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Original Article

Analysis of the Effect of Warehousing Management System and Employee Ability on Work Productivity through Lean Warehousing in the Warehouses of the National Disaster Management Agency (BNPB) and the Regional Disaster Management Agency (BPBD)

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Abstract

Indonesia is located along the equator and at the convergence of three major tectonic plates, making it prone to natural disasters such as earthquakes, tsunamis, and landslides. BNPB and BPBD manage disaster logistics using technology-based warehouse management systems (WMS) to improve aid distribution efficiency. This study examines the combined impact of warehouse management systems and employee capabilities on work productivity using a Lean Warehousing approach, which has not been extensively explored in previous research. The study was conducted at BNPB Jatiasih warehouse and BPBD warehouses across Java Island using observations, interviews, and questionnaires distributed to 98 respondents. Data were analyzed with SPSS 24.00, employing descriptive statistics, multiple regression, F-tests, t-tests, and the coefficient of determination (R^2). Most respondents were male (76.8%) with a bachelor's degree (39.8%). Validity tests showed that variables including inventory management, picking, item placement, employee skills, and lean warehousing had valid correlations above 0.202. Descriptive analysis indicated that warehouse management at BNPB and BPBD is effective but needs improvements in IT utilization, picking efficiency, inventory recording, and employee skills. Statistical tests confirmed that all variables significantly influence lean warehousing and productivity at a 95% confidence level. The study contributes novel insights by demonstrating how technology and employee capability synergistically enhance lean warehousing performance in disaster logistics. Strategic recommendations include routine employee training, strengthened cooperation through coaching and briefings, and optimized budget use via internal audits and independent utilization of logistical assets.

Keywords: Disaster Logistics, Lean Warehousing, Warehouse Management, Work Productivity.

1. Introduction

Indonesia is located on the equatorial line and is flanked by the Asian and Australian continents as well as the Pacific and Indian Oceans. Its territory consists of large and small islands and is situated at the meeting point of three major tectonic plates in the world, namely Eurasia, Indo-Australia, and Pacific, making it prone to natural disasters such as earthquakes, volcanic eruptions, landslides, and tsunamis. In addition, global climate change affects weather patterns in Indonesia, where the dry season can trigger droughts and forest fires,

while the rainy season increases the risk of floods and landslides. To address these threats, the government established the National Disaster Management Agency (BNPB) through Law Number 24 of 2007, which is responsible for logistics management and distribution of aid to disaster survivors by prioritizing seven accuracies: type of goods, quantity, quality, target, time, reporting, and cost (Coyle et al., 2010).

According to BNPB data for 2024, the highest number of disasters occurred in 2020 with 5,004 cases, while 2024 experienced a decrease with 458 cases until March. The most frequent types of disasters are floods (7,862 incidents), landslides (7,015 incidents), tornadoes (8,063 incidents), and forest and land fires (4,722 incidents). In January 2024, 197 disaster incidents were recorded, mostly hydrometeorological in nature, with casualties of 20 people dead, 40 injured, and 1,174,837 people affected and displaced. In disaster management, an effective logistics management system is essential to ensure aid distribution is on target. The concept of Physical Distribution Management which includes transportation, distribution planning, purchasing, inventory control, and warehousing becomes a key factor in the success of disaster management (Bowersox, 2006).

BNPB Head Regulation No. 04 of 2018 states that the Logistics and Equipment Management System is responsible for the entire logistics process in disaster management, from planning, procurement, storage, distribution, to disposal, so that it runs effectively and efficiently. Good warehouse management becomes an important factor in ensuring optimization of warehouse capacity and accurate arrangement of goods distribution. Humanitarian logistics becomes a crucial aspect in humanitarian crisis situations, where basic needs such as food, clean water, shelter, and health services must be immediately fulfilled. To improve disaster response speed, the approach applied includes three stages: pre-disaster through preparation and planning, during disasters with fast and efficient coordination, and post-disaster with evaluation and recovery (BNPB Head Regulation No. 13 of 2008).

In practice, the effectiveness of logistics distribution often faces obstacles due to miscommunication, poor coordination, and limitations in storage facilities, budget, and human resources. Problems in this logistics system can cause delays in aid distribution to disaster-affected communities. In addition, logistics warehouses have a strategic role as the main transit point in the disaster aid supply chain, but the limited number of warehouses that function optimally can hinder distribution to affected areas. Therefore, the implementation of an integrated logistics system, supported by technology and good coordination, becomes the key to improving the accuracy and speed of disaster response in the future (Hehanussa, 2012).

Research by Safapour (2022) shows that the success of post-disaster reconstruction is greatly influenced by logistics management, workforce productivity, and effective coordination. The efficiency of logistics and warehouse systems plays an important role in accelerating aid distribution and reducing delays, making warehouse capacity enhancement and employee capability development crucial in disaster response. Warehousing plays an important role in the supply chain, both in storing raw materials and finished products ready for marketing. In modern warehouse management, Warehouse Management System (WMS) technology is applied to improve efficiency and accuracy in warehousing activities such as receiving, storing, sorting, and distributing goods. WMS enables real-time inventory monitoring and process automation that increases productivity and reduces the risk of errors in stock recording. The implementation of this system is also applied in BNPB warehouses in Jatiasih to support preparedness in disaster management.

BNPB and BPBD have strategic roles in disaster logistics management based on applicable regulations, such as Law No. 24 of 2007 and BNPB Head Regulation No. 13 of 2008. Warehousing becomes part of the logistics system that must be managed accurately and

efficiently to ensure the availability of goods in emergency situations. The transfer of BNPB warehouses from rental locations to Jatiasih Warehouse is an effort to achieve efficiency in costs and operations, as well as support the implementation of better warehousing systems. To support warehouse effectiveness, capacity building of personnel through training on logistics and equipment management continues to be carried out to ensure readiness in facing disasters.

The concept of lean warehousing is applied to improve operational efficiency by optimizing space, labor, and time. This approach ensures fast and accurate logistics distribution to disaster-affected areas and reduces waste in goods management. The warehouse transfer to Jatiasih is also a strategic step in reducing dependence on rental warehouses and increasing BNPB's independence in disaster logistics management. With a more modern system and trained workforce, BNPB can be more responsive in handling disasters by ensuring stock availability and optimal distribution.

In emergency situations such as natural disasters, the implementation of lean warehousing enables aid distribution processes to become faster, more precise, and responsive, as emphasized by Baharmand (2019), Delshad (2024), and Fazli (2024) who highlight the importance of efficiency and reliability of logistics systems under crisis conditions. However, most existing research focuses more on technical aspects such as route optimization, distribution locations, and resource allocation using mathematical models, while the role of warehouse management systems and human resource capabilities in supporting productivity through lean warehousing remains underexplored (Chen, 2019; Ellison, 2020; Rimadeni, 2024).

This research presents novelty by integrating warehouse management systems, employee capabilities, and Lean Warehousing approaches in the context of disaster logistics. To the researcher's knowledge, previous studies have still focused on technological aspects such as the use of IoT, robotics, and automation (Adriaensen, 2023; Jarašūnienė, 2023; Yoshitake, 2019; Zadgaonkar, 2021), risk evaluation (Ambarwati, 2024; Hanafiah, 2022), as well as operational efficiency in manufacturing and service industries (Calzavara, 2019; Dinis-Carvalho, 2023; Michlowicz, 2024).

Based on the background outlined, this study focuses on analyzing the influence of warehouse management systems and employee capabilities on work productivity through the Lean Warehousing approach at the National Disaster Management Agency (BNPB) and Regional Disaster Management Agency (BPBD) warehouses. This research aims to evaluate the effectiveness of warehouse management systems in improving operational efficiency, as well as how employee capabilities contribute to optimizing work productivity. By applying the Lean Warehousing concept, this study also examines the extent to which this method can reduce waste, accelerate logistics distribution, and improve warehouse performance in supporting emergency disaster response. The results of this research are expected to provide strategic recommendations in improving warehouse management efficiency and employee empowerment to support BNPB and BPBD preparedness and operational effectiveness. Considering the limitations of previous research and the importance of disaster logistics preparedness, this study is directed to analyze the influence of warehouse management systems and employee capabilities on work productivity through the Lean Warehousing approach, so as to provide strategic recommendations for improving the response effectiveness of BNPB and BPBD.

2. Literature Review

2.1. Warehouse Management System (WMS)

Warehouse Management System (WMS) is a system used in warehouse management to regulate processes from receiving, storing, to shipping goods efficiently with the help of computerized technology, such as barcodes, pallets, and forklifts. WMS aims to improve inventory data accuracy and accelerate warehouse operations by recording every transaction automatically. This system has several types, including Standalone WMS for small businesses, Enterprise Resource Planning (ERP) integrated with supply chain management systems, Cloud-Based WMS which is web-based with high flexibility, and Supply Chain Execution (SCE) which covers various aspects of the supply chain. WMS advantages include time efficiency, stock accuracy, and implementation of FIFO (First In First Out) principles, while disadvantages include challenges in controlling goods movement and system evaluation. The main factor in WMS implementation is optimal goods placement, which includes storage methods such as random storage, fixed storage, class-based storage, and shared storage to maximize space and warehouse operational efficiency.

2.2. Inventory Management

Inventory management aims to maintain the availability of needed goods, especially in facing market demand fluctuations, and reduce inventory costs (Martono, 2018). Inventory management involves providing safety stock, anticipation inventory to face demand fluctuations, and inventory in transit (Ristono, 2019). The goods picking process in warehouses uses strategies such as Pick to Order, Batch Picking, Zone Picking, and Wave Picking, each having advantages and disadvantages related to time efficiency, accuracy, and warehouse operator workload.

2.3. Previous Research

Previous research related to this study includes various studies on warehouse management system (WMS) implementation and its impact on warehouse performance and work productivity. For example, Prasidi & Lesmini (2019) found that WMS implementation at PT CEVA Logistics significantly improved goods distribution smoothness. Herdianzah et al. (2022) showed that WMS implementation positively affects warehouse performance, while Putra & Abdul (2021) stated that Lean method implementation directly affects warehouse productivity improvement. Additionally, Bestari & Fatma (2020) found that Lean Warehousing implementation can improve warehouse activity performance by reducing the time required for goods receiving. These studies provide an important foundation in examining the influence of warehouse management systems and Lean Warehousing on work productivity, which is relevant for studies on BNPB and BPBD.

2.4. The Influence of Inventory Management on Lean Warehousing

Inventory management in warehouses becomes crucial for storage process efficiency. This aligns with the principles of the lean method that eliminates waste and activities that do not add value in a process, in this case lean warehousing. The purpose of this design is to determine the optimal configuration of production and storage areas. With a well-planned structure, production processes and related systems must run smoothly, enabling workers to perform their jobs to the best of their ability (Russell & Taylor, 2019).

H1: It is suspected that there is a positive influence of inventory management on lean warehousing at BNPB Warehouses and Regional Disaster Management Agency

2.5. The Influence of Picking on Lean Warehousing

Picking can encompass all handling operations in the warehouse, for example: receiving stock with receipt documentation and storage labels, creating pick lists, picking stock for picking displays, replenishing picking displays, etc (Emmett, 2005). The lean method that eliminates waste and activities that do not add value can be supported through picking; all processes in warehouses that implement technology will support effective work.

H2: It is suspected that there is a positive influence of picking on lean warehousing at BNPB Warehouses and Regional Disaster Management Agency

2.6. The Influence of Goods Placement on Lean Warehousing

Goods placement in warehouses can encompass all handling operations in the warehouse, for example: receiving stock with receipt documentation and storage labels, creating pick lists, picking stock for picking displays, replenishing picking displays, etc. (Emmett, 2005). The lean method that eliminates waste and activities that do not add value can be supported through picking; all processes in warehouses that implement technology will support effective work.

H3: It is suspected that there is a positive influence of goods placement on lean warehousing at BNPB Warehouses and Regional Disaster Management Agency

2.7. The Influence of Employee Skills on Lean Warehousing

Employee skills are abilities or expertise that enable employees to work maximally with the skills they possess, used to improve warehouse efficiency by coordinating warehouse activities and maintaining accurate inventory by recording warehouse transactions and through database documentation. Proper and effective use of Warehouse Management Systems can greatly improve warehouse efficiency and productivity (Herdianzah et al., 2022). With warehousing activities integrated with Information Technology systems, it will help storage teams process goods, increasing work productivity and making work more accountable because every transaction in the warehouse will be recorded in the system.

H4: It is suspected that there is a positive influence of employee placement skills on lean warehousing at BNPB Warehouses and Regional Disaster Management Agency

2.8. The Influence of Work Experience on Lean Warehousing

Work experience can be defined as mastery of work, with high frequency of workplace changes. Work experience is a form of learning process and increased development of behavioral potential from both formal education and non-formal education aspects. From behavioral factors obtained from experience, understanding and practice serve as learning. A person's work experience can be demonstrated through the types of work they have performed and provides opportunities to do better work. With good work experience, especially in warehouse goods handling, it can minimize costs, time, and effort, particularly in lean warehousing.

H5: It is suspected that there is a positive influence of work experience on lean warehousing at BNPB Warehouses and Regional Disaster Management Agency

2.9. The Influence of Inventory Management, Picking, Goods Placement, Employee Skills, and Work Experience on Lean Warehousing

Warehouse Management Systems have strategic impact because they establish organizational competitive priorities in terms of capacity, processes, flexibility, and costs, as well as quality of work life, customer contact, and image. With good inventory management, picking, goods placement, employee skills, and work experience, warehouse management

activities can be carried out effectively, especially regarding lean warehousing. Warehouse employees are able to complete their work on time, with correct quantity and quality. Employee work life will also be better organized with a work environment having good layout, which can certainly be a factor that increases work productivity of warehouse storage teams.

H6: It is suspected that there is a positive simultaneous influence of inventory management, picking, goods placement, employee skills, and work experience on lean warehousing at BNPB Warehouses and Regional Disaster Management Agency

2.10. The Influence of Lean Warehousing on Work Productivity

Warehouse Management Systems, especially Lean Warehousing, have strategic impact because they establish organizational competitive priorities in terms of capacity, processes, flexibility, and costs, as well as quality of work life, customer contact, and image (Heizer et al., 2019). Good layout will increase employee work productivity because it will help employees complete their work on time, with correct quantity and quality. Employee work life will also be better organized with a work environment having good layout, which can certainly be a factor that increases work productivity of warehouse storage teams.

H7: It is suspected that there is a positive influence of lean warehousing on work productivity at BNPB Warehouses and Regional Disaster Management Agency

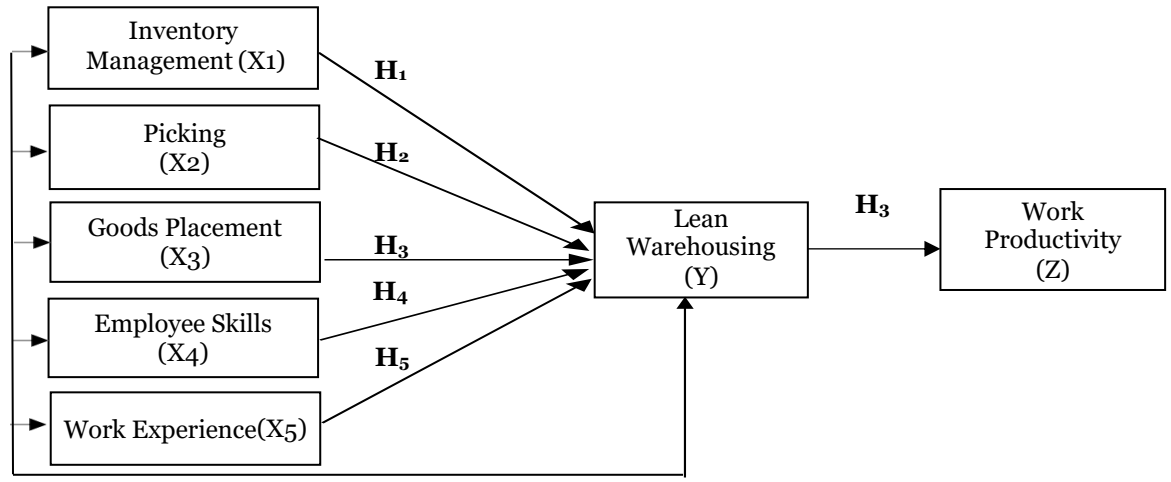

Figure 1. Research framework

3. Methods

This research consists of several stages, starting with exploratory research to identify issues, followed by data collection through identification of information sources such as books, journals, and online media related to warehouse management, employee capabilities, productivity, and Lean warehousing topics. Data was collected through observation, interviews, and documentation, then analyzed to produce conclusions. This research was conducted at BNPB Jatiasih warehouse and BPBD Provinces throughout Java Island, with data collection time from early 2024. The research population involved employees from 7 warehouses consisting of various provinces, with a sample size of 98 respondents selected using purposive sampling technique. The characteristics of the sample that have been determined are employees/personnel in the warehouse section at BNPB and BPBD in Java Island Province, as well as active in handling disasters. The sample size of 98 respondents is considered adequate based on methodological references that suggest a minimum of 30–100 samples is sufficient for regression-based analysis (Bougie & Sekaran, 2016). In addition,

according to the "10 times rule" in PLS-SEM (Hair Jr et al., 2019), the number of samples exceeds the minimum requirement since the most complex structural path in the model involves fewer than 10 indicators. Therefore, the sample size meets the statistical requirements for the analyses conducted.

Table 1. Operational Definition

Variable	Operational Definition (Indicator)	Reference
Inventory Management	1) Creating and recording stock item lists	Reksohadiprodjo (2016)
	2) Periodic inventory monitoring	
	3) Creating stock estimates	
	4) Separating old and new stock	
	5) Using control methods	
	6) Analyzing supplier performance	
	7) Using appropriate digital logistics	
Picking	1) Pick to Order	Winardi (2017)
	2) Batch Picking	
	3) Zone Picking	
	4) Wave Picking	
Goods Placement	1) Designing goods placement methods	Winardi (2017)
	2) Proper and correct goods placement	
	3) Providing labels/identification	
	4) Goods recording	
	5) Creating boundary lines in the workplace	
Employee Skills	1) Education level	Soekidjo (2017)
	2) Age	
	3) Experience	
Work Experience	1) Duration or working hours	Sedarmayanti (2018)
	2) Skill level	
	3) Mastery of work and equipment	
Lean Warehousing	1) Transportation	Naus et al. (2009)
	2) Waiting	
	3) Over production	
	4) Defect	
	5) Inventory	
	6) Motion	
	7) Over Processing	
Work Productivity	1) Capability	Sutrisno (2019)
	2) Improving achieved results	
	3) Work ethic.	
	4) Self-development	
	5) Quality	
	6) Efficiency	

Data collection methods used field research through interviews, questionnaires, and library research to obtain relevant information. Data was analyzed using SPSS 24.00 application with quantitative approaches and descriptive statistics. This study uses path analysis to test direct and indirect effects between exogenous and endogenous variables. Analysis techniques used include regression testing, F-test, and t-test. Regression testing aims to test hypotheses through multiple regression analysis by measuring significance using simultaneous tests (F-test and R^2) and partial tests (t-test). Determination test (R^2) measures the extent to which the model can explain variations in dependent variables, with values approaching 1 indicating a good model. F-test tests simultaneous variable effects on service

quality, while t-test tests partial variable effects on service quality. Additionally, path analysis method is used to map causal relationships between variables through structural equations and path diagrams, measuring direct and indirect contributions of related variables. Hypothesis testing is conducted by formulating structural hypotheses and testing path coefficients using Anova tables, followed by significance analysis using probability criteria (p-value). Indirect effect significance testing is conducted using z-statistic formulas to evaluate effects through moderating (intervening) variables.

4. Results and Discussion

4.1. Research Results

4.1.1. Respondent Characteristics

Research samples were selected using purposive sampling technique, with 98 respondents consisting of employees in seven warehouses including BNPB Warehouse and several BPBD warehouses in various provinces. Respondent characteristics show that the majority are male (76.8%), with the most education being Bachelor's degree (S1) at 39.8%. Most respondents are aged between 19-30 years (43.9%) and have work experience between 6-10 years (40.8%). This data illustrates that the majority of warehouse employees are young workers with higher education and relatively sufficient work experience.

Table 2. Respondent Characteristics

Description	Type	Total	Percentage (%)
Gender	Male	77	76.08
	Female	21	21.04
Age	19-30 years old	43	43.09
	31-40 years old	21	21.04
	41-50 years old	21	21.04
	>50 years old	13	13.03
Education	High School/Vocational School	17	17.03
	Diploma (D3)	33	33.07.
	Bachelor (S1)	39	39.08.
	Master (S2)	9	09.02
Work Experience	2 – 5 years	22	22.04
	6 – 10 years	40	40.08
	11 – 15 years	22	22.04
	>15 years	14	14.03
Position	Warehouse Head	7	07.01
	Warehouse Operational Personnel	47	48.00
	Driver	27	27.06
	Security	17	17.03

Source: Primary Data (processed)

4.1.2. Partial Test

Table 3. Partial Test of Work Productivity Variable

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.787	1.826		.949	.000
	Inventory Management	.970	.290	.071	1.783	.006
	Picking	.930	.320	.738	3.217	.002
	Goods Placement	.806	.341	.101	3.543	.001
	Employee Skills	.704	.267	.923	5.640	.000
	Work Experience	.928	.279	.940	4.151	.000

a. Dependent *Variable*: Work Productivity

Source: Processed data, 2024

The t-test proves that all five independent variables (inventory management, picking, goods placement, employee skills, and work experience) significantly influence work productivity at BNPB and BPBD at the 5% significance level. Although the t-value for inventory management (1.783) is below the t-table (1.986), the p-value of 0.006 confirms significance. Other variables such as picking, goods placement, employee skills, and work experience are also significant ($p < 0.05$) with the largest contribution from work experience (92.8%) and goods placement (80.6%). These results confirm that all variables make important contributions to improving work productivity.

4.1.3. Partial Test of Work Productivity Variable on Lean Warehousing

Based on the estimation results in the previous table, the following are the t-test results using SPSS_24.00 program. The t-value for work productivity is 7.882 with prob. 0.00. Meanwhile, the t-table value for a total observation of 98 at 5% significance level and degrees of freedom (df) = 98 – 7 = 71 is 1.986. Therefore, it is found that t-value exceeds t-table or 2.767 > 1.986, and it can be seen through the prob. value not exceeding the significance level (α) of 5% or 0.045 < 0.05, meaning it can be concluded that work productivity significantly affects lean warehousing, concluding that H0 is rejected and Ha is accepted. This states that lean warehousing significantly influences work productivity with a 95% confidence level or 5% error rate. The Beta value for work productivity variable is 0.450, meaning 45% of work productivity affects lean warehousing, while the rest is influenced by other factors.

Table 3. Partial Test of Lean Warehousing Variable

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std.Error	Beta		
1	(Constant)	24.390	2.792	.627	8.735	.000
	Work Productivity	.450	.057		7.882	.000

a. Dependent Variable: Lean Warehousing

Source: Processed data, 2024

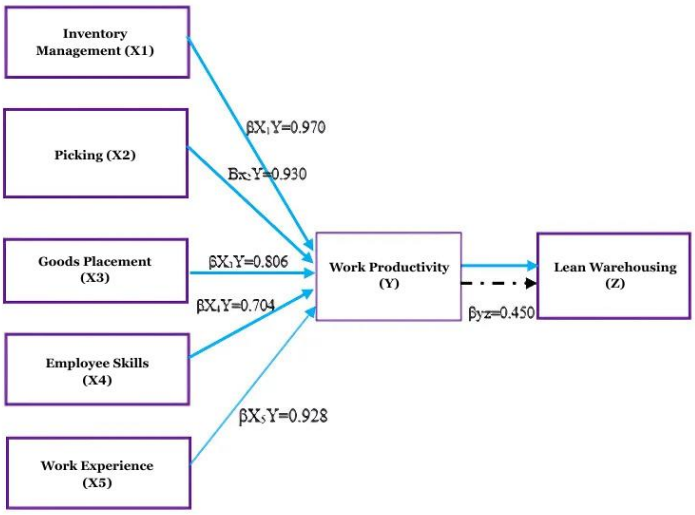

Figure 2. Partial Test Analysis

4.1.4. Simultaneous Test

Table 4. ANOVA Test of Work Productivity Variable

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	1718.242	5	343.648	30.407	.000[b]
	Residual	1039.758	92	11.302		
	Total	2758.000	97			

a. Dependent Variable: Work Productivity
b. Predictors: (Constant), Work Experience, Inventory Management, Employee Skills, Picking, Goods Placement

Source: Processed data, 2024

Based on these test results, it can be seen that the F-value is 93.876 with a sig. value of 0.000000. The F-table value for a total observation of 98 at 5% alpha level and k or the total number of all variables (both independent and dependent) is 7, so N1 = k -1 = 7 - 1 = 6, N2 = n - k = 98 - 7 = 91 is 2.47. Therefore, it is found that F-value exceeds F-table or 30.407 > 2.20 and it can be seen through the prob. value not exceeding the significance level (α) of 5% or 0.000000 < 0.05, meaning it can be concluded that warehouse management, picking, goods placement, employee skills, and work experience variables simultaneously affect work productivity at BNPB Warehouses and Regional Disaster Management Agencies, concluding that Ho is rejected and Ha is accepted.

4.1.5. Third Stage Analysis

1) Indirect Effect

From the results of the two analyses above, a summary is made in the following table:

Table 5. Path Analysis Results

Direct Effect Between Variables	Path Coefficient (pij)	Standard Error (sbi)	t-value	ρ-value	Conclusion	R^2
X1 to Y(βX1Y)	0.533	0. .043	2.767	0.0045		
X2 to Y(βX2Y)	0.629	0.153	4.096	0.005		

Direct Effect Between Variables	Path Coefficient (pij)	Standard Error (sbi)	t-value	ρ-value	Conclusion	R^2
X_3 to Y($\beta X_1 Y$)	0.790	0.163	4.839	0.000	Significant	0.955
X_4 to Y($\beta X_4 Y$)	0.730	0.128	5.708	0.002		
X_5 to Y($\beta X_5 Y$)	0.584	0.230	2.237	0.019		
Y to Z (βYZ)	0.450	0.627	7.882	0.000	Significant	0.693

From the table above, the following path analysis model can be generated:

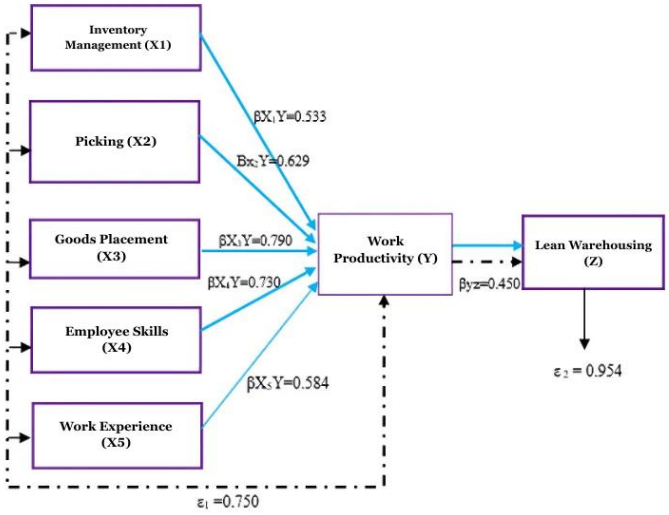

Figure 3. Path Analysis

: Direct Effect
: Indirect Effect

From the figure 3 above, the coefficients of direct effects, indirect effects, and total effects can be determined as follows:

Table 6. Calculation of Direct, Indirect, and Total Effects

Variable Effect	Path Coefficient	Effect		
		Direct	Indirect Through Y	Total
X_1 to Y	0.533	0.533	-	0.533
X_2 to Y	0.629	0.629	-	0.629
X_3 to Y	0.790	0.790	-	0.790
X_4 to Z	0.730	0.730	-	0.730
X_5 to Z	0.584	0.584	-	0.584
Y to Z	0.450	0.450	-	0.450
X_1 to Z	0.533	0.533	0.23985	0.12784005
X_2 to Z	0.629	0.629	0.28305	0,1783215
X_3 to Z	0.790	0.790	0.3555	0,280845
X_4 to Z	0.730	0.730	0,3285	0,239805
X_5 to Z	0.584	0.584	0,2628	0.1534752
ε_1	0.450	$0.750^2 = 56.25$		
ε_2	0,630	$0.954^2 = 91.01$		

Based on the findings and comparative analysis results in table 6, lean warehousing proves to mediate the relationship between operational and human resource variables on work

productivity. Inventory management has a direct effect on lean warehousing of 0.533 and an indirect effect on work productivity through lean warehousing of 0.23985, with a total effect of 0.12784. Picking has a direct effect of 0.629 on lean warehousing and an indirect effect on work productivity through lean warehousing of 0.28305, resulting in a total effect of 0.17832. Goods placement shows a direct effect of 0.790 on lean warehousing and an indirect effect of 0.3555 on work productivity, with a total effect of 0.28085. Employee skills contribute directly 0.730 to lean warehousing and indirectly 0.3285 to work productivity, with a total effect of 0.23981. Work experience provides a direct effect of 0.584 on lean warehousing and an indirect effect of 0.2628 on work productivity, resulting in a total effect of 0.23. Meanwhile, lean warehousing itself directly affects work productivity by 0.450. These findings confirm that lean warehousing plays a significant role in strengthening the relationship between input variables and work productivity as an outcome.

4.2. Discussion

4.2.1. Effect of Inventory Management on Lean Warehousing

Effective inventory management has proven to play a crucial role in supporting the implementation of lean warehousing, which is a warehouse system oriented toward efficiency, waste reduction, and value enhancement. In this context, the organization's ability to systematically and integratedly plan, organize, and control inventory flow becomes the main foundation for promoting streamlined workflows, avoiding waste of time and resources. This research shows that the better the inventory management system is implemented through methods such as goods classification, digital recording, FIFO/FEFO stock rotation, and information system integration, the more optimal the implementation of lean in the warehouse environment.

These results align with Emmett (2005) view that effective inventory management is the main foundation for creating efficiency in logistics systems. Similarly, Prasidi & Lesmini (2019) affirm that well-designed warehouse management systems contribute to smooth goods distribution and support accurate recording, labeling, and control of incoming and outgoing goods processes. In this context, the existence of reliable and automated information systems becomes a crucial supporting element for organizations to consistently apply lean principles.

Various studies show that integration of inventory management with lean approaches and modern business process technology consistently improves operational efficiency across various industrial sectors. Research in distribution, textile, and automotive sectors (Acevedo-Aybar, 2024; Aguilar-Paz, 2023; Balakrishnan, 2021) confirms that implementing lean tools and streamlined internal logistics management accelerates stock turnover and reduces waste. Order postponement strategies (Li, 2025) and the utilization of Warehouse Management Systems (WMS) (Theuer, 2020) also support reducing conventional warehouse needs and strengthening inventory tracking accuracy.

Even in emergency contexts, such as BNPB and BPBD operations, technology-based automation systems have proven to accelerate logistics response and improve resource allocation efficiency. Therefore, it can be concluded that inventory management implemented effectively, adaptively, and integrated with information technology is one of the main determinants in implementing lean warehousing. This approach not only provides efficiency at the operational level but also strengthens supply chain resilience through improved data accuracy, optimal stock control, and speed in decision-making based on real-time and precise information.

4.2.2. Effect of Picking on Lean Warehousing

Research results show that picking significantly affects lean warehousing. In the operational context of warehousing at public institutions like BNPB and BPBD, the picking process not only includes physical goods retrieval activities but also involves data management, request fulfillment according to procedures, and coordination with inventory management systems connected digitally through Warehouse Management System (WMS). This finding supports Emmett (2005), view that goods retrieval is one of the key functions in warehouse management because it directly relates to efficiency, accuracy, and distribution speed.

In practice, observation results show that picking processes conducted without referring to standard procedures, particularly regarding timing accuracy and retrieval sequence based on entry dates, can potentially cause logistical dysfunction such as goods accumulation, shipping errors, and increased operational costs. This finding is reinforced by test results showing that picking has a significant effect on lean warehousing, marked by increased warehouse process efficiency and reduced operational waste. Improper picking procedures cause warehouse inefficiency. This research proves that picking significantly affects lean warehousing because it can improve efficiency and reduce waste. This finding is supported by studies from Fares (2025), Rahman (2024), Shah (2023), and complements previous national research that has not specifically highlighted the strategic role of picking.

Indirectly, lean warehousing also mediates the relationship between picking and work productivity. This means that implementing proper picking procedures can strengthen warehouse system efficiency while impacting employee performance in handling requests and goods distribution. This shows that picking optimization is not only important in the context of logistics efficiency but also in building productive and adaptive work systems to demand dynamics. Considering these results and implications, it is recommended to review and enforce stricter picking SOPs, provide regular technical training for warehouse personnel, and utilize supporting technology to monitor and evaluate goods retrieval activities in real-time. This approach is believed to improve lean warehousing effectiveness and support overall work productivity achievement.

4.2.3. Effect of Goods Placement on Lean Warehousing

Systematic goods placement that supports WMS principles has proven to be a key factor in improving lean warehousing. Goods arrangement based on space availability, usage frequency, and location grouping enables efficient storage, reduces employee travel time, and accelerates retrieval processes. In the context of BNPB and BPBD, suboptimal recording practices for incoming, outgoing, and stock goods become a source of potential retrieval errors and order fulfillment delays. With more accurate goods placement and careful recording, warehouse efficiency and effectiveness can be significantly improved.

This finding is consistent with those using lean warehouse to reorganize warehouse layout, with results showing improved operational efficiency through reducing excessive movement and waiting time (waiting and motion waste) because frequently used goods are placed in more accessible locations (Rachmawati, 2025). Additionally, Mohamud et al. (2023) show that layout designs such as U-shaped flow and placement strategies based on ABC analysis can reduce pick, scan, and dispatch time by almost half while accelerating cross-docking time. Baby et al. (2018) also confirm that optimal warehouse layout selection including aisle orientation, rack layout, and accessibility can reduce travel distance and improve overall operational performance. Therefore, this research underlines that goods placement is not merely an operational aspect but plays a strategic role in supporting lean warehousing. Through appropriate storage location arrangement and accurate recording,

procurement, storage, and goods distribution processes can proceed more efficiently, which will subsequently significantly increase work productivity.

4.2.4. Effect of Employee Skills on Lean Warehousing

Research results show that employee skills have a significant effect on lean warehousing. This is reflected in the importance of warehouse employees' ability to work quickly and accurately, especially when facing emergency conditions such as logistics requests for disaster management. In BNPB and BPBD environments, despite still finding limitations in work experience, warehouse management training conducted regularly has contributed to improving professionalism and employee work efficiency.

This finding aligns with research by Herdianzah et al. (2022) revealing that employee skills become an important factor in implementing modern warehouse management systems. Implementation of Warehouse Management System (WMS) accompanied by employee capability improvement impacts smooth distribution flow and achievement of logistics efficiency standards. Jaehrling (2019) highlights that work transformation in the digital era does not automatically eliminate the importance of individual skills. In complex logistics work contexts, such as at Amazon, highly standardized work structures still demand adaptive skills from workers. This reinforces findings that lean warehousing will only be optimal if supported by a workforce with adequate practical skills and situational knowledge.

Besides having direct effects, employee skills also prove to have indirect effects on work productivity through the mediating role of lean warehousing. This means employee skills support the creation of efficient lean warehousing practices, which in turn drives increased work productivity of warehouse employees. This result is supported by Putra & Abdul (2021) who studied the application of lean methods on warehousing productivity. In that study, it was found that lean warehousing improves work process speed and efficiency, which ultimately impacts increased employee work output. Similarly, Bestari & Fatma (2020) confirm that lean approaches can significantly shorten work time, creating a more productive work environment, especially when managed by competent workers. Therefore, employee skills not only play a direct role in warehouse system efficiency but also serve as an important foundation in improving productivity through structured and waste-minimized lean approaches.

4.2.5. Effect of Work Experience on Lean Warehousing

Research results show that warehouse employee work experience significantly affects lean warehousing. Employees with good work experience tend to be able to respond to logistics needs more quickly and accurately, especially in emergency situations such as disaster relief goods distribution in BNPB and BPBD environments. Work experience makes employees more skilled in handling goods release and receipt processes, making these processes more effective and efficient.

This finding aligns with research by Putra & Abdul (2021) which confirms that lean methods in warehouse systems are greatly influenced by human resource readiness, especially in terms of work experience. Employees who have long been involved in warehousing activities have a better understanding of workflows and resource management, enabling them to reduce waste and improve warehouse operational efficiency.

Furthermore, research results also show that work experience not only directly impacts lean warehousing but also influences work productivity through lean warehousing as a mediator. This shows that lean warehousing plays an important role as a mechanism bridging employee work experience with productivity improvement. The better employee experience in

warehouse management, the more optimal the application of lean principles, which ultimately impacts more productive work results.

This result is strengthened by findings from Sari & Liliana (2022) stating that work experience is one of the important factors affecting employee productivity, because through work experience, employees can develop skills, work speed, and ability to complete tasks efficiently. Similarly, Wairooy (2019) emphasizes that good work experience contributes to improving effectiveness and efficiency in logistics operations, including warehouse management. Therefore, research results confirm the importance of considering work experience as a strategic factor in lean warehousing implementation, which will ultimately improve overall employee work productivity.

4.2.6. Effect of Lean Warehousing on Work Productivity

Research results show that lean warehousing implementation provides significant influence on improving warehouse employee work productivity at BNPB and BPBD institutions. Lean warehousing plays a role in eliminating non-value added activities and promoting operational efficiency, especially in goods transportation processes and stock data management. However, it was found that transportation cost aspects are still not optimal, causing potential waste, indicating the need for institutional evaluation of logistics efficiency, including options between renting or purchasing transportation fleets.

This finding is consistent with research by Putra & Abdul (2021) stating that lean methods influence warehousing productivity by eliminating time, energy, and cost waste. Lean implementation in warehouse systems significantly improves work efficiency and productivity, especially if the process is conducted structurally and continuously. This research is also reinforced by studies from Bestari & Fatma (2020) showing that lean warehousing approaches can accelerate goods receipt process time and improve workflow effectiveness in warehouses. Lean implementation proves capable of minimizing cycle time and improving coordination between activities in warehouses.

In the context of warehouse HR management, research results find that work productivity is still hampered by warehouse employees' lack of information technology mastery. Therefore, information system training and socialization programs are needed, especially introduction to software and Warehouse Management System (WMS) applications. This aligns with findings from Sihaloho & Hidayati (2023) confirming that system quality, information, and service in WMS implementation greatly affect overall warehouse operational performance.

In line with this, Herdianzah et al. (2022) mention that improving employee skills in managing digital systems contributes greatly to warehouse process efficiency and accuracy. These skills also minimize data input errors and support real-time data-based decision making. Therefore, research results confirm the importance of integrating lean warehousing with information technology competency strengthening and comprehensive evaluation of logistics and operational aspects. Implementing this strategy not only impacts cost efficiency but also continuously improves warehouse storage team work productivity.

5. Conclusion

Based on data analysis results, it can be concluded that implementing lean warehousing methods at BNPB and BPBD warehouses provides significant improvement to operational efficiency. Before implementing lean warehousing, warehouse processes experienced various inefficiencies such as many non-value added activities, long processing times, high operational costs, and high operational error rates. After implementing lean warehousing, processes

became more efficient with shorter processing times, decreased operational costs, and lower error rates, resulting in waste reduction and improved customer experience. Lean warehousing implementation also enables better management in picking and goods shipping processes, excess stock reduction, and improved inventory accuracy. Statistical test results also show that inventory management, picking, goods placement, employee skills, and work experience variables significantly affect lean warehousing, with simultaneous influence of 97.7%. Additionally, lean warehousing contributes 62.7% to work productivity. There are also direct and indirect effects between variables, where inventory management, picking, goods placement, employee skills, and work experience affect work productivity both directly and through lean warehousing. This shows that lean warehousing plays a role as a significant mediating variable in improving work productivity at BNPB and BPBD warehouses.

These findings provide evidence-based recommendations for BNPB and BPBD management in optimizing disaster logistics through systematic waste reduction and workforce efficiency improvement. Theoretically, this research enriches lean warehousing literature by extending its application to disaster logistics contexts, where speed, accuracy, and responsiveness are crucial. This study emphasizes the importance of integration between human resource factors such as skills and experience with process improvements to maximize lean practice effectiveness in disaster management supply chains.

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