# Acceptability and Sustainability of Warehouse Management System: Extended Technology Acceptance Model 3 and Sustainable Approach

Review of Integrative Business & Economics Research

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**ABSTRACT**

Warehousing is a designated facility for the storage of goods, and it is responsible for facilitating their movement within each supply chain of the company. Consequently, the substantial workload necessitates the implementation of Warehouse Management System (WMS). There exists research indicating the occasional non-acceptance of WMS and the persistently low level of employee engagement in its utilization. A comprehensive investigation is also imperative to ascertain how employees can embrace WMS, enabling the realization of its sustainable application within the company. Therefore, this research used a novel synthesis model, known as Extended Technology Acceptance Model 3 (Technology Acceptance Model 4) and Sustainable Warehouse Management System (SWMS), to scrutinize the acceptance and sustainability of WMS. SEM PLS analysis was also employed to examine the determinants influencing the proposed model using the collected data. The results showed that Attitude (AT) factor reflected the acceptance towards WMS, and impacted the employees' Behavior Iintention (BI), facilitating the adoption of WMS. The construction of Sustainable Warehouse (SW) was also mediated by BI to exert influence on sustainability of WMS implementation.

Keywords: Warehouse Management System, Extended Technology Acceptance Model 3; Technology Acceptance Model 4, Sustainable Warehouse Management System.

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## 1. INTRODUCTION

Warehousing is a pivotal location for the storage and movement of goods. Additionally, it functions as an information hub, facilitating activities such as receiving goods, transferring goods, putting away goods, order fulfillment, cross-docking, and the shipping process (Alias *et al.*, 2017). Warehousing supports the movement of goods and fulfills vital functions such


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as storing raw materials and finished products, organizing shipments, collecting and storing inventory, and preparing for shipping (Amanda Istiqomah *et al.*, 2020).

The implementation of an efficient and effective warehousing system plays a critical role in supply chain management. Over the years, there has been improvement in system to enhance operations within companies. The role extends beyond mere physical storage, encompassing broader aspects such as procurement, transportation management, and other complex functionalities (Kučera, 2017).

The warehousing system utilized within the company is commonly known as Warehouse Management System (WMS), which strives to enhance warehouse efficiency through its comprehensive database. The primary objective is to ensure the accuracy of inventory by recording all transactions, thereby facilitating integrated storage activities (Amanda Istiqomah *et al.*, 2020; Miralam, 2017; Shiau and Lee, 2010). WMS is also an administrative system to track the location and amount of items. In addition, WMS includes system of controlling, monitoring, and optimizing complex storage and distribution system within an enterprise (Alias *et al.*, 2017).

According to a research on international companies, modern warehousing technology such as WMS is still unreliable. This is because more than 60% of these international companies fail to take advantage of WMS. Consequently, many companies express dissatisfaction, reporting reduced competitiveness and profitability compared to their industry counterparts. The findings emphasize the necessity for employees within these companies to possess a comprehensive understanding of modern technology adoption in warehousing. The knowledge fostered advancements in warehouse system development, promote more effective employee training methods, and facilitate policy approach that encourage the automation of warehousing processes (Škerlič et al., 2017).

This is also consistent with (Röhrig and Spieker, 2008), where WMS managed by a central database is prone to errors because the database system is often updated for every storage and retrieval activity in the supply chain management (Röhrig and Spieker, 2008). In another research, WMS technology often has human errors due to workload, bullwhip effects, and the amount of time needed to use WMS manually when observing goods. This resulted in less accurate and real information due to ambiguity and instability to the supply chain (BEKTAS & KORKMAZ, 2015). In addition, WMS is unable to provide warehousing information in a timely and accurate manner because the technology system relies on data from warehouse staff or users to enter data manually or through the barcode system (Lu *et al.*, 2014; Poon *et al.*, 2009; Richards, 2017; Sexton *et al.*, 2000).

This research addresses the aforementioned challenges by examining the acceptance and sustainability of existing WMS implementations. The goal is to assess the extent to which warehouse users accept and sustain WMS, providing valuable insights for companies to enhance the development, ensure user acceptance, enable usability for warehouse staff, and foster long-term sustainability. Consequently, it becomes imperative to conduct research that analyzes the acceptance and sustainability of WMS within warehousing companies. This research analyses how WMS users adopt, adapt, or embrace these technologies, using Extended Technology Acceptance Model 3 (TAM 4) and Sustainable Warehouse Management System (SWMS) methods.


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# 2. LITERATURE REVIEW

## Extended TAM 3 (TAM 4)

TAM 3 model is used to examine the acceptance and use of technology through PEOU (Perceived Ease of Use) and PU (Perceived of Usefulness). The original TAM model was developed by adding external factors to the two main endogenous variables (Chen *et al.*, 2021; Del Giudice Lopez in Business and Taiwan, 2021; Venkatesh, 2014; Venkatesh and Bala, 2008). However, TAM 3 was considered insufficient to provide information about the new system from users of the information system or technology. It was developed and expanded by paying attention to the users of the technology, the context of specialization in the field, the target technology analyzed by TAM 3 model, the characteristics of the main users, and the complexity characteristics (Calisir et al., 2009; Fahmi et al., 2021; Moon & Kim, 2001; Zabukovšek et al., 2019). Extended TAM 3 or TAM 4 became necessary to be developed to address the intentions, behaviors and Attitude (AT) of specific and complex technology users such as WMS (Fahmi *et al.*, 2021; Fahmi, Kostini, *et al.*, 2022; Torabizadeh *et al.*, 2020) (Figure 1).

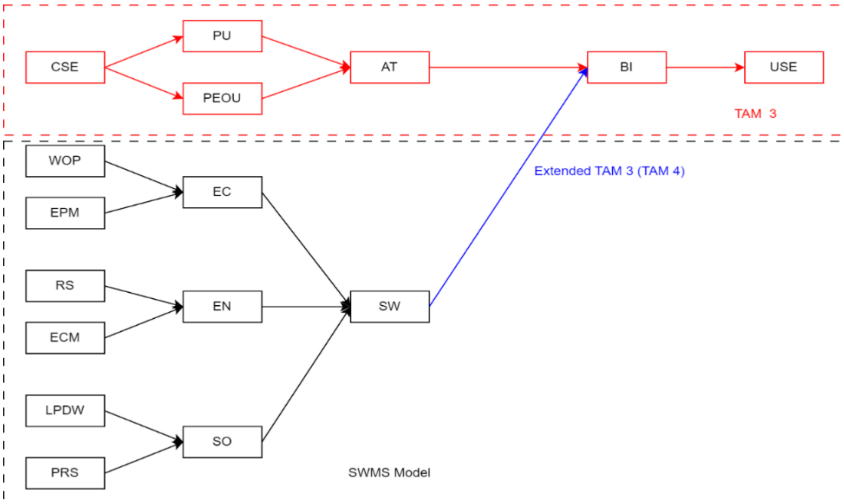


**Figure 1.** Extended TAM 3 (TAM 4)

## SWMS

WMS helps companies to improve their warehousing operations to be more flexible, efficient, and reliable. Furthermore, it is a collection of software programs developed to inspect warehousing operations, handle existing resources and increase productivity through reducing operational costs. This system can also be said to be an application that integrates radio frequency communication equipment as well as barcode system. WMS functionality in addition to receiving goods, also directs the location where the goods are stored, the storage, the process of filling the goods, picking up goods, the packaging and transportation planning for the entry and exit of goods (Faber et al., 2002; Lu et al., 2014; Poon et al., 2009; Richards, 2017).

SWMS is sustainable warehousing information system that considers Economic, Social, and Environment aspects. Economic aspect consists of Warehouse Operation Performance (WOP) and Economic Performance Measurement (EPM) indicators. Environment aspect include Resources (RS) indicators and emission waste and Environment Commitment (ECM). Social aspect consists of Product Responsibility and Society (PRS), as well as Labor Practice and Decent Work product (LPDW) (Torabizadeh *et al.*, 2020) (Figure 2).


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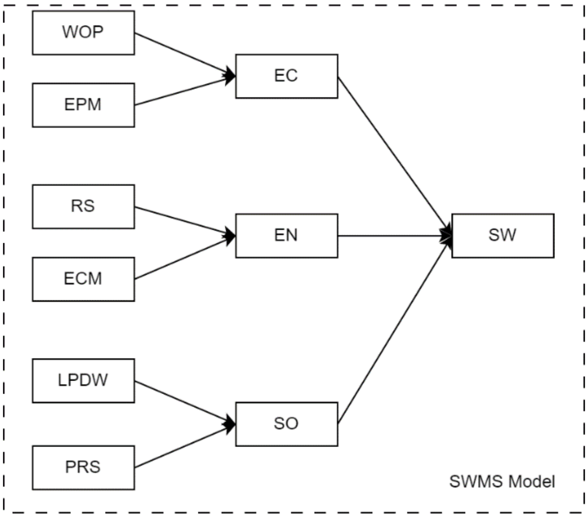


**Figure 2**. SWMS Model

## Empirical Review and Hypothesis Development

This research analyzed the acceptance and sustainability of WMS using SWMS model and Extended TAM 3 (TAM 4) model. The research model was identified as Computer Self-Efficacy (CSE), PU, PEOU, AT, Behavior Intention (BI), Actual Use (USE), WOP, EPM, RS, ECM, LPDW, PRS, Economic (EC), Environment (EN), Social (SO), and Sustainable Warehouse (SW). Several research by (Fahmi *et al.*, 2021; Fahmi, Kostini, *et al.*, 2022; Torabizadeh *et al.*, 2020; Venkatesh, 2014; Venkatesh and Bala, 2008; Zabukovšek *et al.*, 2019) presented a new synthesis model concerning How to Make WMS Acceptable and Sustainable. Extended TAM 3 and SWMS can be seen in Figure 3.

Figure 3 shows a new synthesis model that will be tested. From Figure 3 the following hypotheses were identified:
H1: CSE positively and significantly affects PU.
H2: CSE positively and significantly affects PEOU.
H3: PU positively and significantly affects AT.
H4: PEOU positively and significantly affects AT.
H5: AT positively and significantly affects BI.
H6: BI positively and significantly affects USE.
H7: WOP positively and significantly affects EC.
H8: EPM positively and significantly affects EC.
H9: RS positively and significantly affects EN.
H10: ECM positively and significantly affects EN.
H11: LPDW positively and significantly affects SO.
H12: PRS positively and significantly affects SO.
H13: EC positively and significantly affects SW.
H14: EN positively and significantly affects SW.
H15: SO positively and significantly affects SW.
H16: SW positively and significantly affects BI.


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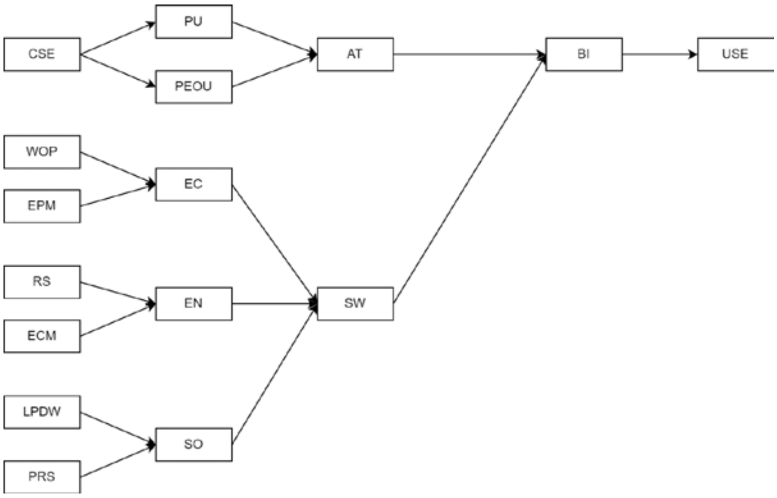


**Figure 3.** New Synthesis Model

## 3. RESEARCH AND METHODOLOGY

This research was conducted quantitatively using a survey method. Data were also collected by distributing closed questionnaires containing alternative answers designed using a Likert scale. Moreover, a total of 255 respondents from employees at private companies were selected as samples using a purposive sampling method (Hair Jr et al., 2021). This company is a logistics company that provides digital-based logistics service solutions that have an extensive network with integrated, competitive, reliable and trusted solutions. The services offered by this company are warehousing, logistics service and supply chain management provider. Statistical analysis was used to examine the relationship between the variables, and this involved the application of SEM as well as PLS.

## 4. FINDINGS AND DISCUSSIONS

CSE, PU, PEOU, AT, and BI were measured using four indicators, while USE was measured using three. Furthermore, WOP and EPM were measured using six and five indicators, respectively. RS and ECM were measured using five and six indicators. In addition, LPDW and PRS were measured using six and five indicators. Economic, Environment, and Social were measured using four indicators, while SW was measured using three.

### Descriptive Analysis

At this stage, a descriptive data statistical analysis instrument was presented to measure the USE WMS factor in warehouse employees. Table 1 showed that employee perceptions are dominated by agreeing AT towards answering questions on the research instruments. The highest index in this descriptive analysis is found in WOP3 indicator and item, "WMS can improve the accuracy of time, quality and quantity of orders promptly." As for the lowest index, there is an indicator and item EPM 3, "There is financial assistance received from the government or vendors in improving WMS performance."

**Table 1.** Descriptive Analysis

| Name | Mean | Standard deviation | Excess kurtosis | Skewness |
|---|---|---|---|---|
| WOP1 | 4.03 | 0.797 | -0.193 | -0.509 |
| WOP2 | 3.879 | 0.888 | -0.442 | -0.481 |
| WOP3 | 4.303 | 0.615 | -0.626 | -0.297 |


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| Name | Mean | Standard deviation | Excess kurtosis | Skewness |
|---|---|---|---|---|
| WOP4 | 4.182 | 0.588 | -0.302 | -0.064 |
| WOP5 | 4.326 | 0.691 | -0.12 | -0.677 |
| WOP6 | 3.955 | 0.787 | -0.716 | -0.202 |
| EPM1 | 4.311 | 0.664 | 0.038 | -0.607 |
| EPM2 | 3.955 | 0.787 | -0.94 | -0.108 |
| EPM3 | 3.72 | 0.948 | -0.621 | -0.489 |
| EPM4 | 3.78 | 0.89 | -0.765 | -0.202 |
| EPM5 | 3.833 | 0.799 | -0.145 | -0.408 |
| RS1 | 3.803 | 0.811 | -0.203 | -0.397 |
| RS2 | 3.909 | 0.733 | -0.593 | -0.089 |
| RS3 | 3.992 | 0.848 | -0.189 | -0.588 |
| RS4 | 4.098 | 0.706 | -0.526 | -0.274 |
| RS5 | 4.106 | 0.741 | 1.11 | -0.851 |
| ECM1 | 3.977 | 0.763 | 0.306 | -0.581 |
| ECM2 | 4.144 | 0.818 | 0.168 | -0.778 |
| ECM3 | 3.909 | 0.723 | -0.791 | 0.018 |
| ECM4 | 3.977 | 0.763 | -0.756 | -0.168 |
| ECM5 | 4.273 | 0.617 | 0.408 | -0.449 |
| ECM6 | 3.841 | 0.815 | -0.566 | -0.207 |
| LPDW1 | 3.614 | 0.885 | -0.33 | -0.218 |
| LPDW2 | 4.008 | 0.733 | -0.475 | -0.245 |
| LPDW3 | 3.886 | 0.794 | -0.113 | -0.434 |
| LPDW4 | 4.061 | 0.842 | 0.305 | -0.81 |
| LPDW5 | 4.053 | 0.71 | -0.601 | -0.206 |
| LPDW6 | 3.773 | 0.893 | -0.71 | -0.245 |
| PRS1 | 3.947 | 0.924 | -0.452 | -0.594 |
| PRS2 | 4.098 | 0.92 | -0.235 | -0.789 |
| PRS3 | 4.03 | 0.887 | -0.453 | -0.587 |
| PRS4 | 4.03 | 0.768 | -0.444 | -0.357 |
| PRS5 | 4.258 | 0.831 | 0.424 | -0.997 |
| EC1 | 3.803 | 0.83 | -0.489 | -0.259 |
| EC2 | 3.917 | 0.905 | -0.489 | -0.516 |
| EC3 | 4.091 | 0.793 | 0.212 | -0.534 |
| EC4 | 3.924 | 0.794 | -0.201 | -0.414 |
| EN1 | 3.773 | 0.884 | -0.651 | -0.267 |
| EN2 | 4.061 | 0.736 | -1.149 | -0.097 |
| EN3 | 4.068 | 0.642 | 0.069 | -0.237 |
| EN4 | 4.25 | 0.722 | -0.478 | -0.543 |
| SO1 | 3.962 | 0.763 | -0.767 | -0.143 |
| SO2 | 4.235 | 0.787 | 1.406 | -1.011 |
| SO3 | 3.939 | 0.756 | -0.742 | -0.111 |
| SO4 | 3.886 | 0.893 | -0.009 | -0.741 |
| SW1 | 3.758 | 0.922 | -0.52 | -0.259 |
| SW2 | 3.894 | 0.731 | 0.188 | -0.42 |
| SW3 | 3.826 | 0.821 | -0.232 | -0.412 |
| CSE1 | 3.97 | 0.706 | -0.632 | -0.087 |
| CSE2 | 4.091 | 0.821 | 0.215 | -0.753 |
| CSE3 | 4.152 | 0.68 | -0.838 | -0.2 |


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| Name | Mean | Standard deviation | Excess kurtosis | Skewness |
|---|---|---|---|---|
| CSE4 | 4.136 | 0.746 | 1.143 | -0.892 |
| PU1 | 4.008 | 0.754 | 0.541 | -0.657 |
| PU2 | 4.159 | 0.796 | 0.177 | -0.751 |
| PU3 | 3.856 | 0.73 | -0.624 | -0.005 |
| PU4 | 4.076 | 0.735 | -0.766 | -0.237 |
| PEOU1 | 4.311 | 0.592 | 0.645 | -0.446 |
| PEOU2 | 3.924 | 0.794 | -0.403 | -0.322 |
| PEOU3 | 3.742 | 0.822 | -0.542 | -0.149 |
| PEOU4 | 4 | 0.718 | -0.341 | -0.249 |
| AT1 | 4 | 0.769 | 0.041 | -0.506 |
| AT2 | 4.076 | 0.858 | 0.16 | -0.802 |
| AT3 | 4.114 | 0.714 | -0.581 | -0.298 |
| AT4 | 4.068 | 0.79 | -0.018 | -0.589 |
| BI1 | 4.136 | 0.86 | 0.37 | -0.92 |
| BI2 | 4.182 | 0.886 | 0.444 | -1.028 |
| BI3 | 4.061 | 0.823 | -0.378 | -0.526 |
| BI4 | 4.167 | 0.698 | -0.407 | -0.378 |
| USE1 | 4.295 | 0.805 | 0.933 | -1.12 |
| USE2 | 3.886 | 0.832 | -0.466 | -0.342 |
| USE3 | 3.962 | 0.883 | -0.293 | -0.594 |

**Outer Model**

The outer model analysis aimed to analyze the ability of observation variables to represent the measured latent variables. The first measurement conducted was a convergent validity test using outer loadings and average variance extracted (AVE) data. Previous research indicated that the obtained outer loading values needed to be greater than 0.5, and the AVE values had to exceed 0.6 (Eko Nurseto and Fahmi, 2023; Fahmi, 2022a, 2022b; Fahmi, Ana Khalisa, *et al.*, 2022; Fahmi, Arifianti and Hakim, 2023; Fahmi, Arifianti, Nurfauzia, *et al.*, 2023; Fahmi *et al.*, 2021; Fahmi, Kostini, *et al.*, 2022; Fahmi, Luh Darmayanti, *et al.*, 2023; Fahmi, Novel, *et al.*, 2022; Fahmi, Nurfauzia and Yulyadin, 2023; Fahmi, Nurfauzia, Yulita, *et al.*, 2023; Fahmi, Nurfitriani, Nurfauzia, *et al.*, 2023; Ghozali and Latan, 2015; Novanda Sari and Ainul Fahmi, 2022) (see Table 2).

**Table 2.** Convergent Validity

| Indicator | Outer Loading | AVE | Result |
|---|---|---|---|
| AT1 | 0.958 | 0.858 | Valid |
| AT2 | 0.923 | | Valid |
| AT3 | 0.866 | | Valid |
| AT4 | 0.954 | | Valid |
| BI1 | 0.844 | 0.739 | Valid |
| BI2 | 0.809 | | Valid |
| BI3 | 0.928 | | Valid |
| BI4 | 0.852 | | Valid |
| CSE1 | 0.736 | 0.711 | Valid |
| CSE2 | 0.836 | | Valid |
| CSE3 | 0.908 | | Valid |
| CSE4 | 0.883 | | Valid |


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| Indicator | Outer Loading | AVE | Result |
|---|---|---|---|
| EC1 | 0.836 | 0.643 | Valid |
| EC2 | 0.848 | | Valid |
| EC3 | 0.730 | | Valid |
| EC4 | 0.787 | | Valid |
| ECM1 | 0.801 | 0.597 | Valid |
| ECM2 | 0.768 | | Valid |
| ECM3 | 0.769 | | Valid |
| ECM4 | 0.786 | | Valid |
| ECM6 | 0.737 | | Valid |
| EN1 | 0.833 | 0.692 | Valid |
| EN2 | 0.797 | | Valid |
| EN3 | 0.864 | | Valid |
| EPM2 | 0.654 | 0.643 | Valid |
| EPM3 | 0.878 | | Valid |
| EPM4 | 0.838 | | Valid |
| EPM5 | 0.819 | | Valid |
| LPDW1 | 0.714 | 0.698 | Valid |
| LPDW2 | 0.871 | | Valid |
| LPDW3 | 0.881 | | Valid |
| LPDW4 | 0.848 | | Valid |
| LPDW5 | 0.856 | | Valid |
| LPDW6 | 0.831 | | Valid |
| PEOU2 | 0.861 | 0.725 | Valid |
| PEOU3 | 0.862 | | Valid |
| PEOU4 | 0.832 | | Valid |
| PRS1 | 0.760 | 0.691 | Valid |
| PRS2 | 0.844 | | Valid |
| PRS3 | 0.869 | | Valid |
| PRS4 | 0.809 | | Valid |
| PRS5 | 0.867 | | Valid |
| PU1 | 0.845 | 0.655 | Valid |
| PU2 | 0.719 | | Valid |
| PU3 | 0.810 | | Valid |
| PU4 | 0.855 | | Valid |
| RS1 | 0.772 | 0.631 | Valid |
| RS2 | 0.813 | | Valid |
| RS3 | 0.762 | | Valid |
| RS4 | 0.828 | | Valid |
| RS5 | 0.795 | | Valid |
| SO1 | 0.890 | 0.770 | Valid |
| SO3 | 0.894 | | Valid |
| SO4 | 0.847 | | Valid |
| SW1 | 0.808 | 0.760 | Valid |
| SW2 | 0.896 | | Valid |
| SW3 | 0.908 | | Valid |
| USE1 | 0.844 | 0.704 | Valid |
| USE2 | 0.856 | | Valid |
| USE3 | 0.816 | | Valid |


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| Indicator | Outer Loading | AVE | Result |
|---|---|---|---|
| WOP1 | 0.857 | 0.679 | Valid |
| WOP2 | 0.863 | | Valid |
| WOP3 | 0.762 | | Valid |
| WOP4 | 0.809 | | Valid |

Based on the table, all measuring items met the Outer Loading test requirements because all question indicators and AVE were above 0.60 and 0.50. Since there is no problem with convergent validity, the next step to be tested is related to discriminant validity for each construct with the correlation value (Garson, 2016; Putra, 2022) and the method is referred to as Cross Loading. The results show that all cross-loading values in each of the intended constructs are more significant than other constructs. Therefore, the indicators are valid, and there are no problems with discriminant validity. The reliability of each latent construct was assessed using Cronbach's alpha and composite reliability scores. In addition to using Cronbach's alpha and composite reliability, the rho_a value can be considered to ensure the reliability of the PLS construction score (Dijkstra and Henseler, 2015; Rinaldi and Putra, 2022) Cronbach's alpha and composite reliability should be higher than 0.70 (Hair et al., 2017), while the rho_a value must be 0.70 or greater, which indicates the composite reliability (see Table 3).

**Table 3.** Reliability Analysis

| Variables | Cronbach's alpha | Composite reliability (rho_a) | Composite reliability (rho_c) |
|---|---|---|---|
| AT | 0.944 | 0.946 | 0.960 |
| BI | 0.881 | 0.886 | 0.918 |
| CSE | 0.862 | 0.872 | 0.907 |
| EC | 0.813 | 0.819 | 0.878 |
| ECM | 0.834 | 0.846 | 0.881 |
| EN | 0.779 | 0.791 | 0.871 |
| EPM | 0.811 | 0.831 | 0.877 |
| LPDW | 0.913 | 0.926 | 0.932 |
| PEOU | 0.811 | 0.814 | 0.888 |
| PRS | 0.889 | 0.913 | 0.918 |
| PU | 0.825 | 0.842 | 0.883 |
| RS | 0.855 | 0.862 | 0.895 |
| SO | 0.855 | 0.881 | 0.909 |
| SW | 0.840 | 0.841 | 0.904 |
| USE | 0.790 | 0.795 | 0.877 |
| WOP | 0.844 | 0.863 | 0.894 |

The variables had ideal validity and reliability as indicated by the cronbach alpha and composite reliability coefficient values which were higher than 0.7 (>0.7) and AVE coefficient values and more significant than 0.5 (>0.5).

## Inner Model

The inner level of this model determined the causal relationship between the variables researched. The results of the variables are presented in Table 4 and Figure 4.


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**Table 4.** Hypothesis Test

| Hypothesis | Path Coefficient | t-statistics | p-values |
|---|---|---|---|
| CSE -> PU | 0.724 | 16.714 | 0.000 |
| CSE -> PEOU | 0.723 | 15.118 | 0.000 |
| PU -> AT | 0.334 | 3.265 | 0.001 |
| PEOU -> AT | 0.553 | 5.641 | 0.000 |
| AT -> BI | 0.672 | 12.133 | 0.000 |
| BI -> USE | 0.874 | 33.067 | 0.000 |
| WOP -> EC | 0.383 | 5.324 | 0.000 |
| EPM -> EC | 0.434 | 5.394 | 0.000 |
| RS -> EN | 0.162 | 1.569 | 0.117 |
| ECM -> EN | 0.561 | 5.413 | 0.000 |
| LPDW -> SO | 0.057 | 0.466 | 0.641 |
| PRS -> SO | 0.551 | 4.600 | 0.000 |
| EC -> SW | 0.373 | 5.926 | 0.000 |
| EN -> SW | 0.233 | 2.770 | 0.006 |
| SO -> SW | 0.271 | 3.082 | 0.002 |
| SW -> BI | 0.285 | 5.203 | 0.000 |

Based on Figure 4 and Table 4, CSE has a positive and significant influence on PU and PEOU. It is indicated by the test results between CSE with PU and PEOU, where path coefficient values of 0.724 and 0.723, close to the +1 value, and T-Statistic values are 16.714 and 15.118 (>1.96), f-square values are 1.102 and 1.094, and all p-values are valued at 0.000 (<0.05). The test results demonstrate that both PU and PEOU exert a noteworthy positive influence on AT. This is evident from the path coefficient values of 0.334 and 0.553, which closely approach a positive value of +1. Moreover, the corresponding T-Statistic values, 3.265 and 5.641 (>1.96) support the significance of these coefficients. The f-square values of 0.132 and 0.361 indicate substantial impact, while the p-values of 0.001 and 0.000 (<0.05) reinforce the statistical significance of the findings.

According to the analysis presented in Figure 4 and Table 4, it is evident that AT exerts a substantial positive impact on BI. The test results show a path coefficient value of 0.672, which closely approach a positive value of +1. This coefficient is supported by a T-Statistic value of 12.133, which exceeds the threshold of 1.96, signifying its statistical significance. Moreover, the f-square value of 1.226 indicates a considerable effect size, while the p-value of 0.000 (<0.05) reinforces the statistical significance of the relationship between AT and BI. It is observed that BI has a positive and significant influence on USE. This is supported by the result between BI and USE, which indicates a path coefficient value of 0.874, closely approaching +1. Furthermore, the T-Statistic value of 33.067 (>1.96), the f-square value of 3.227, and the p-value of 0.000 (<0.05) provide strong evidence to support the significance of this relationship. According to Figure 4 and Table 4, WOP and EPM exert a positive influence on EC. This observation is supported by the path coefficient values of 0.383 and 0.434 for WOP and EPM, which closely approach +1. Furthermore, the respective T-Statistic values of 5.324 and 5.394 (>1.96), f-square values of 0.173 and 0.221, and p-values of 0.000 and 0.000 (<0.05) confirm the significance of these relationships.

The influence of RS on EN is found to be insignificant, while ECM shows a positive effect on EN. This is evidenced by the path coefficient values of 0.162 and 0.561 for RS and ECM,


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which closely approximate +1. Moreover, the respective T-Statistic values of 1.569 and 5.413 (>1.96), f-square values of 0.017 and 0.204, and p-values of 0.117 (>0.05) and 0.000 (<0.05) provide additional support for the significance of these relationships. According to the analysis of Figure 4 and Table 4, LPDW does not have a significant impact on SO. However, PRS exhibits a positive and significant effect on SO. This is supported by the test results for LPDW and PRS to SO, showing path coefficient values of 0.057 and 0.551, which are close to +1. Furthermore, the T-Statistic values of 0.466 and 4.600 (>1.96), f-square values of 0.002 and 0.168, and p-values of 0.641 (>0.05) and 0.000 (<0.05) validate the significance of these associations. The variables EC, EN, and SO exhibit a positive and significant influence on SW. This is evident from the test results for EC, EN, and SO to SW, which indicate path coefficient values of 0.373, 0.233, and 0.271 closely approaching +1. Moreover, the T-Statistic values of 5.926, 2.770, and 3.082 (>1.96), the f-square values of 0.177, 0.064, and 0.095, and the p-values of 0.000, 0.006, and 0.002 (<0.05) provide strong evidence supporting the significance of these relationships. It is observed that SW has a positive and significant impact on BI. This is supported by the result between SW and BI, where a path coefficient value of 0.285 is close to +1. Furthermore, the T-Statistic value of 5.203 (>1.96), the f-square value of 0.220, and the p-value of 0.000 (<0.05) provide strong evidence for the significance of this relationship.

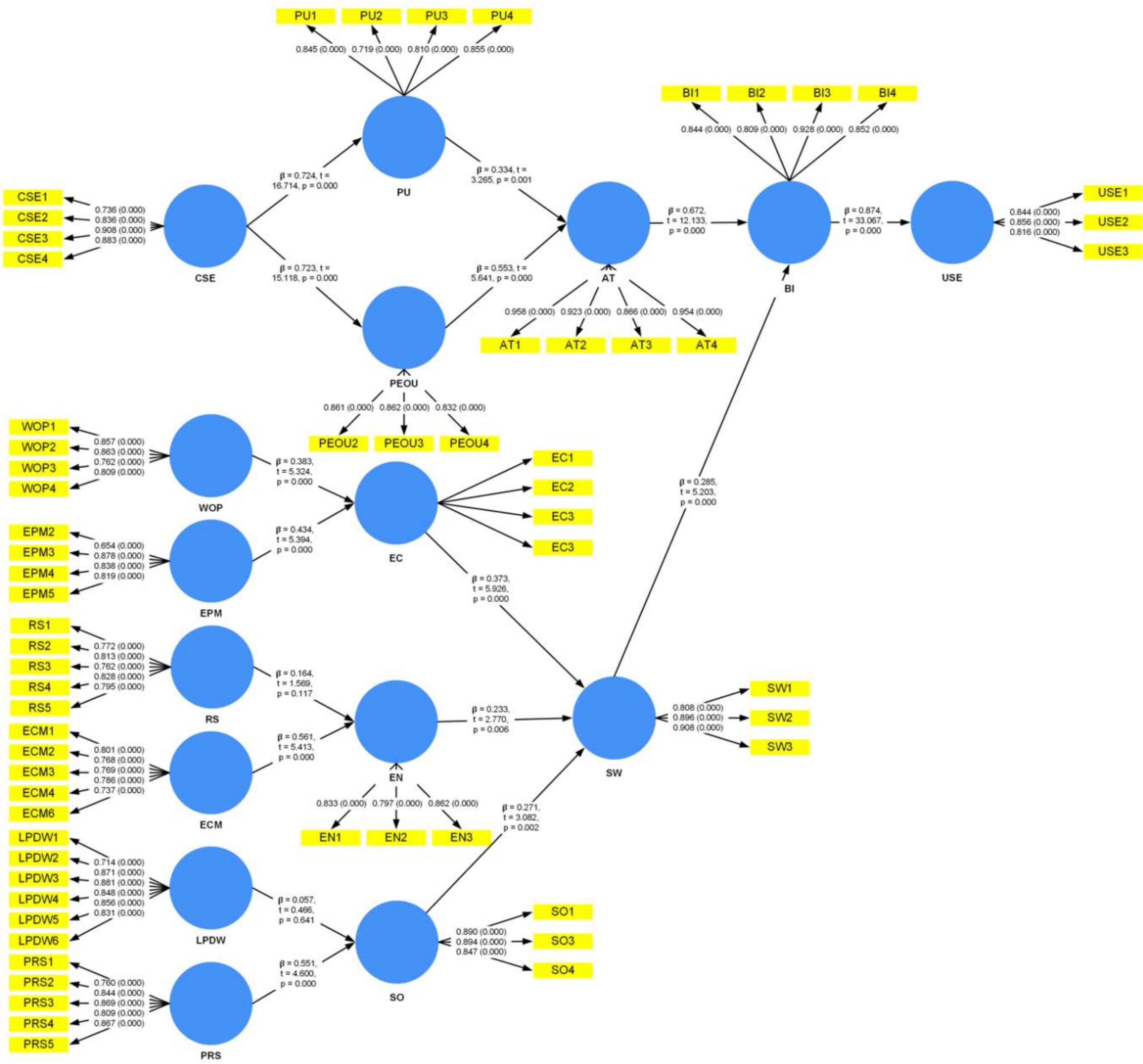


**Figure 4.** Bootstrapping Test Results; Source: Smart PLS 4.0 Output Results (2023)


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**Discussions**

CSE is a factor that positively and significantly influences PU and PEOU. The results are in line with research conducted by (Fahmi *et al.*, 2021; Fahmi, Kostini, *et al.*, 2022; Venkatesh, 2014; Venkatesh and Bala, 2008; Zabukovšek *et al.*, 2019), where CSE was a significant determinant of PU and PEOU of employees to carry out WMS in warehousing. According to (Fahmi *et al.*, 2021; Fahmi, Kostini, *et al.*, 2022; Venkatesh, 2014; Venkatesh and Bala, 2008; Zabukovšek *et al.*, 2019), the process of technology acceptance begins with individuals acquiring knowledge about the specific technology. This serves as a foundation for making the utilization of certain technologies, such as WMS in warehousing companies, easier and more beneficial. Therefore, it can be concluded that hypotheses H1 and H2 are accepted. Computer self-efficacy refers to an individual's belief in their ability to effectively use computers and information technology. In the context of a warehouse management system (WMS), this belief plays a crucial role in shaping the perceptions of users regarding its ease of use and usefulness. When users possess high computer self-efficacy, they tend to approach the WMS with confidence, believing they can easily navigate and master its functionalities. As a result, they are more likely to perceive the system as easy to use, as their belief in their own capabilities aligns with the actual ease of interacting with the WMS. Furthermore, individuals with high computer self-efficacy are also more likely to explore and experiment with the WMS, leading to a deeper understanding of its features and potential benefits. This exploration fosters a positive perception of the system's usefulness, as users can identify how it addresses their specific needs and simplifies their warehouse management tasks.On the other hand, individuals with low computer self-efficacy might feel overwhelmed or uncertain when using the WMS, leading to a negative perception of its ease of use and usefulness. They may struggle to navigate the system, perceive it as complex, and ultimately fail to recognize its potential benefits for streamlining warehouse operations. In summary, computer self-efficacy significantly influences how users perceive the ease of use and usefulness of a warehouse management system. High self-efficacy leads to positive perceptions, making users more likely to embrace and effectively utilize the system, while low self-efficacy can result in negative perceptions and potential resistance to adopting the technology. Therefore, fostering computer self-efficacy through training and support can be crucial in enhancing user acceptance and successful implementation of a warehouse management system.

PU and PEOU positively and significantly influence AT. The results are in line with research conducted by (Venkatesh, 2014) where PU and PEOU have a positive and significant effect on AT of employees to carry out WMS in warehousing. Therefore, it can be concluded that hypotheses H3 and H4 are accepted. Perceived ease of use and perceived usefulness are two key factors that greatly influence a user's attitude towards a warehouse management system (WMS). When users perceive a WMS as easy to use, they believe that interacting with the system will not require significant effort or complexity. This positive perception creates a sense of comfort and confidence, leading to a more favorable attitude towards the technology. Users are more likely to approach the WMS with a positive mindset and be willing to invest time in learning its functionalities. Similarly, the perceived usefulness of the WMS plays a crucial role in shaping user attitudes. If users believe that the system offers tangible benefits and advantages, such as streamlining warehouse operations, improving efficiency, and enhancing decision-making, they are more inclined to view the technology positively. The perceived usefulness directly impacts users' motivation to adopt the WMS and integrate it into their daily workflow. Together, the perceived ease of use and perceived


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usefulness contribute to a user's overall attitude towards the WMS. A positive attitude encourages acceptance, enthusiasm, and willingness to embrace the technology, while a negative attitude may lead to resistance, reluctance, and potential reluctance to utilize the system to its full potential. Therefore, when designing and implementing a warehouse management system, it is essential to focus on enhancing ease of use and demonstrating its usefulness to positively influence user attitudes and ensure successful adoption and integration of the WMS into the warehouse environment.

AT positively and significantly influences BI. The results are in line with research conducted by (Fahmi *et al.*, 2021; Fahmi, Kostini, *et al.*, 2022; Venkatesh, 2014; Venkatesh and Bala, 2008; Zabukovšek *et al.*, 2019), where AT has a positive and significant effect on BI of employees to carry out WMS in warehousing. According to research (Venkatesh, 2014), the main factor influencing individuals' ability to accept a certain technology is their AT. This research shows that the AT of employees using WMS has successfully inspired them to express intention to adopt the concept within their company. Therefore, it can be concluded that hypothesis H5 is accepted. Thus, it can be conclude that an user's attitude towards a warehouse management system (WMS) significantly influences their behavioral intention, which refers to their willingness and readiness to engage in actual behaviors related to using the system. When users have a positive attitude towards the WMS, they generally perceive it as beneficial, easy to use, and valuable for their tasks and responsibilities in the warehouse. This positive evaluation creates a sense of satisfaction and enthusiasm, leading to a stronger intention to adopt and utilize the technology effectively. On the other hand, a negative attitude towards the WMS can lead to resistance and reluctance to engage with the system. Users may perceive it as cumbersome, unnecessary, or even threatening to their established work routines. Such negative evaluations decrease the user's behavioral intention, as they may be hesitant to invest time and effort in learning and using the system. The user's attitude acts as a mediating factor between the perceived ease of use, perceived usefulness, and the actual behavioral intentions. Positive attitudes foster a greater inclination to adopt the WMS, whereas negative attitudes hinder users from embracing the technology and may result in reduced usage or abandonment of the system. Understanding the impact of user attitudes on behavioral intentions is essential for successful WMS implementation. It highlights the importance of addressing user perceptions and concerns, providing appropriate training and support, and emphasizing the benefits of the system to cultivate positive attitudes and promote user acceptance and effective use of the warehouse management system.

BI positively and significantly influences USE. The results are in line with research conducted by (Fahmi *et al.*, 2021; Fahmi, Kostini, *et al.*, 2022; Venkatesh, 2014; Venkatesh and Bala, 2008; Zabukovšek *et al.*, 2019), where BI can influence USE of employees to carry out WMS in warehousing. According to the research, BI is a bridge aspect used by individuals to directly use technology starting from AT of acceptance and the intention to use begins to exist and ends in the day-to-day use. Therefore, it can be concluded that hypothesis H6 is accepted. Behavioral intention plays a crucial role in influencing the actual behavioral use of a warehouse management system (WMS). Behavioral intention refers to an individual's readiness and willingness to engage in specific behaviors related to using the technology. When users have a strong positive behavioral intention towards the WMS, it serves as a motivational force that drives them to act on their intentions and actually use the system in their daily warehouse operations. Positive behavioral intentions are typically influenced by factors such as perceived ease of use, perceived usefulness, and the user's overall attitude towards the WMS. If users perceive the system as easy to use, valuable, and beneficial, they are more likely to develop a favorable intention to incorporate it into their


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workflow. This intention provides a sense of purpose and commitment, leading users to allocate time and effort to learn, experiment, and adopt the WMS effectively. On the contrary, if users have a weak or negative behavioral intention towards the WMS due to perceptions of complexity or lack of perceived benefits, they are less likely to invest the necessary effort to use the system. This may result in limited or sporadic use of the technology, reducing its impact on warehouse operations. Therefore, behavioral intention acts as a bridge between users' attitudes and their actual behavioral use of the WMS. It shapes the level of engagement and commitment towards using the system, ultimately determining whether users will fully embrace and integrate the WMS into their daily routines. As such, understanding and influencing behavioral intention are essential considerations when implementing a WMS, as it directly impacts the successful adoption and utilization of the technology within the warehouse environment.

WOP and EPM positively and significantly influence Economic. The results are in line with research conducted by (Torabizadeh *et al.*, 2020), where WOP and EPM have the highest total effect on Economic. As the demand for value-added services continues to grow with the operation of WOP. This expansion is driven by the increasing requirements of EC (Bank and Murphy, 2013) Furthermore, SW company would consider EC, such as rent and operations costs (Tan *et al.*, 2009). Economic category identifies metrics effectively measuring the interaction with relevant customers and market segments that contribute to financial goals (Presley *et al.*, 2007). Therefore, it can be concluded that hypotheses H7 and H8 are accepted. Warehouse Operation Performance (WOP) and Economic Performance Measurement (EPM) play significant roles in influencing the economic sustainable warehousing information system. WOP encompasses various key performance indicators (KPIs) related to warehouse efficiency, productivity, accuracy, and inventory management. By tracking and optimizing these metrics, the warehousing information system can enhance operational processes, reduce costs, and improve overall performance, which in turn contributes to economic sustainability. EPM, on the other hand, focuses on measuring the financial outcomes and profitability of warehouse operations. It involves assessing factors such as cost-effectiveness, return on investment (ROI), revenue generation, and cost reduction. By analyzing the economic performance of the warehouse through EPM, decision-makers can identify areas for improvement, allocate resources effectively, and make informed decisions that align with the organization's financial goals. Integrating WOP and EPM into the warehousing information system enables a holistic approach to economic sustainability. The data collected through WOP provides valuable insights into the warehouse's day-to-day operations, allowing for continuous improvement and resource optimization. By correlating this operational data with EPM metrics, businesses can gain a comprehensive understanding of the economic impact of their warehousing activities and strategies. Ultimately, an economically sustainable warehousing information system leverages the insights from both WOP and EPM to drive efficient operations, reduce waste, cut unnecessary costs, and increase profitability. It fosters a proactive and adaptive approach to meet changing market demands and environmental considerations while ensuring the long-term viability and success of the warehouse and the broader business. Such a system promotes economic sustainability by aligning operational efficiency with financial performance, benefiting the organization, its stakeholders, and the environment in the long run.

RS does not affect Environment, while ECM has a positive and significant effect on Environment. The result is not consistent with (Torabizadeh *et al.*, 2020), where RS affect Environment. This is because resource factors are considered less important to affect Environment maintenance performance. The RS factor affects supply chain performance


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more in improving SWMS because the resources used are less than usual replaced by the existence of an information system in the form of WMS (Atieh et al., 2016). Meanwhile, the determinant ECM has a positive and significant effect on Environment. The results are in line with research conducted by (Torabizadeh *et al.*, 2020), where ECM has a positive and significant effect on Environment. This is also evidenced by (Nikolaou *et al.*, 2013), where Environment indicators are based on waste management reduction, elimination of influences on biodiversity, and emissions impact minimization (ECM). It can be concluded that hypothesis H9 is declined, while H10 is accepted. It is important to clarify that resources do influence the environment of a sustainable warehousing information system. Resources, in this context, encompass various inputs such as energy, materials, water, human capital, technology, and financial investments, among others. These resources directly impact the environmental performance of the warehousing system and the organization's overall sustainability efforts. Efficiently managing and optimizing resources can significantly reduce the environmental impact of warehousing operations. For instance, implementing energy-saving measures, using renewable energy sources, and adopting eco-friendly technologies can help minimize carbon emissions and energy consumption. Proper waste management and recycling initiatives also contribute to reducing the environmental footprint. Furthermore, investing in human resources through training and education on sustainable practices enables employees to make environmentally conscious decisions in their daily tasks, promoting resource efficiency and reducing wastage. While challenges may exist in transitioning to sustainable practices, resource utilization remains a central aspect of influencing the environmental impact of a warehousing information system positively. Sustainable resource management not only benefits the environment but also aligns with the organization's long-term goals, enhancing its reputation, cost-effectiveness, and resilience in a rapidly changing world focused on environmental stewardship.

LPDW does not affect Social, while PRS has a positive and significant effect on Social. This result is not consistent with (Torabizadeh *et al.*, 2020), where LPDW affect Social. LPDW factor is crucial in achieving increased efficiency and reducing manual work within warehousing operations. However, the lack of warehouse management training and improvement initiatives hinders the potential impact of the LPDW factor on the main Social determinant. It is imperative to address this gap and implement measures to enhance the productivity and effectiveness of employee skills while ensuring that warehousing employees are not overwhelmed with excessive workloads (Nikolaou *et al.*, 2013; Tan *et al.*, 2009). Meanwhile, determinant PRS has a positive and significant effect on Social. The results are in line with (Torabizadeh *et al.*, 2020), where PRS has a positive and significant effect on Social. This is also evidenced by (Nikolaou *et al.*, 2013) that Social dimension includes some indicators such as quality of management, health and safety, wages and benefits, equal opportunities policy, child labor, forced labor, freedom of association, human rights (including indigenous and security), suppliers and products and services. It can be concluded that hypothesis H11 is rejected, while H12 is accepted.

Economic, Environment, and Social have a positive and significant effect on SW. This result is consistent with the research of (Nikolaou *et al.*, 2013; Torabizadeh *et al.*, 2020), where Economic, Environment, and Social affect SW. This is evidenced by the research of Tan, et al. (2009), where SW is about integrating, balancing, and managing Economic, Environment, and Social inputs and outputs of warehouse operations. According to (Torabizadeh *et al.*, 2020), decision-makers and managers should decrease Environment and Social issues when Economic impacts of SWMS are considered. Environment factors contribute to sustainability of warehousing within a company. The role of warehouse is crucial as it serves as a secure location for storing products, ensuring that Environment


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elements not adversely impact the quality of the goods (Miralam, 2017). Other research also mention that reducing Environment impact (EV) can be conducted by using space-saving storage facilities to achieve sustainability and green (SW) aspects (Nordin and Hassan, 2019). Moreover, it is imperative to acknowledge the significance of Social issues as catalysts for business risks to gain a competitive edge by improving Social performance and bolstering corporate reputation. The formulation of Social impact management plan must be seamlessly integrated with the proponent's system and processes, such as WMS, to effectively align objectives and ensure comprehensive implementation (Bank and Murphy, 2013; Esteves *et al.*, 2012). Therefore, SW management model needs to address the inter-relationships of economic objectives, employee welfare, and minimization of Environment impacts (Tan *et al.*, 2009). It can be concluded that hypotheses H13, H14, and H15 are accepted.

SW has a positive and significant effect on BI. The result shows that BI bridges the USE of warehousing with sustainability principles used by employees. Therefore, SW principle influences the occurrence of BI to use the actual WMS and hypothesis H16 is accepted. A sustainable warehouse can significantly influence the behavioral use of a warehouse management system (WMS) due to its alignment with environmental and social responsibility. When a warehouse adopts sustainable practices, it creates a culture of awareness and consciousness among its employees towards environmental impact. This heightened awareness fosters a positive attitude towards using the WMS to its full potential, as employees understand the system's role in supporting sustainable operations. By promoting sustainability, the warehouse communicates a clear message to its workforce about the importance of resource efficiency, waste reduction, and environmental conservation. This motivates employees to embrace the WMS as a tool to optimize operations, minimize waste, and contribute to the warehouse's sustainability goals. Moreover, sustainable warehouses often integrate eco-friendly technologies and practices that streamline processes, reduce energy consumption, and lower the carbon footprint. The WMS plays a central role in coordinating these sustainable initiatives, making it an indispensable tool in achieving the warehouse's environmental objectives. The positive association between sustainability and the WMS encourages employees to actively engage with the system and utilize its features effectively. By supporting sustainable practices through the WMS, employees also feel a sense of pride and purpose, further reinforcing their commitment to its use. In conclusion, a sustainable warehouse creates an environment where the WMS is seen as a critical enabler of sustainability efforts. This fosters a strong behavioral intention among users to embrace and utilize the system in a manner that aligns with the warehouse's ecological and social values, leading to increased adoption and effective use of the warehouse management system.

## 5. CONCLUSIONS

In conclusion, there were 2 rejected and 14 accepted hypotheses in this research. CSE positively and significantly influenced PU and PEOU. PU and PEOU positively and significantly influenced AT. Furthermore, AT positively and significantly influenced BI, which also had a positive and significant effect on USE. WOP and EPM positively and significantly influenced Economic. Even though RS did not affect Environment, ECM had a positive and significant influence on the variable. LPDW did not affect Social. PRS also had a positive and significant effect on Social. Economic, Environment, and Social had a positive and significant effect on SW. In addition, SW had a positive and significant effect on BI. This research proved that knowledge of technology and concepts from aspects of SW management was needed in increasing the acceptance and sustainability of WMS technology


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use. It also proposed the use of a new empirical concept, namely TAM 4, which added external determinant components of CSE and SWMS. The result was used to measure the acceptance and sustainability of WMS technology in the warehousing of a company.

The study's findings demonstrate that computer self-efficacy (CSE) positively influences perceived ease of use (PEOU) and perceived usefulness (PU) of the warehouse management system (WMS). This aligns with previous research, confirming that users' confidence in their computer skills directly impacts their perception of the WMS's usability and value. Additionally, perceived ease of use and perceived usefulness both influence user attitudes (AT) towards the WMS, further corroborating existing research on the significance of these factors in shaping users' perceptions and acceptance of technology. Furthermore, user attitudes play a crucial role in determining behavioral intention (BI) towards the WMS. A positive attitude fosters a strong intention to use the system, while a negative attitude can lead to resistance or limited adoption. The study supports the link between AT and BI, emphasizing the importance of cultivating favorable attitudes to drive user engagement and effective utilization of the WMS. Moreover, the study highlights the impact of Warehouse Operation Performance (WOP) and Economic Performance Measurement (EPM) on economic sustainable warehousing information systems. By optimizing warehouse operations and measuring economic performance, businesses can enhance efficiency, reduce costs, and achieve economic sustainability. This reinforces the significance of incorporating performance metrics and economic considerations in warehouse management practices.

The research also underscores the role of resources in influencing the environment of a sustainable warehousing information system. Efficient resource management, including energy conservation, waste reduction, and eco-friendly technologies, contributes to reducing the environmental impact of warehousing operations. The study recognizes the importance of aligning resource utilization with environmental responsibility to promote sustainability. Moreover, the study sheds light on the influence of sustainable warehouse practices on the behavioral use of the warehouse management system. A sustainable warehouse fosters a positive attitude and intention towards using the WMS to support environmental and social responsibility efforts. This positive association encourages employees to actively engage with the system and maximize its benefits, driving increased adoption and effective use of the WMS.

In conclusion, this research highlights the interconnectedness of various factors that influence the successful implementation and utilization of a warehouse management system. It emphasizes the significance of fostering computer self-efficacy, promoting positive user attitudes, optimizing warehouse operations, measuring economic performance, and embracing sustainable practices to achieve economic, environmental, and social sustainability within the warehousing context. By recognizing and leveraging these interrelated factors, businesses can enhance their warehouse management practices, reduce environmental impact, and work towards building a more sustainable future.

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