) further explained that a sample of 100 respondents is considered adequate for exploratory PLS-SEM research. In addition, a power analysis based on Cohen (1992) indicated that a minimum of 85 respondents was sufficient for this study, confirming that the sample size used meets the statistical requirements for SEM analysis.

Research Location and Period

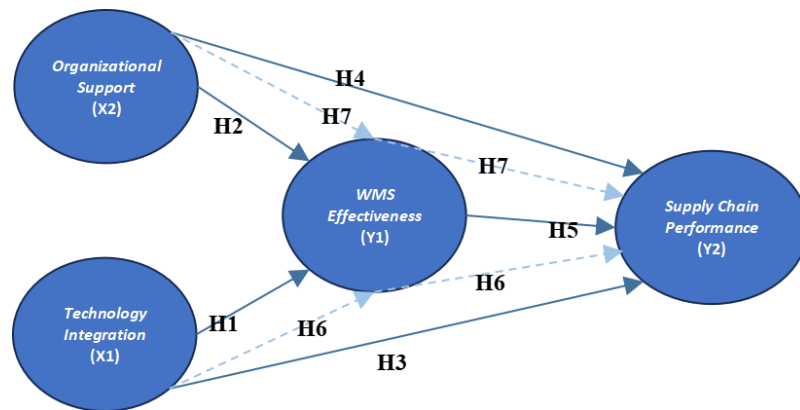
The study was conducted in manufacturing and logistics companies located in Central Java, Indonesia, particularly companies that had implemented digital warehouse systems. Data collection was carried out during the research period through direct observation, interviews, and questionnaire distribution.

The selection of manufacturing companies was based on the increasing implementation of digital technologies within warehouse and logistics operations, making this context relevant

for examining the relationship among technological readiness, supply chain performance, and organizational readiness.

Research Instrument and Variables

The conceptual framework of this study is presented in Figure 1. Based on the Technology–Organization–Environment (TOE) framework and the Resource-Based View (RBV), the model examines the effects of Technology Integration and Organizational Support on Supply Chain Performance, both directly and indirectly through WMS Effectiveness as a mediating variable.



Source: Research Results
Figure 1. Research Model

The primary data were collected using a structured questionnaire adapted from established studies and modified to fit the warehouse digitalization context. All items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

This study investigates four latent variables. Technology Integration (X1) refers to the extent of integration between WMS and supporting digital technologies such as ERP, IoT, RFID, and cloud-based systems. Organizational Support (X2) reflects managerial commitment, employee readiness, training programs, and organizational support for digital transformation. WMS Effectiveness (Y1) represents the operational benefits achieved through WMS implementation, including inventory accuracy, operational efficiency, processing speed, and service quality. Supply Chain Performance (Y2) refers to organizational logistics performance measured through responsiveness, delivery reliability, operational flexibility, customer service, and logistics efficiency.

The validity and reliability of the measurement instrument were assessed through convergent validity, discriminant validity, composite reliability, and Cronbach’s alpha before evaluating the structural relationships among the constructs.

Relationship Between Variables

Technology integration enhances information visibility, operational coordination, and data synchronization across warehouse activities, while organizational support strengthens the successful implementation of digital transformation through leadership commitment, employee readiness, and organizational adaptability (de Vass et al., 2018; Suri et al., 2024). Effective utilization of WMS further improves inventory accuracy, process efficiency, and operational responsiveness, which contribute to superior supply chain performance (Kodithuwakku et al., 2022; Tikwayo & Mathaba, 2023). Accordingly, this study proposes that WMS Effectiveness

functions as a mediating mechanism through which Technology Integration and Organizational Support are translated into improved Supply Chain Performance.

Technology Integration and WMS Effectiveness

Technology Integration refers to the extent to which digital technologies are interconnected and capable of exchanging information across organizational functions. In warehouse environments, the integration of ERP, RFID, IoT, cloud computing, and WMS enhances information visibility, operational synchronization, and decision-making quality (Canon et al., 2025; De Assis et al., 2024; de Vass et al., 2018). Previous studies indicate that integrated technologies improve inventory accuracy, process automation, and warehouse efficiency (Tikwayo & Mathaba, 2023; Vaičiūtė & Katinienė, 2025). Consistent with the TOE framework, technological capability is expected to enhance system utilization and operational effectiveness. Therefore, the following hypothesis is proposed:

H1: Technology Integration positively affects WMS Effectiveness.

Organizational Support and WMS Effectiveness

Organizational Support reflects the extent to which management commitment, leadership involvement, employee readiness, organizational culture, and training programs facilitate digital transformation initiatives. Although technological infrastructure is essential for successful WMS implementation, previous studies indicate that organizational factors often determine whether technology investments generate operational value (de Vass et al., 2018; Shchegoleva et al., 2023). Employees must possess adequate digital competencies, management must provide strategic direction, and organizations must establish supportive cultures capable of facilitating technological change.

According to the TOE framework, organizational readiness represents one of the primary determinants of successful technology implementation. Organizations with strong managerial support, effective communication systems, and continuous learning cultures tend to experience higher implementation success rates than organizations lacking these characteristics ((Kamble & Gunasekaran, 2019; Suri et al., 2024). Furthermore, RBV suggests that organizational capability itself constitutes a valuable strategic resource. Leadership commitment, employee expertise, and organizational learning mechanisms enable firms to maximize the utilization of technological assets and improve operational performance. Consequently, organizations that provide stronger support for digital transformation initiatives are expected to achieve greater WMS effectiveness.

H2: Organizational Support positively affects WMS Effectiveness.

Technology Integration and Supply Chain Performance

Supply Chain Performance refers to an organization's ability to achieve responsiveness, reliability, flexibility, efficiency, and customer satisfaction throughout supply chain operations. Technology integration has become increasingly important in modern supply chains due to the growing need for information visibility and real-time decision making. Integrated digital technologies enable organizations to synchronize activities across procurement, warehousing, transportation, and distribution functions (Kamble & Gunasekaran, 2019).

Research has consistently demonstrated that technology integration improves supply chain visibility, information quality, operational coordination, and logistics performance (de Vass et al., 2018; Hasahatan et al., 2025; Zhao et al., 2023). Organizations capable of integrating multiple digital technologies are better positioned to respond to market uncertainty,

improve delivery reliability, and reduce operational inefficiencies. From an RBV perspective, technological integration represents a strategic capability that directly contributes to organizational performance by improving process efficiency and operational flexibility. Therefore, organizations with higher levels of technology integration are expected to achieve superior supply chain performance.

H3: Technology Integration positively affects Supply Chain Performance.

Organizational Support and Supply Chain Performance

Organizational Support is a critical organizational factor that enables effective supply chain operations. According to the TOE framework, management commitment, employee readiness, and organizational culture influence an organization's ability to implement operational improvements and enhance supply chain effectiveness (Louis et al., 1990). Previous studies have shown that leadership support, organizational culture, and employee involvement contribute to better coordination, knowledge sharing, and operational performance across supply chain activities (Dubey et al., 2019; Erna et al., 2019; Zanon et al., 2021).

From the RBV perspective, organizational support represents a valuable organizational resource that strengthens a firm's capability to improve operational efficiency and responsiveness (Jay Barney et al., 1991). Therefore, organizations with stronger organizational support are expected to achieve superior supply chain performance. Furthermore, employee involvement and organizational learning contribute to knowledge sharing and innovation, which are essential for maintaining supply chain competitiveness in dynamic business environments (Suri et al., 2024). The Resource-Based View suggests that organizational support mechanisms constitute valuable organizational resources capable of generating superior performance outcomes. Accordingly, organizations demonstrating stronger organizational support are expected to achieve better supply chain performance.

H4: Organizational Support positively affects Supply Chain Performance.

WMS Effectiveness and Supply Chain Performance

Warehouse Management System Effectiveness refers to the extent to which WMS successfully improves warehouse operations through enhanced inventory accuracy, process efficiency, service quality, and operational responsiveness.

Warehouses represent critical nodes within supply chain networks. Consequently, warehouse effectiveness directly influences inventory availability, order fulfillment performance, transportation planning, and customer satisfaction (Faber et al., 2013). Previous studies have consistently reported that effective WMS implementation improves operational efficiency, reduces inventory discrepancies, enhances order accuracy, and shortens fulfillment lead times (Kodithuwakku et al., 2022; Tikwayo & Mathaba, 2023). These operational improvements ultimately contribute to broader supply chain performance outcomes.

Within the RBV framework, WMS effectiveness can be viewed as an operational capability that transforms organizational resources into measurable performance improvements. Organizations capable of effectively utilizing WMS are more likely to achieve superior logistics performance and supply chain competitiveness. Therefore, greater WMS effectiveness is expected to improve supply chain performance.

H5: WMS Effectiveness positively affects Supply Chain Performance.

The Mediating Role of WMS Effectiveness

Technology integration and organizational support are expected to improve supply chain performance through the effective utilization of Warehouse Management Systems. According to the Resource-Based View, organizational resources create value when they are transformed into operational capabilities (Jay Barney et al., 1991). In this context, Technology Integration and Organizational Support represent enabling resources, while WMS Effectiveness functions as an operational capability that translates these resources into performance outcomes. Similarly, the TOE framework suggests that technological and organizational readiness influence implementation outcomes through actual system utilization and operational effectiveness (Louis et al., 1990). Previous studies have also shown that digital technologies improve organizational performance only when they are effectively embedded within operational processes (Anugrah & Patil, 2023). Therefore, WMS Effectiveness is expected to mediate the relationships between Technology Integration, Organizational Support, and Supply Chain Performance.

H6: WMS Effectiveness mediates the relationship between Technology Integration and Supply Chain Performance.

H7: WMS Effectiveness mediates the relationship between Organizational Support and Supply Chain Performance.

Data Analysis Technique

The analysis of the data was executed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4 software. This analysis was conducted in two stages. First, we evaluated the measurement model to assess construct validity and reliability through outer loading, Average Variance Extracted (AVE), discriminant validity, Cronbach's alpha, and composite reliability. Second, we assessed the structural model using the coefficient of determination (R^2), path coefficients, t-statistics, and p-values obtained through the bootstrapping procedure. Additionally, we performed mediation analysis to examine the indirect effects of Technology Integration and Organizational Support on Supply Chain Performance through WMS Effectiveness.

RESULTS AND DISCUSSION

Respondent Profile

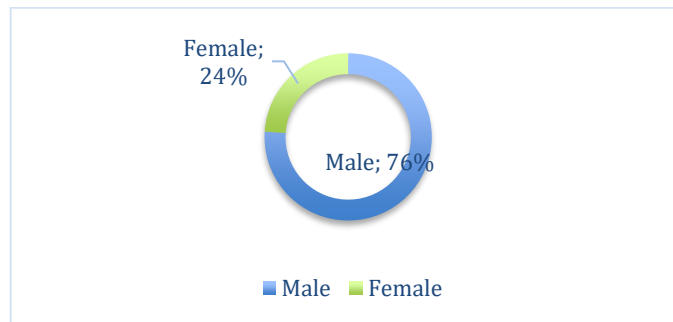
This study involved employees from manufacturing companies who were directly engaged in logistics, warehouse, and supply chain activities. The study's total participation count was 100 respondents. Respondents were selected from among those involved in warehouse, logistics and supply chain activities, in order to ensure that the collected data reflected operational and managerial perspectives related to the implementation of a Warehouse Management System (WMS).

The respondents represented a wide range of roles, genders, educational backgrounds and work experience. The selection of respondents was designed to ensure that participants had sufficient experience and understanding of the implementation of Warehouse Management Systems (WMS) and warehouse operations. The demographic profile of the respondents is summarized as follows :

Gender Distribution

The respondent composition is presented in Figure 2 and dominated by male participants. Overall, 76 of the respondents were males and 24 were females, indicating that operational and

logistics activities within manufacturing and warehouse environments are still primarily represented by male employees.

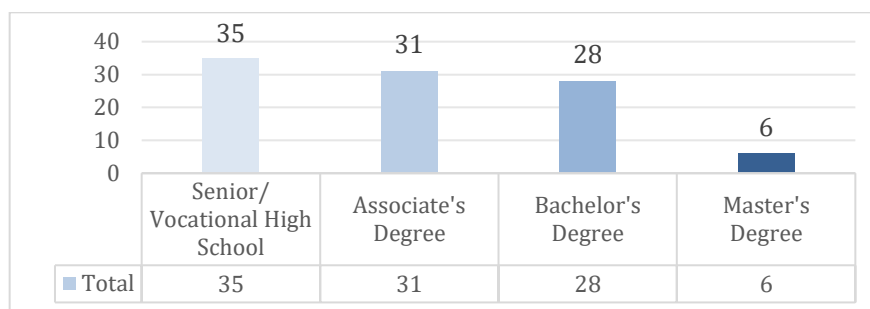


Source: Research Results

Figure 2. Respondents by Gender

Educational Background

The respondents possessed diverse educational backgrounds. The majority of respondents graduated from senior or vocational high school (35%), followed by Diploma III graduates (31%), bachelor degree holders (28%), and master degree holders (6%). The findings indicate that the majority of respondents had sufficient educational qualifications to understand warehouse operational systems and digital logistics processes.

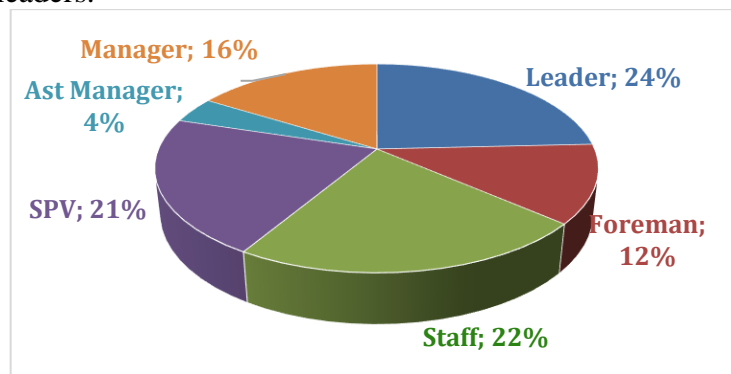


Source: Research Results

Figure 3. Respondents by Educational

Position Distribution

The respondents occupied various strategic and operational positions within the company, consisting of 16 managers, 4 assistant managers, 21 supervisors, 22 staff members, 12 foremen, and 24 leaders.



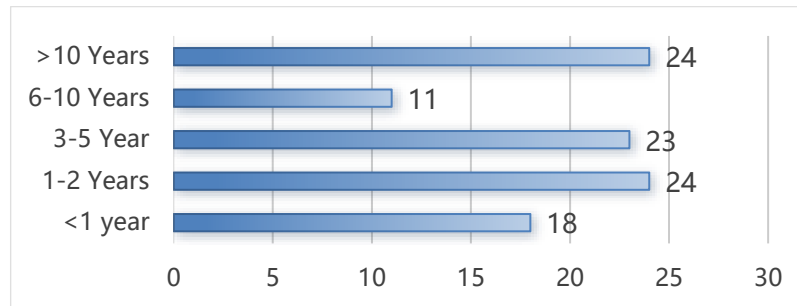
Source: Research Results

Figure 4. Respondents by Position Distribution

Questionnaire distribution was prioritized toward leadership and supervisory levels because these positions are directly involved in operational decision-making and warehouse management activities.

Work Experience

Most respondents had considerable professional experience in logistics and warehouse operations. Respondents with less than one year of experience accounted for 18%, while 24% had one to two years of experience, 23% had three to five years, 11% had six to ten years, and 24% had more than ten years of work experience.



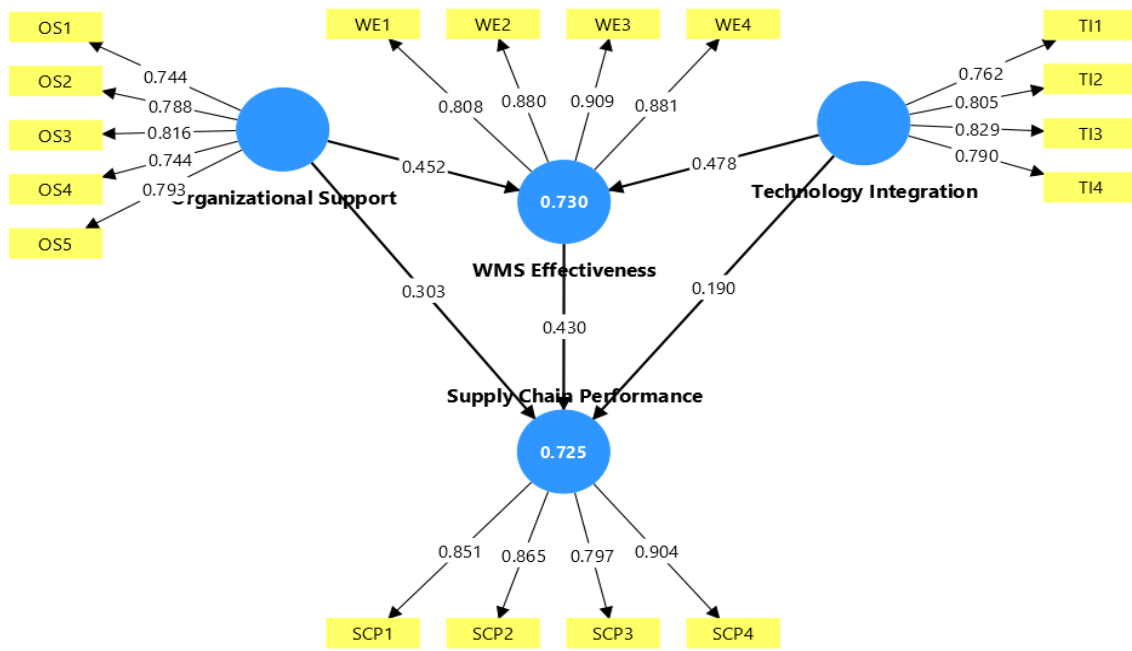
Source: Research Results

Figure 5. Respondents by Work Experience

These findings suggest that the respondents possessed adequate practical knowledge and professional experience to provide reliable assessments regarding WMS implementation and supply chain operations. Overall, the respondent profile demonstrates that the study involved participants with relevant educational backgrounds, operational responsibilities, and professional experience, thereby strengthening the credibility and reliability of the collected data. The respondent profile indicates that the majority had more than two years of experience in logistics and warehouse operations, suggesting that the collected responses adequately represented organizational practices related to warehouse digitalization and supply chain activities.

Measurement Model Evaluation (Outer Model)

Before proceeding to hypothesis testing, the measurement model evaluation was conducted to assess its validity and reliability. The assessment included Convergent validity, Discriminant validity, and Reliability analysis. Furthermore, the structural model was assessed to examine the direct and indirect relationships among Technology Integration, Organizational Support, WMS Effectiveness, and Supply Chain Performance. The model also demonstrates the explanatory power of the proposed framework based on the SEM-PLS results. The structural model (outer model) presented in Figure 6 illustrates the causal relationships among the latent variables developed in this study.



Source: Research Results
Figure 6. Bootstrapping Graphic

From a measurement perspective, all constructs are represented by indicators with acceptable outer loading values. This suggests that each indicator accurately represents its respective latent variable. Organizational Support shows loading values ranging from 0.744–0.816, Technology Integration ranges from 0.762–0.829, WMS Effectiveness ranges from 0.808–0.909, and Supply Chain Performance ranges from 0.797–0.904. These results indicate that all indicators have sufficient contribution in measuring their respective constructs and demonstrate satisfactory measurement quality.

The structural model also shows positive relationships among variables. Organizational Support ($\beta = 0.452$) and Technology Integration ($\beta = 0.478$) positively influence WMS Effectiveness. Meanwhile, Supply Chain Performance is directly influenced by Organizational Support ($\beta = 0.303$), Technology Integration ($\beta = 0.190$), and WMS Effectiveness ($\beta = 0.430$). The model's explanatory power is strong, as evidenced by its R^2 values of 0.730 for WMS Effectiveness and 0.725 for Supply Chain Performance. These figures indicate that the proposed research model significantly explains the endogenous variables.

Measurement Model Evaluation (Outer Model)

One of the key stages in evaluating an outer model is testing convergent validity through outer loadings. These outer loadings show how strongly the indicators are correlated with their construct variables.

Table 1. Outer Loadings

	Organizational Support	Supply Chain Performance	Technology Integration	WMS Effectiveness
OS1	0.744			
OS2	0.788			
OS3	0.816			
OS4	0.744			

	Organizational Support	Supply Chain Performance	Technology Integration	WMS Effectiveness
OS5	0.793			
SCP1		0.851		
SCP2		0.865		
SCP3		0.797		
SCP4		0.904		
TI1			0.762	
TI2			0.805	
TI3			0.829	
TI4			0.79	
WE1				0.808
WE2				0.880
WE3				0.909
WE4				0.881

Source: Research data

The outer loading results show that all indicators exceeded the recommended threshold of 0.70, confirming adequate convergent validity and supporting the suitability of the measurement model for further analysis.

Discriminant Validity

The next stage involved evaluating discriminant validity in order to confirm that each construct in the model represents a unique concept and avoids overlap with other constructs. For this study, the Heterotrait–Monotrait Ratio (HTMT) approach was used in SmartPLS to assess discriminant validity. This approach is considered to be more sensitive and reliable than traditional methods such as cross-loading and the Fornell–Larcker criterion. Generally, discriminant validity is considered acceptable when HTMT values are below 0.90, though values below 0.85 are preferred for more stringent confirmatory studies.

Table 2. Discriminant Validity

	Organizational Support	Supply Chain Performance	Technology Integration	WMS Effectiveness
Organizational Support				
Supply Chain Performance	0.896			
Technology Integration	0.824	0.871		
WMS Effectiveness	0.899	0.914	0.912	

Source: Research data

The results showed table 2, The HTMT results indicate that most construct relationships met the recommended threshold, including Organizational Support–Supply Chain Performance (0.896), Technology Integration–Supply Chain Performance (0.871), Technology Integration–Organizational Support (0.824), and WMS Effectiveness–Organizational Support (0.899). These findings confirm that the constructs are conceptually distinct and acceptable discriminant validity has been demonstrated.

However, the relationships between WMS Effectiveness–Supply Chain Performance (0.914) and WMS Effectiveness–Technology Integration (0.912) slightly exceeded the recommended threshold. This suggests a strong association among these constructs, reflecting the close linkage between technological integration, WMS effectiveness, and supply chain performance. Given the small deviation and strong theoretical support, the discriminant validity remains acceptable for this study.

Construct Reliability and Average Variance Extracted (AVE)

Average Variance Extracted (AVE) was assessed to evaluate convergent validity. In SEM-PLS, an AVE value above 0.50 indicates that a construct explains more than half of the variance of its indicators, confirming adequate representation of the latent variables.

Table 3. Construct Reliability and Validity AVE

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Organizational Support	0.836	0.839	0.884	0.605
Supply Chain Performance	0.877	0.883	0.916	0.731
Technology Integration	0.809	0.811	0.874	0.635
WMS Effectiveness	0.893	0.897	0.926	0.757

Source: Research data

Based on Table 3, all constructs achieved AVE values above the recommended threshold of 0.50, confirming adequate convergent validity. The AVE values ranged from 0.605 to 0.757, indicating that the constructs sufficiently explain the variance of their indicators and that the measurement model is suitable for further analysis.

Convergent Validity

The evaluation of convergent validity was done using factor loading values and Average Variance Extracted (AVE). To confirm acceptable construct validity, indicator loadings should exceed 0.70, and AVE values should be greater than 0.50, according to the recommended criteria.

Table 4. Convergent Validity

	R-square	R-square adjusted
Supply Chain Performance	0.725	0.717
WMS Effectiveness	0.73	0.724

Source: Research data

The Convergent Validity results presented in Table 4 show that all indicators have acceptable validity and can adequately represent their respective constructs. Results from the structural modelling evaluation further suggest that the proposed research design has strong explanatory power. Supply Chain Performance achieved R² and Adjusted R² values of 0.725 and 0.717 respectively, meaning that 72.5% is explained by the included independent variables, with the remaining 27.5% influenced by factors outside the scope of this study. Similarly, WMS effectiveness obtained an R² value of 0.730 and an adjusted R² value of 0.724, showing that 73.0% of its variance is explained by the exogenous variables in the model. The small differences between the R² and adjusted R² values for both endogenous variables suggest that the model is stable and has good predictive accuracy.

Significant Path Coefficient Validity

After the measurement model (outer model) was confirmed to meet the required validity and reliability criteria, the evaluation proceeded to the structural model (inner model) through path coefficient analysis and bootstrapping to examine the proposed hypotheses. The results of the SEM-PLS analysis can be seen in table 5.

Table 5. Significant Path Coefficient Validity

	Original sample (O)	Sample mean (M)	Standard Deviation (STDEV)	T statistics (O/STDEV)	P values
Organizational Support -> Supply Chain Performance	0.303	0.317	0.138	2.191	0.028
Organizational Support -> WMS Effectiveness	0.452	0.45	0.073	6.170	0
Technology Integration -> Supply Chain Performance	0.190	0.188	0.090	2.122	0.034
Technology Integration -> WMS Effectiveness	0.478	0.478	0.072	6.660	0
WMS Effectiveness -> Supply Chain Performance	0.430	0.411	0.121	3.561	0

Source: Research data

Based on the Convergent Validity results presented in Table 5, The results indicate that all relationships among constructs are positive and statistically significant, as reflected by T-statistics values above 1.96 and P-values below 0.05. Technology Integration demonstrated the strongest influence on WMS Effectiveness ($\beta = 0.478$; $T = 6.660$; $P = 0.000$), followed by Organizational Support ($\beta = 0.452$; $T = 6.170$; $P = 0.000$), indicating that both technological readiness and organizational support are critical factors in achieving effective WMS implementation. In addition, Supply Chain Performance was positively influenced by WMS Effectiveness ($\beta = 0.430$; $T = 3.561$; $P = 0.000$), Organizational Support ($\beta = 0.303$; $T = 2.191$; $P = 0.028$), and Technology Integration ($\beta = 0.190$; $T = 2.122$; $P = 0.034$).

Overall, these findings suggest that effective WMS implementation plays a strategic role in connecting organizational and technological capabilities to improved supply chain performance, highlighting that sustainable operational improvements require not only advanced technology but also strong organizational support.

Significant Path Coefficient Validity

The mediation effect analysis was conducted to examine whether WMS Effectiveness serves as an intervening mechanism linking Organizational Support and Technology Integration to Supply Chain Performance. The results show that both indirect relationships are positive and statistically significant. The results of the mediation effect analysis can be seen in Table 6.

Table 6. Mediation Effect Analysis

	Original sample	Sample mean	Standard deviation	T statistics (O/STDEV)	P values
Organizational Support -> WMS Effectiveness -> Supply Chain Performance	0.194	0.183	0.058	3.344	0.001
Technology Integration -> WMS Effectiveness -> Supply Chain Performance	0.205	0.199	0.072	2.871	0.004

Source: Research data

The indirect effect of Organizational Support → WMS Effectiveness → Supply Chain Performance produced a coefficient of 0.194 (T = 3.344; P = 0.001), indicating that stronger organizational support enhances supply chain performance by improving the effectiveness of WMS implementation. Similarly, the indirect relationship of Technology Integration → WMS Effectiveness → Supply Chain Performance generated a coefficient of 0.205 (T = 2.871; P = 0.004), demonstrating that better technological integration contributes to higher supply chain performance through more effective WMS utilization. These findings confirm overall that WMS effectiveness mediates significantly, suggesting that improvements in supply chain performance are achieved not only through organisational and technological factors, but also through a company’s ability to optimise WMS implementation within logistics operations.

Discussion

This finding is consistent with Erna et al. (2019), who found that organizational collaboration and innovation-oriented capabilities positively influence supply chain performance in Indonesian logistics companies. The positive influence of technology integration suggests that the integration of digital technologies enhances information visibility, operational coordination, and warehouse process efficiency. This finding supports the Technology–Organization–Environment (TOE) framework, which emphasizes the role of technological readiness in successful system implementation, and is consistent with previous studies highlighting the benefits of integrated digital technologies in warehouse operations (de Vass et al., 2018; Tikwayo & Mathaba, 2023)

The significant effect of organizational support demonstrates that successful warehouse digitalization requires more than technological investment. This study is consistent with the findings of Mulyati (2020), who reported that organisational collaboration and innovation capabilities are key drivers of improved supply chain performance in logistics organisations. The significant impact of organisational support shows that successful warehouse digitalisation requires more than just technological investment. This finding serves to reinforce the organisational element of the TOE framework and is in alignment with preceding studies that have placed significant emphasis on the pivotal role of organisational readiness in digital transformation initiatives (Kamble & Gunasekaran, 2019; Suri et al., 2024).

Furthermore, the results reveal that technology integration, organizational support, and WMS effectiveness contribute positively to supply chain performance. Among these relationships, WMS effectiveness exhibits the strongest influence, indicating that effective warehouse operations play a critical role in improving responsiveness, inventory accuracy, logistics efficiency, and delivery reliability. From the Resource-Based View (RBV) perspective, WMS effectiveness can be viewed as an operational capability through which technological and organizational resources are transformed into superior supply chain performance. Overall, the findings support the complementary roles of TOE and RBV in explaining how technological and organizational factors jointly enhance supply chain outcomes through effective warehouse management practices.

CONCLUSION

This study examined the relationships among Technology Integration, Organizational Support, WMS Effectiveness, and Supply Chain Performance within manufacturing companies. The findings confirm that Technology Integration and Organizational Support significantly enhance WMS Effectiveness and Supply Chain Performance. In addition, WMS Effectiveness was found to have a significant positive impact on Supply Chain Performance and serves as an important mediating mechanism through which technological and organizational capabilities generate operational value.

In theory, this study adds to the existing literature on supply chain and warehouse management by integrating the Technology–Organization–Environment (TOE) framework and the Resource-Based View (RBV) into a unified modelling approach. The findings show that technology and organizational readiness influence performance not only directly but also indirectly through the effectiveness of warehouse management systems, thereby providing a more comprehensive explanation of warehouse digital transformation.

From a practical point of view, these results indicate that manufacturing companies are better off not only adopting technology, but also strengthen organizational support, employee readiness, and managerial commitment to maximize the benefits of warehouse digitalization. By aligning technological capabilities with organizational resources, firms can improve warehouse operations, inventory visibility, logistics responsiveness, and overall supply chain performance.

The study has several limitations. Firstly, the research focused on manufacturing companies in Central Java, which may limit the generalisability of the findings. Secondly, the study used a cross-sectional design. Further research could explore different geographical areas and industrial sectors, examining additional factors such as environmental uncertainty, digital maturity and supply chain resilience, in order to gain a more comprehensive overview of warehouse digital transformation and its impact on performance.

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