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Email : editorijhess@gmail.com

Analysis Of The Implementation Of A Portable Data Terminal (PDT)-Based Warehouse Management System In Increasing Warehouse Productivity And Cost Efficiency At XYZ Company

Irsyad Thalib Abdillah[1)], Ebi Suryana[2)], Muhammad Ghalib Massaid Waryanto[3)]
[1,2,3)] Industrial Engineering Study Program, Universitas Setia Budhi Rangkasbitung

*Corresponding Author
Email : irsyad.thalib10@gmail.com

Abstract

The Indonesian logistics industry is currently facing pressure to achieve operational efficiency due to the rapid growth of e-commerce. Many warehouses still rely on manual processes, leading to inventory inaccuracies and suboptimal distribution. This study aims to analyze the impact of implementing a Warehouse Management System (WMS) integrated with a Portable Data Terminal (PDT) on the operational performance of XYZ Company. Using a mixed-methods case study approach, data was collected through structured observations, interviews with 25 key personnel, and historical document analysis. This study used Current Value Stream Mapping to identify operational waste and measure performance through cycle time, lead time, and process cycle efficiency. The results showed that the implementation of WMS-PDT significantly improved operational performance, reducing incoming process cycle time by 62% and outgoing process time by 50%. Furthermore, this digital transformation successfully minimized wasteful waiting and motion time, resulting in a reduction in inventory costs of IDR 13.7 billion with a benefit-to-cost ratio of 3.25:1. The study concluded that the integration of PDT into the WMS provides a robust framework for real-time data capture, effectively improving operational accuracy and service levels. These findings provide a strategic roadmap for logistics companies to leverage digital technologies to increase competitiveness.

Keywords: Logistics Efficiency, Supply Chain Management, Warehouse Management System, Portable Data Terminal, Digital Transformation.

INTRODUCTION

The logistics and warehousing industry is currently undergoing a profound digital transformation, driven by the demand for operational efficiency and instant distribution speed amidst the growth of global and national e-commerce. Globally, the adoption of Warehouse Management Systems (WMS) has become a major trend since 2023, with the integration of technologies such as IoT and AI capable of increasing inventory accuracy by up to 40% and reducing picking process times by 30% (Sakinah, 2025; 6Wresearch, 2025). In Indonesia, the warehousing sector is projected to grow by 12.53% in 2025, supported by government infrastructure policies that accelerate supply chain digitalization, making it both scientifically relevant for understanding operational dynamics and practically relevant for logistics companies in reducing costs (Chen & Damian, 2024; Intramega Global, 2025).

Furthermore, the specific context in Indonesia demonstrates a field phenomenon where many warehouses still rely on manual or semi-digital systems, leading to anomalies such as stock inaccuracies and distribution delays, as seen in Company XYZ with increased operational costs due to minimal real-time data visibility (Alamsah et al., 2024; Akhmad & Prawirosastro, 2026). Empirical data from the PT Shippindo Logistics case study confirms that prior to WMS, stock recording errors reached a high level, which could only be reduced after the adoption of automated technology (Sakinah, 2025).

Previous research has shown that WMS significantly improves warehouse efficiency through inbound-outbound process automation and RFID integration, with key findings showing productivity increases of up to 40% across various industry scenarios (Budiyanto & Muslim, 2024; Sakinah, 2025). However, these studies generally focus on general WMS implementations without a deeper focus on synergies with Portable Data Terminals (PDTs), which enable point-of-activity data verification to instantly reduce human error (Chen & Damian, 2024).

However, research findings regarding implementation challenges are inconsistent; some studies report long-term cost reductions through RFID-WMS (Akhmad & Prawirosastro, 2026), while others highlight barriers such as the lack of standardization of warehouse processes and high costs for SMEs in Indonesia, which limit scalability (6Wresearch, 2025; 6Wresearch, 2025). Methodological limitations in previous studies often lie in general quantitative approaches without specific case analysis of local companies, as well as a lack of contextual evaluation of RFID integration against operational bottlenecks (Alamsyah et al., 2024).

An explicit research gap lies in the lack of holistic studies on PDT-based WMS implementation in the context of Indonesian logistics companies like XYZ Company, where manual systems still dominate and lead to stock inefficiencies and low productivity. This problem statement emphasizes the need for an in-depth analysis of how WMS-PDT synergy can empirically transform operational accuracy, reduce costs, and improve service levels.

This study aims to analyze the impact of PDT-based WMS implementation on warehouse operational performance at XYZ Company, with high urgency considering the national logistics growth in 2025–2026 that demands rapid digital adaptation. The novelty lies in PDT's integrative approach to real-time data capture that has not been specifically explored in the local context, differing from previous general studies; the theoretical contribution enriches the supply chain digital transformation literature, while the practical one provides an optimization roadmap for similar companies to increase competitiveness (Budiyanto & Muslim, 2024; Sakinah, 2025).

RESEARCH METHODS

Penelitian ini mengadopsi desain studi kasus kualitatif dengan pendekatan mixed methods yang dominan deskriptif-analitis, bertujuan untuk menggali dinamika operasional gudang secara mendalam sebelum dan sesudah intervensi digital melalui Warehouse Management System (WMS) berbasis Portable Data Terminal (PDT). Pendekatan ini dipilih karena kemampuannya dalam memvisualisasikan alur proses secara holistik, mengidentifikasi pemborosan, dan mengevaluasi dampak transformasi teknologi pada konteks spesifik Perusahaan XYZ, sebagaimana direkomendasikan dalam kerangka studi kasus eksploratif (Yin, 2018; Sugiyono, 2023). Selain itu, integrasi elemen kuantitatif seperti pengukuran cycle time dan lead time memperkuat validitas temuan, sesuai dengan praktik mixed methods dalam penelitian manajemen rantai pasok terkini (Creswell & Plano Clark, 2021; Hidayat & Sari, 2024).

Populasi penelitian mencakup seluruh aktivitas operasional gudang Perusahaan XYZ di Depok, Jawa Barat, dengan fokus pada 25 karyawan inti yang terlibat dalam proses incoming, storage, dan outgoing, serta tiga manajer tingkat menengah sebagai pemangku kepentingan utama. Teknik purposive sampling digunakan untuk memilih partisipan berdasarkan kriteria inklusi seperti pengalaman minimal dua tahun di area gudang dan keterlibatan langsung dalam proses manual, sementara eksklusi diterapkan pada staf administratif non-operasional untuk menjaga relevansi data lapangan (Sudaryono, 2022; Emzir, 2021). Pemilihan sampel ini didasarkan pada saturasi data, di mana wawancara dan observasi dihentikan setelah tidak ada informasi baru yang muncul, konsisten dengan standar kualitatif dalam studi logistik Indonesia (Nugroho & Pratama, 2023).

Instrumen penelitian terdiri dari lembar observasi terstruktur untuk memetakan aktivitas dan waktu siklus, panduan wawancara semi-terstruktur dengan indikator seperti tingkat kesalahan stok dan bottleneck proses, serta formulir dokumentasi untuk analisis laporan historis. Validitas instrumen diuji melalui triangulasi sumber data dan uji pilot pada lima partisipan awal, sementara reliabilitas dicapai dengan pendekatan inter-rater reliability antarpeneliti, mencapai koefisien Cronbach's alpha 0,87 untuk metrik kuantitatif (Sugiyono, 2023; Taherdoost, 2022). Indikator utama meliputi cycle time, lead time, value added (VA), non-value added (NVA), dan process cycle efficiency (PCE), yang disesuaikan dengan prinsip Lean Warehouse untuk memastikan kesesuaian dengan tujuan penelitian (Womack & Jones, 1996; Chen & Damian, 2024).

The research procedure was carried out chronologically starting from the preparation stage in the form of coordination with the management of XYZ Company to obtain field access for two weeks in May 2026, followed by data collection through direct observation for 40 working hours, documentation study of the 2025 monthly report, and interviews with 28 participants. Next, the data was processed into Current Value Stream Mapping (CVSM) to identify seven wastes, followed by the development of alternative WMS-PDT solutions and cost-benefit analysis, with scientific justification based on process simulation to predict a reduction in lead time of up to 35% (Rother & Shook, 2003; Alamsah et al., 2024). Each step was documented in detail to support replicability.

The data analysis technique combined quantitative descriptive analysis using Microsoft Excel and Minitab to calculate metrics such as PCE, productivity, and efficiency, with qualitative thematic analysis through data reduction, waste categorization, and step-by-step inferences to confirm inefficiency patterns. This approach aligned with the objective of measuring the impact of WMS-PDT, where qualitative data from interviews was quantified into VA/NVA percentages, while inferences were made through pre-post comparisons of simulation implementations (Emzir, 2021; Braun & Clarke, 2021). NVivo software was used to cluster waste identification themes, ensuring comprehensive analysis depth.

Ethical considerations for the study included providing written informed consent to all participants, ensuring the confidentiality of XYZ Company's identity and personal data through code anonymization, and obtaining formal approval from management prior to data collection. There were no significant physical or psychological risks, and all data was securely stored in an encrypted cloud with restricted access, in accordance with Indonesian research ethics guidelines from the University Research Ethics Commission (Sugiyono, 2023; Resnik, 2022). Ethical clearance was obtained from the Depok Research Ethics Institute in April 2026, ensuring compliance with international standards.

RESULTS AND DISCUSSION

Identification of Actual Conditions and Waste

Based on field observations and value stream mapping using Current Value Stream Mapping (VSM), it was found that warehouse operations at XYZ Company are still dominated by manual processes, leading to significant inefficiencies. Actual conditions indicate that the lead time for incoming processes reaches 5.4 days, while the outgoing process takes 1.7 days. This high duration is caused by the accumulation of unfinished stock and delays in data synchronization with the SAP system.

Through the Seven Waste analysis, three dominant waste categories were identified: Waiting, Motion, and Transportation. Waiting time was the largest, totaling 252 minutes per pallet, driven by document verification queues and manual administrative processes. Furthermore, there was 69 minutes of motion waste per pallet, as operators had to travel back and forth from the field to the office just to input data into the computer. This was exacerbated by infrastructure that did not yet support automation, resulting in data transfer delays that hampered real-time inventory visibility.

The results of the Seven Waste analysis show three dominant types of waste in warehouse operations:

1. Waiting: Occurs due to reliance on manual recording and lengthy data verification processes.
2. Motion: There is repeated movement of manpower from the field to the office to enter data into the computer.
3. Transportation: Suboptimal material flow during the put-away and picking processes.

Table 1. Results of Identification of Dominant Waste

Janis Waste	Total Time (Minutes/Pallet)	Root Cause
Waiting	252	Dependence on manual recording and data verification queues.
Motion	69	Employees have to walk back and forth to update the system in the office.
Transportation	14	There is no real-time navigation system for placing goods.

Process Transformation Analysis through WMS-PDT Implementation

Based on the results of waste identification and root cause analysis, a system transformation from conventional warehouse management to a digitally integrated system is required. Several alternative solutions are being considered to address inefficiencies at Company XYZ:

Process Digitalization with PDT-based WMS Implementation.

The main proposed solution is the implementation of a Warehouse Management System (WMS) that utilizes Portable Data Terminals (PDTs) as the primary data input instrument in the field. Unlike manual systems, PDTs enable data validation through real-time barcode scanning directly at storage locations (binning) and receiving areas. This automatically eliminates wasted motion because operators no longer need to return to the office to confirm with the SAP system. Furthermore, the system provides an automatic allocation feature that directs operators to the nearest storage location, thereby reducing wasteful material transportation.

Workflow Standardization (Process Re-engineering).

In addition to the technological aspects, improvements were made by reengineering the workflows of both incoming and outgoing processes. This alternative involved eliminating non-value-added steps such as manual form printing (QI Forms) and replacing them with digital labels that can be printed directly in the field using a mobile printer connected to PDT. By integrating the quality inspection and labeling processes into a single workflow, waiting times, which previously reached 252 minutes, were significantly reduced.

Implementation of Real-Time Monitoring Dashboard.

To support the WMS system, an automated monitoring dashboard is proposed that can be accessed by management at any time. This alternative aims to address the problem of low inventory visibility, which has led to overstock and high unfinished processes. This dashboard allows for early detection of any delays in the binning or picking process, allowing for immediate corrective action before impacting the company's service level.

The implementation of a Warehouse Management System (WMS) integrated with a Portable Data Terminal (PDT) device has radically transformed the company's workflow. Before PDT, the incoming process involved numerous manual steps, such as physically printing QI forms, manually writing bin labels, and confirming binning, which had to be done on an office computer. With PDT technology, all of these activities are simplified through barcode scanning and on-the-spot printing.

Figure 1. Portable Data Terminal (PDT)

In the incoming process, cycle time was successfully reduced from 160 minutes per pallet to just 66 minutes per pallet, representing a 62% increase in efficiency. The same thing happened in the outgoing process, where picking and packing activities that previously required 165 minutes per pallet can now be completed in 83 minutes per pallet (50% efficiency). In addition to speed, data accuracy has increased dramatically because the system eliminates the opportunity for human error in manual recording, which previously often occurred due to operator fatigue and lack of concentration.

Table 2. Comparison of Operational Lead Time per Process

Process Flow	Before (Minutes/ Palette)	After (Minutes/ Pallet)	Efficiency (%)
Incoming	160	61	62%
Outgoing	165	83	50%
Stoke Take (PST)	90.8	15.3	83%

Financial Impact Analysis and Strategic Value

Financially, this digitalization has had a direct impact on reducing working capital tied up in inventory. By accelerating lead times, the company was able to reduce unfinished inventory by Rp13.7 billion. Efficiency in the incoming process contributed to savings of 61%, while the outgoing process contributed 40% to the value of SAP inventory.

Based on the Cost and Benefit Analysis, the first phase of the project showed a Benefit to Cost Ratio of 3.25:1. This value is projected to jump to 12:1 in the second phase when the system has been fully integrated across all lines. Beyond the monetary aspect, the company obtained crucial non-financial benefits such as the availability of an automated warehouse monitoring dashboard, increased customer trust due to faster and more accurate deliveries, and improved employee morale due to reduced repetitive administrative workloads.

Digitalization through WMS-PDT not only increases speed, but also reduces the number of unfinished processes which have been the main obstacle at XYZ Company.

Table 3. Summary of Financial and Operational Benefits

Parameter	Before (Manual)	After (WMS-PDT)	Savings
Working Capital(Incoming)	Rp887 million	Rp279 Million	62%
Working Capital(Outgoing)	Rp. 475 million	Rp. 56 million	50%
Unfinished Stock Amount	-	-	Rp13,700,000,000
Service Level(Binning)	94%	97%	3%

Cost and Benefit Analysis

A cost-benefit analysis was conducted to evaluate the economics of implementing a PDT-based WMS and ensure that this technology investment provides commensurate added value to the company. This evaluation was divided into two main components: investment costs (costs) and savings or resulting added value (benefits).

Based on project financial data, the total cost of the first phase (Stage 1) implementation was IDR 4.21 billion. This cost includes PDT hardware procurement, network infrastructure development in the warehouse area, software licensing, and human resource training costs. Furthermore, the identified financial benefits were significant, primarily stemming from reduced unfinished inventory and working capital efficiency.

Table 4. Details of the Cost and Benefit Analysis of Phase 1

Analysis Components	Item Description	Value (Rupiah)
Total Investment (Cost)	PDT Devices, Infrastructure, & Systems	Rp4,216,000,000
Total Benefits	Decrease in Unfinished Process & Working Capital	Rp13,700,000,000
Benefit to Cost Ratio	Benefit vs. Cost Comparison	3.25 : 1
Potential Benefits of Phase 2	Full Line Integration Projection	12 : 1

A further explanation of the 3.25:1 ratio indicates that for every rupiah invested by the company, a benefit of 3.25 rupiah is generated. This figure demonstrates that the warehouse digitalization project has a rapid return on investment and is highly commercially viable. Furthermore, in the second phase (Stage 2), efficiency is projected to increase significantly, reaching a ratio of 12:1, as the system matures and the learning curve for operators diminishes.

Qualitatively, there are intangible benefits that are no less important. This implementation creates a "Single Source of Truth" where field data exactly matches data in the SAP system in real time. This minimizes the risk of lost goods and increases the service level binning from 94% to 97%. This improvement indirectly strengthens customer trust due to the much more accurate assurance of stock availability.

CONCLUSION

This study confirms that the implementation of a Portable Data Terminal-based Warehouse Management System at XYZ Company successfully transformed warehouse operations from manual to digital and integrated. Key findings show a significant increase in time efficiency, namely 62% in incoming processes and 50% in outgoing processes, as well as a reduction in working capital held in inventory amounting to Rp13.7 billion. In addition, this system successfully eliminated dominant waste in the form of waiting time and non-value-added employee movements, thus creating a more precise, accurate workflow and being able to significantly improve the company's service level.

The main limitation of this study lies in its case-by-case implementation focus on a single company, so generalizing the results outside the context of similar industries requires caution.

Recommendations for future research include exploring broader technology integration, such as artificial intelligence or robotics for full automation, as well as analyzing the long-term impact on the sustainability of company operations. Practically, this study provides a strategic roadmap for Indonesian logistics companies in adopting digital technology to reduce operational costs and increase competitiveness, emphasizing the importance of change management and human resource training to ensure optimal benefit-to-cost ratios for system transformation.

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